

**TECHNICAL MANUAL**

**INTERMEDIATE DIRECT SUPPORT AND  
INTERMEDIATE GENERAL SUPPORT**

**MAINTENANCE MANUAL**

**LOCOMOTIVE, DIESEL-ELECTRIC,  
56-1/2-INCH GAGE, 80-TON, 670 HP,  
0-4-4-0 WHEEL,  
MODEL B-B-160/160-4GE747-A1  
NSN 2210-01-158-2980**

**Approved for public release; distribution is unlimited**

**WARNING****EXHAUST GASES CAN BE DEADLY**

Exhaust gases can produce symptoms of headache, dizziness, loss of muscular control, or coma. Permanent brain damage or death can result from severe exposure. You can ensure your safety by following this rule:

**DON'T** operate the engine in an enclosed area unless it is properly ventilated.

If you notice exhaust odors or exposure symptoms, **IMMEDIATELY VENTILATE** the area. If the symptoms persist, remove the affected personnel and treat them as follows:

- Expose them to fresh air.
- Keep them warm.
- **DON'T PERMIT PHYSICAL EXERCISE.** If necessary, give artificial respiration. Refer to FM 21-11, First Aid for Soldiers.

**WARNING**

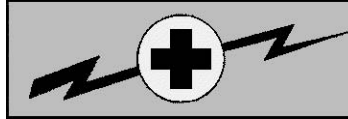
A blue signal flag shall be placed on both ends of the locomotive while doing maintenance on, under, or around it. The locomotive shall not be moved or coupled while the blue signal flag is displayed. Only the maintenance personnel who placed the blue signal flag(s) have authority to remove it. Failure to observe this warning may result in injury or death to personnel.

**WARNING**

High voltage is used in the operation of equipment. Do not be misled by the term **LOW VOLTAGE**. Potentials as low as 50 volts may cause death.

**WARNING**

Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.

**WARNING****WARNING****HIGH VOLTAGE**

is used in the operation of this equipment.  
**DEATH ON CONTACT**

may result if personnel fail to observe safety precautions.

Never work on electrical equipment unless there is at least one other person nearby who is familiar with the operation and hazards of that equipment. That person should also be competent in giving first aid. When an operator helps a technician, he must be warned about dangerous areas.

Whenever possible, shut off the power supply to equipment before beginning work. When working inside the equipment with power off, take special care to ground every capacitor likely to hold a dangerous potential. Electrical shock may occur if personnel fail to observe safety precautions.

Be careful not to contact high-voltage connections when installing or operating this equipment.

Whenever possible, keep one hand away from the equipment to reduce the hazard of current flowing through vital organs of the body.

**WARNING**

When traction motor or under-locomotive equipment must be inspected while the engine is running, remove excitation from the main generator and set airbrakes. Move reverser to center position and remove from the controller. Place a chain or a block of wood at the front and rear of one wheel. This will prevent accidental movement of the locomotive.

**WARNING**

Should a fire develop on the locomotive and carbon dioxide is used to extinguish the flame, do not breathe the fumes. These fumes are toxic.

**WARNING**

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. Shut off engine and do not smoke while refueling.

**WARNING**

Fuel and oil are slippery and can cause falls. To avoid injury, wipe up spilled fuel or oil with rags.

**WARNING**

Never remove the engine cooling system cap when the engine is hot. This is a high-pressure cooling system, and escaping steam or hot water can cause serious burns.

**WARNING**

Operation of this locomotive presents a noise hazard to personnel in the area. The noise level exceeds the allowable limits for unprotected personnel. Wear aural protectors or earplugs.

**WARNING**

Water/rain make catwalk and steps slippery and may cause death or injury. Be careful when using wet catwalks and steps.

**WARNING**

If an engine has been shut down from a suspected crankcase bearing failure, do not open hand hole covers or top deck covers until engine has completely cooled. Overheated bearings and an inrush of oxygen (air), combined with hot oil vapors, could cause an explosion and fire.

**WARNING**

Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38-59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.

**WARNING**

Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**WARNING**

When machining parts of locomotive, be careful of hot, sharp chips. Wear adequate eye protection. Use leather welding gloves. Cover exposed skin areas. Do not use hands to remove shavings, even with leather gloves; use a hook or welding rod.

**WARNING**

Be careful not to short out battery terminals. Do not smoke or use open flame near batteries. Batteries may explode from a spark. Battery acid is harmful to skin and eyes.

**WARNING**

Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.

**WARNING**

Procedures specify the heating and cooling of parts to aid in disassembly and assembly. Heated and cooled parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.

**WARNING**

Pressurized steam is specified in cleaning operations, which may cause injury to personnel if safety precautions are not followed. Use rubberized gloves, boots, suit, hood, and face shield for protection against burns and scalding.

**WARNING**

Valve assemblies may be under a spring load. Use caution during disassembly and assembly procedures so that no parts fly out, causing injury to personnel.

**WARNING**

Prior to performing engine maintenance, be sure that battery switch is in OPEN position and tagged. This is to prevent engine from being started while personnel are working on engine components.

**WARNING**

Flash fire may result in injury to personnel if crankcase covers are removed within 15 minutes after emergency shutdown. Do not restart engine until cause for shutdown has been corrected.

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TECHNICAL MANUAL

NO. 55-2210-224-34

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON, D.C., 21 July 1987

INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL

LOCOMOTIVE, DIESEL-ELECTRIC,  
56-1/2-INCH GAGE, 80-TON, 670 HP,  
0-4-4-0 WHEEL, MODEL B-B-160/160-4GE747-A1  
NSN 2210-01-158-2980

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REPORTING OF ERRORS AND RECOMMENDING IMPROVEMENTS

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You can help improve this manual. If you find any mistakes, or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 (Recommended Changes to Equipment Technical Publications), located in the back of this manual direct to: Commander, US Army Troop Support Command, ATTN: AMSTR-MCTS, 4300 Goodfellow Blvd. , St. Louis, MO 63120-1798. A reply will be furnished to you.

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## CHAPTER 1

### INTRODUCTION

#### Section I. GENERAL INFORMATION

##### 1-1. SCOPE

MODEL NUMBER AND NAME: B-B-160/160-4GE747-A1, 80-ton diesel-electric locomotive.

PURPOSE OF EQUIPMENT: Used for general yard switching or short-line railway service. Can be used as a single unit or connected in multiple-unit operation under one operator.

TYPE OF MANUAL: Intermediate Direct Support and Intermediate General Support Maintenance.

- a. This manual is published for the use of personnel engaged in the inspection and maintenance of the 80-ton diesel-electric locomotive. It shall be used as a guide for regulations, standards, and procedures governing such work assignments.
- b. Maintenance portion of this manual provides guidance to intermediate direct support and intermediate general support level maintenance personnel. The purpose of each assembly and subassembly, and general overall locomotive maintenance procedures are given. Also included is a general troubleshooting guide to aid in inspection, removal, disassembly, cleaning, inspection, repair, assembly, and installation of components. General functions of the main features are given as an aid to provide a concise understanding of major and minor components.

##### 1-2. MAINTENANCE FORMS, RECORDS, AND REPORTS

Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 738-750, The Army Maintenance Management System (TAMMS).

##### 1-3. PREPARATION FOR STORAGE OR SHIPMENT

Refer to TM 55-2210-224-12, Operator and Unit Maintenance Manual for Locomotive, for information pertaining to the preparation for storage or shipment.

**1-4. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)**

- a. Refer to Federal Railroad Administration (FRA) Form 6180-49A to document 92-day Locomotive Inspection and Repair Record in accordance with Locomotive Inspection Act, 36 State, 913. The form must be completed and signed by the personnel conducting the inspection. The completed form shall be placed in the card holder in the locomotive cab. A copy shall be retained for a period of 2 years. Refer to TB 55-2200-207-15/1, Inspection and Maintenance Checklist for Diesel-Electric Locomotive, for intermediate direct support and intermediate general support maintenance's 92-day inspection of the locomotive. The checklist and DA Form 2407, Maintenance Request, will be used as prescribed in DA PAM 738-750.
- b. Refer to TB 55-2200-207-15/1 for intermediate direct support maintenance inspection of the locomotive. The checklist in TB 55-2200-207-15/1 and DA Form 2407 will be used as prescribed in DA PAM 738-750.

**1-5. CALIBRATION**

Measuring and test equipment used to determine equipment conformance will be calibrated in accordance with MIL-STD-120, Gage Inspection, MIL-STD-45662, Calibration Systems Requirements, and MIL-I-45607, Acquisition, Maintenance, and Disposition of Inspection Equipment.

**1-6. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR)**

If your locomotive needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you do not like about your equipment. Let us know why you do not like the design or performance. Tell us why a procedure is hard to perform. Put it on an SF 368 (Quality Deficiency Report). Mail it to: Commander, US Army Troop Support Command, ATTN: AMSTR-QX, 4300 Goodfellow Blvd. , St. Louis, MO 63120-1798. We'll send you a reply.

**1-7. WARRANTY INFORMATION**

- a. The NTA-855-L4 diesel engine is warranted by Cummins Engine Company for 12 months or 1000 hours of operation, whichever comes first. Warranty starts on the date found on DA Form 2408, Equipment Log Assembly, or DA Form 2410, Component Removal and Repair/Overhaul Record, in the logbook.
- b. The AVLALBBF99999 Air Compressor is warranted for 1 year from the date of receipt of the warranty card by the Gardner Denver Division of Cooper Industries. Upon receipt of the locomotive, the warranty card must be properly filled out and sent to the manufacturer. Report defects in material or workmanship to your supervisor, who will take appropriate action.

## Section II. EQUIPMENT DESCRIPTION AND DATA

### 1-8. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES

#### CHARACTERISTICS

An eight-wheel, four-traction-motor-driven, 80-ton diesel-electric locomotive.

#### CAPABILITIES

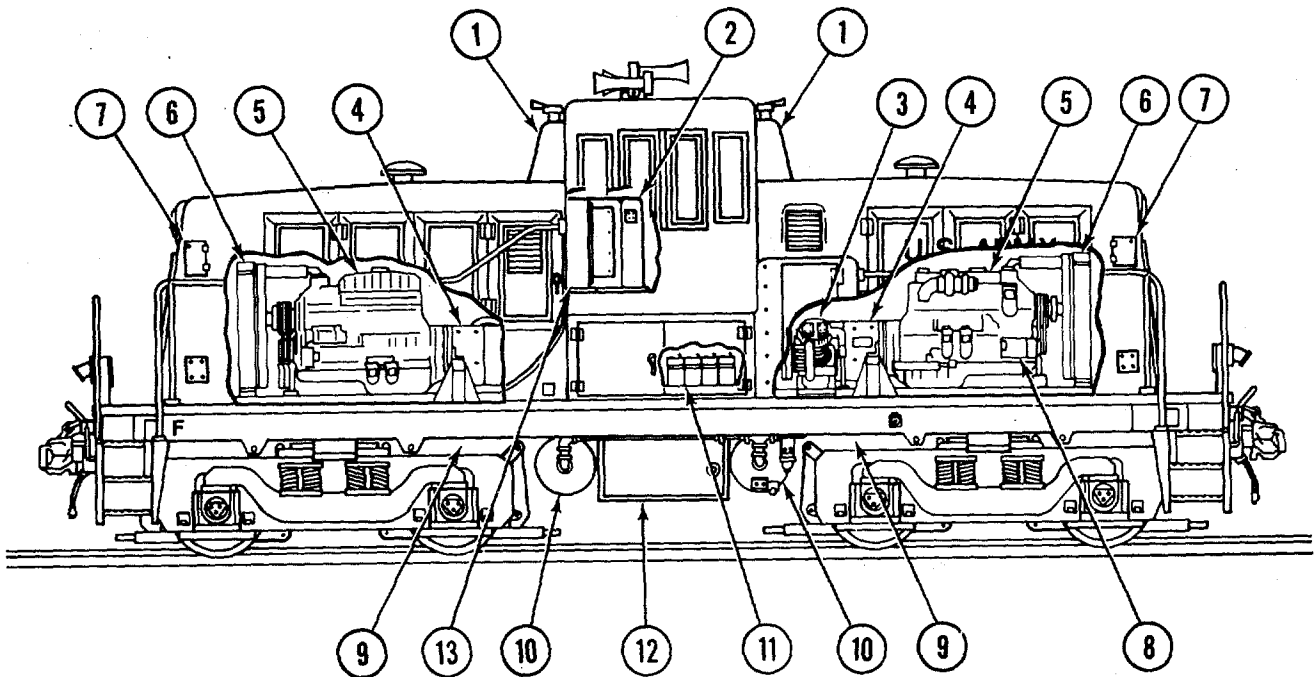
Used as a yard switching locomotive or short-line railway service and includes features listed below. Description of major components and systems is listed in the applicable maintenance paragraphs. Can also be operated as a single unit or connected with other units of the same type for multiple unit operation.

#### FEATURES

Include the following:

- Diesel engines
- Main generators
- Battery charging alternators
- Traction motors
- Air compressors
- Airbrake system
- Sanding system

## 1-9. LOCATION AND DESCRIPTION OF MAJOR COMPONENTS



**FIGURE 1-1. Major components - location.**

- 1 TAILPIPE HOUSING. Provides a means of supporting the tailpipe.
- 2 MASTER CONTROLLER. Contains the throttle, reverser, brake controls, and other controls and indicators used by operator to operate and monitor the locomotive and is located in the cab of the locomotive.
- 3 AIR COMPRESSORS. The two air compressors are compound, V-type, two-cylinder compressors and are belt driven by pulleys mounted on the armature shafts of the main generators.
- 4 MAIN GENERATORS. Two main generators furnish direct-current power over a wide range of voltage at various speeds up to 2100 rpm and are self excited. The generators also act as starting motors when the start buttons are pushed and the battery switch is closed.

**1-9. LOCATION AND DESCRIPTION OF MAJOR COMPONENTS (CONT)**

5. DIESEL ENGINES Two six-cylinder in-line, turbocharged, water-cooled, four-cycle, engines provide power. They are directly connected to the two main generators.
6. ENGINE RADIATORS. Two radiators, one for each engine, keep engines at proper operating temperature.
7. NDBOXES AND SAND CONTROLLERS. There are four sandboxes and sand controllers, one for each front and rear wheel. The sand controllers are mounted underneath the sandboxes and deliver a metered amount of sand to the front and rear driving wheels. The sand controller is controlled by the sander control valve.
8. BATTERY CHARGING ALTERNATORS. Two 32-volt, 60-amp, internally regulated alternators, one on each engine, provide power for charging the batteries and operating low-voltage lights and controls.
9. TRACTION MOTORS. Traction motors are axle hung and supported on the truck transoms by spring-loaded suspension. One motor is geared to each axle through a double gear reduction with a final ratio of 14.96:1.
- 10 MAIN RESERVOIR AIR TANKS. Two main reservoir tanks, to the front and rear of the fuel tank, provide a means of storing air for the air system.
11. BATTERY COMPARTMENT. The battery compartment is located beneath the cab, directly beneath the fireman's seat, and contains four batteries used for starting the engines.
12. FUEL TANK. The fuel tank can hold 400 gallons (1 514 liters) of diesel fuel for engine operation. Two fill pipes and two fuel level gages, one on each side of the locomotive, provide a means of filling the tank and monitoring the level of fuel.
13. ELECTRICAL EQUIPMENT CABINET. Contains the automatic switching relays and contactors and is located in the cab of the locomotive. Both high and low voltage are present in the electrical equipment cabinet when the locomotive is in operation.

**1-10. DIFFERENCES BETWEEN MODELS**

This manual covers 80-ton, diesel-electric locomotives. Minor differences may exist in components and component locations and in the electrical conduit and air piping layout. There are no known differences between locomotives.

**1-11. PRINCIPLES OF OPERATION**

Refer to TM 55-2210-224-12 for principles of operation.

## CHAPTER 2

## LOCOMOTIVE MAINTENANCE INSTRUCTIONS

## Section I. REPAIR PARTS, SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

**2-1. COMMON TOOLS AND EQUIPMENT**

For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your unit.

**2-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT**

Special tools, TMDE, and support equipment are listed and illustrated in TM 552210-224-24P, Unit, Intermediate Direct Support, and Intermediate General Support Maintenance Repair Parts and Special Tools List, for the locomotive and in TM 52815-233-24P, Unit, Intermediate Direct Support, and Intermediate General Support Maintenance Repair Parts and Special Tools List, for the engine.

**2-3. REPAIR PARTS**

Repair parts are listed and illustrated in the repair parts and special tools list, TM 55-2210-224-24P, for the locomotive and in TM 5-2815-233-24P for the engine.

**2-4. SERVICE UPON RECEIPT**

Refer to TM 55-2210-224-12 for service upon receipt instructions.

## Section II. QUARTERLY AND ANNUAL CHECKS AND SERVICES (QACS)

**2-5. INTRODUCTION TO QUARTERLY AND ANNUAL CHECKS AND SERVICES**

a. Quarterly and Annual Inspection Worksheet for Diesel-Electric Locomotives. The quarterly and annual inspections will be performed by qualified maintenance personnel of using organizations. The inspections are divided into five sections from A to E denoting the specific items to be checked.

- (1) Section A, mechanical, requires inspection of wheels and truck details, couplers and draft gear, and the condition of the horn, bell, windshield wiper, sander, heater, handbrake, fan, fan drive, etc.
- (2) Section B, engine, requires a complete inspection of engine lubricating oil, fuel oil intake, and cooling systems in conjunction with all bearings, piston assemblies, and governor and throttle linkage.
- (3) Section C, airbrakes, requires a complete inspection of the compressor and its operation, air gages, brake details, and air reservoirs.

**2-5. INTRODUCTION TO QUARTERLY AND ANNUAL CHECKS AND SERVICES (cont)**

- (4) Section D, electrical, requires a complete inspection of the lighting system, battery, rotating electrical equipment, and control circuits.
- (5) Section E requires the inspection of fire extinguishers and lubrication system and a test run of the locomotive.

b. Form FRA F6180-49A, Locomotive Inspection and Repair Record.

- (1) Purpose. This form shows the condition of locomotives and also shows whether the equipment complies with Federal Railroad Administration (FRA) and Department of Transportation (DOT) regulations.
- (2) Use. This form has two uses. It is used to show whether the equipment complies with regulations, and it is also used as a record of maintenance and repairs required by FRA and DOT.
- (3) General Instructions.
  - (a) A quarterly report will be made by qualified personnel.
  - (b) The annual report will be made in three copies by qualified intermediate direct support, intermediate general support, or depot-level personnel. The annual report is also completed after each depot overhaul.
  - (c) The qualified person making the inspection also signs the form.
  - (d) The form is countersigned by the officer in charge. If a non-Army organization does the work, the supervisor will countersign.
  - (e) Form FRA F6180-49A may be obtained from the local Mobile Rail Repair Shop (MRRS).
- (4) Disposition.
  - (a) The original copy of the report remains in the cab of the locomotive. Protect the form with a clear cover.
  - (b) Keep one copy at the user level.
  - (c) Send the third copy to: Commander, USATROSCOM, ATTN: AMSTR-MCFP, 4300 Goodfellow Blvd, St. Louis, MO 63120-1798.
  - (d) Retain copies only until a new report is made. Then destroy the old form.

**NOTE**  
 Maintenance procedures for the following tables will be found  
 in the applicable maintenance chapters.

Table 2-1. Quarterly and Annual Inspection Worksheet

Item	Quarterly	Annual
<b><u>A - MECHANICAL</u></b>		
<b>1. Inspect for wheel and truck details:</b>		
a. Bearings and wheels	X	X
b. Thrust plate and bolts	X	X
c. Wheel flanges	X	X
<b>2. Inspect couplers and draft gears:</b>		
a. Coupler mechanism	X	X
b. Gage knuckles		X
c. Draft gear, carriers, etc.		X
<b>3. Inspect footboards, handrails, steps, and safety appliances.</b>	X	X
<b>4. Inspect cab, hood, doors, windows, platform, etc.</b>	X	X
<b>5. Check operation or condition of:</b>		
a. Horn	X	X
b. Bell	X	X
c. Windshield wipers	X	X
d. Sander equipment	X	X
e. Cab heater	X	X
f. Fan and fan drive	X	X
g. Handbrake	X	X
h. Hoses and hose clamps	X	X
i. Belts and pulleys	X	X
j. Traction motor blowers and duct	X	X
<b>6. Drain water and sludge from fuel tank.</b>	X	X



Table 2-1. Quarterly and Annual Inspection Worksheet (continued)

Item		Quarterly	Annual
<b><u>B - ENGINE</u></b>			
7.	Inspect the following for leaks:		
a.	Fuel system	X	X
b.	Lube system	X	X
c.	Cooling system	X	X
d.	Cylinder heads, crankcase inspection plates, and covers	X	X
e.	Exhaust and intake systems	X	X
8.	Check cooling water level.		
a.	Test antifreeze	X	X
b.	Comparator test water treatment	X	X
9.	Clean and check:		
a.	Fuel strainers and filters	X	X
b.	Lube oil strainers and filters	X	X
c.	Air intake filters	X	X
d.	Crankcase breathers	X	X
e.	Turbo-filters		X
f.	Air boxes	X	X
10.	Check pressures:		
a.	Lube oil	X	X
b.	Fuel oil	X	X
11.	Check the following:		
a.	Engine speeds (Idle: 620 Full: 2100)	X	
b.	Turbocharger		X
c.	Fuel injection, pump timing, and rack setting		X
d.	Intake and exhaust valves and mechanism	X	
	(1) Tappet or lash adjuster clearance		X
	(2) Lubrication, leaks, sticking valves, and broken springs	X	
e.	Governor and throttle linkage		X
12.	Check main and connecting rod bearings (when accessible).		X
13.	Check tightness of engine base bolts.		X
14.	Visually inspect piston rings and cylinders (when accessible).		X

Table 2-1. Quarterly and Annual Inspection Worksheet (continued)

Item		Quarterly	Annual
<b><u>C - AIRBRAKES</u></b>			
15.	Inspect compressor:		
a.	Check coupling.	X	X
b.	Clean air intake filters.	X	X
16.	Check compressor operation.		
a.	Unloading valves:	X	X
	(1) Cuts in: 120 psi (827 kPa)	X	X
	(2) Cuts out: 130 psi (896 kPa)	X	X
b.	Orifice test		X
17.	Check air pressure settings and operation of air gages.	X	X
18.	Check air system for leaks.	X	X
19.	Drain moisture from reservoirs and intercoolers.	X	X
20.	Check brake details:		
a.	Rods, levers, and pins	X	X
b.	Air hoses and couplings	X	X
c.	Handbrake and chain	X	X
d.	Brakeshoes and keys	X	X
e.	Brake cylinders and piston travel	X	X
f.	Centrifugal filters, strainer, etc. (clean items)		X
<b><u>D - ELECTRICAL</u></b>			
21.	Check lights and lighting system.	X	X
22.	Check battery.		
a.	Check level of electrolyte.	X	X
b.	Check specific gravity.	X	X
c.	Wash off battery.	X	X
d.	Clean and lubricate terminals.	X	X

Table 2-1. Quarterly and Annual Inspection Worksheet (continued)

Item		Quarterly	Annual
23.	Inspect rotating electrical equipment.		
a.	Visually check condition; clean and blow out:		
(1)	Commutators and armatures	X	X
(2)	String bands	X	X
(3)	Brushes and pigtailed	X	X
(4)	Brush holders	X	X
(5)	Insulators, field coils, and insulation	X	X
b.	Inspect and check:		
(1)	For proper drive gear lubrication	X	X
(2)	Inspection covers (tighten and clean)	X	X
(3)	Motor nose suspension		X
(4)	For proper traction motor support bearing lubrication	X	X
24.	Inspect control circuits.		
a.	Check condition and operation and clean contact surfaces:	X	X
(1)	Throttle contacts	X	X
(2)	Electrical contactors	X	X
(3)	Reverser	X	X
(4)	Relays	X	X
(5)	Resistors		X
b.	Check connections for tightness.		X
c.	Check knife switch.	X	X
<b><u>E - GENERAL</u></b>			
25.	Check fire extinguishers.	X	X
26.	Clean engines and compartments.	X	X
27.	Lubricate locomotive in accordance with LO 55-2210-224-12.	X	X
28.	Test run locomotive.	X	X
29.	Replace cab card.	X	X

### Section III. GENERAL MAINTENANCE INSTRUCTIONS

#### 2-6. GENERAL

- a. This section provides instructions for performing the stationary vehicle airbrake test, welding, and painting.
- b. Publications which provide additional information on general shop practice techniques, preservation, sheet metal work, etc., are listed in appendix A of this manual.

#### 2-7. PAINTING

Painting on the locomotive shall be done in accordance with TM 43-0139, Painting Instructions for Field Use, and MIL-P-53044, Painting and Marking: Freight and Maintenance Cars; Railway Motive Power and Work Equipment.

#### 2-8. WELDING

Welding on the locomotive shall be done in accordance with TM 9-237, Welding Theory and Application.

#### 2-9. STATIONARY LOCOMOTIVE AIRBRAKE TEST

##### WARNING

**Before beginning stationary locomotive airbrake test, check to see that handbrake has been set, wheels are blocked, reverser is in NEUTRAL position. Failure to do so may result in injury to personnel.**

##### NOTE

- Brake preventive maintenance checks and services (PMCS) will be performed in accordance with TM 55-2210-224-12.
- Before beginning stationary locomotive airbrake test, brake system must be fully charged.

- a. Set handbrake and block wheels.
- b. Start locomotive in accordance with TM 55-2210-224-12.
- c. Set automatic and independent brake valve handles to RELEASE position.

**2-9. STATIONARY LOCOMOTIVE AIRBRAKE TEST (cont)**

- d. Observe gages. Gages shall indicate the following:
  - (1) Main reservoir pressure 120 to 130 psi (827 to 896 kPa).
  - (2) Equalizing reservoir and brake pipe pressures 80 or 90 psi (552 or 621 kPa).
  - (3) Brake cylinder pressure 0 psi (0 kPa).
- e. Use the automatic brake valve and make a 10-psi (69 kPa) brake pipe reduction.
- f. After brake pipe exhaust ceases to blow, move cutoff pilot valve to OUT position and perform the following:
  - (1) Make a visual inspection of each brake cylinder and check that brakes are applied.
  - (2) Observe brake pipe and brake cylinder gage for 1 minute. Brake pipe pressure leakage must not exceed 5 psi (34 kPa) in 1 minute. Brake cylinder pressure should indicate between 10 and 25 psi (69 and 172 kPa).
  - (3) Observe equalizing reservoir and main reservoir gage for 1 minute. No drop in equalizing reservoir pressure is allowed.
  - (4) Press independent brake valve handle down for 7 seconds. Check that brakes release.
  - (5) Move cutoff pilot valve to IN position and make a 15-psi (103 kPa) brake pipe reduction. Check that brakes apply and brake cylinder pressure indicates between 10 to 25 psi (69 to 172 kPa).
  - (6) Move automatic brake valve handle halfway toward RELEASE position. Observe main reservoir and equalizing gage. Check that there is no rise in equalizing reservoir pressure. Any rise in pressure shall require repair of automatic brake valve, distributing valve, and/or associated piping up to the angle cock.
  - (7) Move power throttle to No. 2 position and move automatic brake valve to EMERGENCY position. Observe the following:
    - (a) Brake pipe pressure reduces rapidly to zero.
    - (b) Equalizer reservoir pressure falls to zero in 3 to 5 seconds.
    - (c) Brake cylinder pressure builds up at a rapid rate to no more than 68 to 72 psi (469 to 496 kPa).
    - (d) Sanders are actuated.
  - (8) Move throttle to IDLE.

**2-9. STATIONARY LOCOMOTIVE AIRBRAKE TEST (cont)**

- (9) Press independent brake valve handle down. Check that brakes release.
- (10) Release independent brake valve handle. Check that brakes apply.
- (11) Open and close fireman's emergency brake valve. Check for proper operation.
- (12) Move automatic brake valve handle to EMERGENCY position and wait 2 minutes. Move throttle to IDLE position and move automatic brake valve handle to RELEASE position to charge the brake system. Check that pressure is restored to normal.
- (13) Move independent brake valve handle to FULL APPLICATION position. Check that brakes apply. Brake cylinder pressure shall be 45 psi (310 kPa).
- (14) Move independent brake valve handle to RELEASE position. Check that brakes release.
- (15) With independent brake valve in RELEASE position, make a 15-psi (103 kPa) brake pipe reduction with automatic brake valve. Check that brakes apply. Brake cylinder pressure shall be 10 to 25 psi (69 to 172 kPa).
- (16) Move automatic brake valve handle to RELEASE position. Visually check that brakes release. Brake cylinder pressure shall be 0 psi (0 kPa).

**Section IV. PREPARATION FOR STORAGE OR SHIPMENT****2-10. STORAGE**

Refer to TM 55-2210-224-12 for preparation for storage or shipment instructions.

**CHAPTER 3****INTERMEDIATE DIRECT SUPPORT MAINTENANCE INSTRUCTIONS****Section I. REPAIR PARTS, SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT****3-1. COMMON TOOLS AND EQUIPMENT**

For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your unit.

**3-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT**

Special tools, TMDE, and support equipment are listed and illustrated in TM 55-2210-224-24P for the locomotive and in TM 5-2815-233-24P for the engine.

**3-3. REPAIR PARTS**

Repair parts are listed and illustrated in TM 55-2210-224-24P for the locomotive and in TM 5-2815-233-24P for the engine.

**Section II. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING****NOTE**

**Refer to air piping schematic (FO-2) for location of pipe numbers.**

**3-4. GENERAL**

- a. Table 3-1 lists the common malfunctions which you may find during operation or maintenance of the locomotive or its components. You should perform the tests/inspections and corrective actions in the order listed. These procedures supplement the following troubleshooting procedures for the 80-ton locomotive.
  - (1) Operator/Crew level - TM 55-2210-224-12.
  - (2) Unit level - TM 55-2210-224-12.
  - (3) Engine Operator, Unit, Intermediate Direct Support, and Intermediate General Support level - TM 5-2815-233-14.

**3-4. GENERAL (cont)**

b. This manual cannot list all malfunctions that may occur, nor all tests or inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective actions, notify your supervisor.

**WARNING**

**Operation of a deadlined locomotive without inspection and repair will cause further damage to a disabled component and possible injury to personnel.**

- c. Check the easiest and most obvious things first. This simple rule saves time and trouble.
- d. Doublecheck before disassembly. The source of most problems can be traced to more than one part in a system.
- e. Check tags, service request forms, and locomotive log book for repair history. This may help lead to source of problems.
- f. Before correcting a problem, diagnose the cause of the problem. Do not allow the same failure to occur again.



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**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**AIRBRAKE SYSTEM****1. AIR PRESSURE DOES NOT BUILD UP.**

Step 1. Check for open main reservoir cutout cock.

Close cutout cock.

Step 2. Check for slipping or broken air compressor belts.

Tighten or replace belts Refer to TM 55-2210-224-12.

Step 3. Check for open main reservoir drain valve.

Close main reservoir drain valve.

Step 4. Check for open trainline air angle cock.

Close trainline air angle cock.

Step 5. Check for stuck open unloader valve.

Disassemble and clean unloader valve (para 4-8).

Step 6. Check for stuck open main air reservoir safety valve.

Replace safety valve (para 3-60).

Step 7. Check for stuck open air compressor governor.

Disassemble and clean governor (para 3-44).

Step 8. Check for stuck open high or low air pressure discharge and suction valves.

Rebuild or replace valves (para 4-8).

**2. AIR PRESSURE BUILDS UP SLOWLY.**

Step 1. Check for slipping air compressor belts.

Tighten or replace belts Refer to TM 55-2210-224-12.

Step 2. Check for loose fittings.

Locate and tighten loose fittings.

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>	<b>TEST OR INSPECTION</b>	<b>CORRECTIVE ACTION</b>
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**2. AIR PRESSURE BUILDS UP SLOWLY. (cont)**

Step 3. Check for partially open cocks.

Fully close all cocks.

Step 4. Check for slight leakage on air compressor unloader valve or compressor-head valve.

Disassemble and clean unloader valve or compressor-head valve (para 4-8).

**3. MAIN RESERVOIR AIR PRESSURE NOT PROPERLY CONTROLLED.**

Step 1. Check for closed cutout cock in governor pipe.

Open cutout cock in governor pipe.

Step 2. Check for leaking air compressor valves.

Disassemble and lap valves and valve seats (para 4-8).

Step 3. Check for sticking air compressor governor.

Disassemble and clean governor (para 3-44).

Step 4. Check for leaking air compressor unloader pipe.

Repair or replace air compressor unloader pipe (para 4-8).

Step 5. Check for sticking air compressor unloader valves.

Disassemble and clean air compressor unloader valves (para 4-8).

**4. EQUALIZING RESERVOIR AIR GAGE INDICATES NO PRESSURE OR A LEAK.**

Step 1. Check for leaking equalizing reservoir gage or fittings.

Locate leakage and tighten fittings and/or repair or replace gage (para 3-10).

Step 2. Check for leaking equalizing reservoir gage mounting bracket O-ring.

Locate leakage and tighten or replace mounting bracket O-ring (para 3-10).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**4. EQUALIZING RESERVOIR AIR GAGE INDICATES NO PRESSURE OR A LEAK. (cont)**

Step 3. Check for leaking piping or fittings on pipes 5 and 15.

Locate leakage and tighten or replace piping and/or fittings.

Step 4. Check for leaking equalizing reservoir piping or fittings.

Locate leakage and tighten or replace reservoir piping and/or fittings.

Step 5. Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

Step 6. Check for leaking equalizing reservoir.

Repair or replace equalizing reservoir (para 3-59).

**5. BRAKE PIPE AIR GAGE INDICATES NO PRESSURE OR MORE THAN A 5-PSI LEAKAGE IN 1 MINUTE. (Refer to para 2-9.)**

Step 1. Check for open brake pipe angle cocks on front and rear of locomotive.

Close angle cocks.

Step 2. Check for leaking brake pipe gage or fittings.

Locate leakage and tighten fittings and/or repair or replace gage.

Step 3. Check for leaking piping or fittings on pipe 53.

Locate leakage and tighten or replace piping and/or fittings.

Step 4. Check for defective A-1 charging cutoff pilot valve(Refer to malfunction 24.)

Disassemble, clean, and repair or replace A-1 charging cutoff pilot valve (para 4-15).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

**MALFUNCTION  
TEST OR INSPECTION  
CORRECTIVE ACTION**

---

**6. EQUALIZING RESERVOIR DOES NOT REDUCE WITH SERVICE APPLICATION.**

Step 1. Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

Step 2. Check for defective regulating valve in automatic brake valve.

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

**7. EQUALIZING RESERVOIR REDUCTION IS TOO FAST OR TOO SLOW WITH SERVICE APPLICATION.**

Step 1. Check for leaking equalizing reservoir, piping, or fittings.

Locate leakage and tighten or replace reservoir, piping, and/or fittings.

Step 2. Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

**8. BRAKE PIPE REDUCTION IS TOO SLOW.**

Step 1. Check for dirty or defective exhaust chock plug in automatic brake valve.

Clean or replace exhaust orifice (para 4-11).

Step 2. Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**9. AUTOMATIC BRAKE DOES NOT APPLY FOLLOWING A BRAKE PIPE REDUCTION.**

Step 1. Check for uncharged brake pipe.

Charge brake pipe.

Step 2. Check for closed brake pipe cutout cock.

Open brake pipe cutout cock.

Step 3. Check for partially closed main reservoir cutout cock.

Open main reservoir cutout cock.

Step 4. Check for defective No 24 double check valve in pipe 12.

Replace No 24 double check valve (para 3-54).

Step 5. Check for closed brake cylinder cutout cocks.

Open brake cylinder cutout cocks.

Step 6. Check for defective brake cylinders.

Disassemble, clean, and repair or replace brake cylinders (para 3-58).

Step 7. Check for defective 6-NFR distributing valve(Refer to malfunctions 25 thru 28.)

Disassemble, clean, and repair or replace 6-NFR distributing valve (para 4-13).

**10. UNDESIRE RELEASE OF AN AUTOMATIC BRAKE APPLICATION BY AN INCREASE IN EITHER EQUALIZING RESERVOIR OR BRAKE PIPE PRESSURE.**

Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).



**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**11. BRAKE PIPE PRESSURE DOES NOT REDUCE AT EMERGENCY RATE.**

Step 1. Check for leak in pipe 53.

Locate leakage and repair or replace pipe 53.

Step 2. Check for defective front and/or rear #8 vent valve.

Disassemble, clean, and repair or replace #8 vent valve (para 4-14).

Step 3. Check for defective A-1 charging cutoff pilot valve(Refer to malfunction 24.)

Disassemble, clean, and repair or replace A-1 charging cutoff pilot valve (para 4-15).

Step 4. Check for defective automatic brake valve(Refer to malfunctions 21 and 22.)

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

**12. UNABLE TO RECOVER FROM AN EMERGENCY APPLICATION.**

Step 1. Check for brake open to atmosphere.

Repair or replace piping.

Step 2. Check for defective No 24 double check valve in pipes 9 and 35.

Replace No 24 double check valve (para 3-54).

Step 3. Check for defective A-1 charging cutoff pilot valve(Refer to malfunction 24.)

Disassemble, clean, and repair or replace charging cutoff pilot valve (para 4-15).

Step 4. Check for defective automatic brake valve.

Disassemble, clean, and repair or replace automatic brake valve (para 4-11).

Step 5. Check for stuck open front or rear #8 vent valve.

Disassemble, clean, and repair #8 vent valve (para 4-14).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**13. EMERGENCY APPLICATION OCCURS DURING SERVICE APPLICATION.**

Step 1. Check for defective front or rear #8 vent valve.

Disassemble, clean, and repair or replace #8 vent valve (para 4-14).

Step 2. Check for leaking brake pipe piping and fittings.

Locate leakage and tighten or replace piping and/or fittings.

Step 3. Check for defective brake pipe exhaust choke plug in automatic brake valve.

Replace exhaust choke plug (para 4-11).

**14. INDEPENDENT BRAKE DOES NOT APPLY OR IS TOO WEAK.**

Step 1. Check for a leak in piping system.

Locate leakage and repair or replace piping.

Step 2. Check for defective No 24 double check valve in pipe 12.

Replace No 24 double check valve (para 3-54).

Step 3. Check for defective independent brake valve(Refer to malfunction 23.)

Disassemble, clean, and repair or replace independent brake valve (para 4-12).

**15. INDEPENDENT BRAKE DOES NOT FULLY RELEASE.**

Step 1. Check for automatic brake valve not in release position.

Set automatic brake valve in release position.

Step 2. Check for defective No 24 double check valve in pipe 12.

Replace No 24 double check valve (para 3-54).

Step 3. Check for defective independent brake valve(Refer to malfunction 23.)

Disassemble, clean, and repair or replace independent brake valve (para 4-12).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**16. AUTOMATIC BRAKE CYLINDER PRESSURE FAILS TO APPLY OR APPLIES AND RELEASES.**

Step 1. Check for leaks in piping or fittings between 6-NFR distributing valve and ~~N24~~ double check valve.

Locate leakage and tighten or replace piping and/or fittings.

Step 2. Check for leaks in piping or fittings between 6-NFR distributing valve and port 2 of H-5 relay air valve.

Locate leakage and tighten or replace piping and/or fittings.

Step 3. Check for leaks in piping or fittings between 6-NFR distributing valve port 2 and pipe 12 check valve.

Locate leakage and tighten or replace piping and/or fittings.

**17. BRAKE PIPE PRESSURE DOES NOT RECOVER AFTER AN EMERGENCY BRAKE APPLICATION.**

Check for leaks in piping or fittings of pipe 12 from A-1 charging cutoff pilot valve.

Locate leakage and tighten or replace piping and/or fittings.

**18. THERE IS LOSS OF MAIN RESERVOIR PRESSURE FROM BRAKE PIPE-INITIATED EMERGENCY.**

Check for leaks in piping or fittings of pipe 53 from A-1 charging cutoff pilot valve.

Locate leakage and tighten or replace piping and/or fittings.

**19. THERE IS NO INDEPENDENT BRAKE APPLICATION.**

Check for leaks in piping or fittings of pipe 20 from independent brake valve.

Locate leakage and tighten or replace piping and/or fittings.

**20. THERE IS NO INDEPENDENT RELEASE OF AN AUTOMATIC BRAKE APPLICATION.**

Check for leaks in piping or fittings of pipe 13 from independent brake valve.

Locate leakage and tighten or replace piping and/or fittings.

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

**MALFUNCTION  
TEST OR INSPECTION  
CORRECTIVE ACTION**

---

**AUTOMATIC BRAKE VALVE**

**21. LARGE CAVITY OF THE BRAKE VALVE LEAKS WITH HANDLE IN RELEASE POSITION.**

Step 1. Check for a light blow of air at the brake valve housing exhaust.

Replace O-ring on emergency valve of automatic brake valve (last O-ring) or replace O-rings on suppression valve of automatic brake valve (1st, 2nd, or 5th O-ring) (para 4-11).

Step 2. Check for a heavy blow of air at brake valve cavity exhaust and no brake pipe pressure.

Replace O-ring on cutoff portion of the A-1 charging cutoff pilot valve (bottom O-ring) (para 4-15).

**22. REGULATING VALVE EXHAUST (LOCATED IN SPRING HOUSING NEAR REGULATING VALVE HANDLE) OF THE AUTOMATIC BRAKE VALVE LEAKS.**

Step 1. Check for equalizing reservoir pressure approaching main reservoir pressure.

Replace regulating valve diaphragm of automatic brake valve (para 4-11).

Step 2. Check for equalizing reservoir not registering full pressure, and brake pipe charging slowly; during an automatic brake application, brake pipe exhaust is at the regulating valve.

Replace relay valve diaphragm of the automatic brake valve (para 4-11).

Step 3. Check for continuous blow at exhaust port on top of the automatic brake valve.

Replace supply valve in the relay valve port of the automatic brake valve (para 4-11).

**INDEPENDENT BRAKE VALVE**

**23. THERE IS CONTINUOUS BLOW FROM THE EXHAUST WITH THE HANDLE IN RELEASE POSITION.**

Step 1. Check for a heavy blow of air from exhaust.

Replace O-ring on spool valve separating main reservoir supply and line 20 of the independent brake valve (center O-ring) (para 4-12).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**23. THERE IS CONTINUOUS BLOW FROM THE EXHAUST WITH THE HANDLE IN RELEASE POSITION. (cont)**

Step 2. Check for brake cylinder pressure not approaching main reservoir pressure in APPLICATION position of the independent brake valve.

Replace O-ring in the independent brake valve (center O-ring) (para 4-12).

**A-1 CHARGING CUTOFF PILOT VALVE**

**24. THERE IS CONTINUOUS SANDING.**

Check for air leaking from the sanding choke.

Replace O-ring on the actuating piston of the A-1 charging cutoff valve (2nd O-ring from top) (para 4-15).

**6-NFR DISTRIBUTING VALVE**

**25. AUTOMATIC BRAKE CYLINDER PRESSURE FAILS TO DEVELOP OR APPLIES AND REDUCES TO ZERO.**

Step 1. Check for a blow of air at port 9 of H-5 relay air valve.

Repair or replace H-5 relay air valve seat that is leaking (port 11 to port 9) (para 4-16).

Step 2. Check for a blow of air at automatic brake valve exhaust cavity.

Repair or replace pipe 12 check valve seat that is leaking.

Step 3. Check for a blow of air at safety valve.

Repair or replace safety valve seat that is leaking (para 4-13).

Step 4. Check for a blow of air at application piston exhaust during application.

Repair or replace leak in application valve diaphragm (para 4-13).

Step 5. Check for a blow of air at independent brake valve exhaust.

Replace No. 24 double check valve (port 20) (para 3-54).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>	
<b>TEST OR INSPECTION</b>	
<b>CORRECTIVE ACTION</b>	

---

**26. THERE IS A STEADY BLOW OF AIR AT APPLICATION VALVE EXHAUST WITH BRAKES APPLIED OR RELEASED.**

Check for blow of air stopping while brakes are applying.

Repair or replace application valve supply seat (para 4-13).

**27. THERE IS A STEADY BLOW OF AIR AT APPLICATION VALVE EXHAUST.**

Check for air blowing only when brakes are applied.

Repair or replace application valve seat or repair application piston O-ring (top or middle O-ring) (para 4-13).

**28. BRAKES FAIL TO RELEASE.**

Check for no release of brakes after emergency application.

Adjust safety valve setting to proper pressure.

**AIR COMPRESSOR GOVERNOR**

**29. AIR COMPRESSOR GOVERNOR NOT LOADING AND UNLOADING.**

With locomotive running, observe air pressure gages. Bleed air slowly from system to see if governor controls air compressor unloading and loading.

Remove air compressor governor and test (para 3-44). Repair or replace defective governor.

**BATTERIES**

**30. BATTERIES FAIL TO CHARGE.**

Step 1. Check for low electrolyte level in batteries.

Fill batteries to proper level and test (TM 55-2210-224-12).

Step 2. Check for corroded and/or loose connections on batteries.

Clean and/or tighten connections.

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**30. BATTERIES FAIL TO CHARGE. (cont)**

Step 3. Check for improperly working engine alternator.

Test engine alternator Repair or replace defective engine alternator (TM 5-2815-233-14).

Step 4. Check for start switch contacts not transferring.

Test start switch Replace switch if defective (TM 55-2210-224-12, para 4-29).

**COOLING SYSTEM**

**31. COOLANT TEMPERATURE IS EXCESSIVE.**

Step 1. Check for broken coolant pump shaft or impeller.

Repair or replace pump (TM 5-2815-233-14).

Step 2. Check for faulty water pump operation.

Repair or replace water pump (TM 5-2815-233-14).

Step 3. Check for faulty fan operation.

Repair or replace fan (para 3-40).

Step 4. Check for stuck water temperature regulator.

Repair or replace water temperature regulator (TM 5-2815-233-14).

**32. SYSTEM LOSES COOLANT.**

Step 1. Check for cracked radiator core or tanks.

Repair or replace radiator core or tanks (para 4-7).

Step 2. Check for leaking hoses or clamps.

Replace hoses and/or tighten clamps.

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**33. EMERGENCY SHUTDOWN SYSTEM FAILS TO OPERATE WHEN BUTTONS ARE PUSHED.**

Step 1. Check for faulty emergency shutdown switch.

Replace emergency shutdown switch (para 3-38).

Step 2. Check for malfunctioning engine fuel pump shutdown solenoid valve switch.

Replace engine fuel pump shutdown solenoid valve switch (TM 5-2815-233-14).

**ENGINE FUEL SYSTEM**

**34. LOCOMOTIVE ENGINE SHUTS DOWN DUE TO MALFUNCTIONING FUEL SYSTEM.**

Step 1. Check for malfunctioning fuel pump.

Repair or replace fuel pump (TM 5-2815-233-14).

Step 2. Check for clogged injector lines.

Unclog injector lines (TM 5-2815-233-14).

Step 3. Check for defective injectors.

Repair or replace injectors (TM 5-2815-233-14).

**ENGINE WARNING SYSTEM**

**35. ENGINE OIL PRESSURE GAGE DROPS BELOW SAFE OPERATING RANGE, BUT THERE IS NO WARNING INDICATION.**

Step 1. Check for defective oil pressure gage.

Replace oil pressure gage (para 3-11).

Step 2. Check for clogged oil pressure gage line.

Replace or clean oil pressure gage line.



**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

**MALFUNCTION**
**TEST OR INSPECTION**
**CORRECTIVE ACTION**


---

**35. ENGINE OIL PRESSURE GAGE DROPS BELOW SAFE OPERATING RANGE, BUT THERE IS NO WARNING INDICATION. (cont)**

Step 3. Check for low oil pressure in engine.

Refer to TM 5-2815-233-14 and correct oil pressure problem.

Step 4. Check for defective warning buzzer.

Replace warning buzzer (TM 55-2210-224-12).

**36. ENGINE TEMPERATURE RISES ABOVE SAFE OPERATING RANGE AND HIGH TEMPERATURE WARNING BUZZER DOES NOT ALARM**

Step 1. Check for defective water temperature gage.

Replace temperature gage (para 3-12).

Step 2. Check for defective temperature safety switch.

Replace temperature safety switch (TM 5-2815-233-14).

Step 3. Check for defective warning buzzer.

Replace warning buzzer (TM 55-2210-224-12).

**HORN**

**37. HORN WILL NOT SOUND.**

Step 1. Check for closed auxiliary air cutout cock.

Open auxiliary air cutout cock.

Step 2. Check for defective horn operating valve.

Repair or replace horn operating valve (para 3-9).

Step 3. Check for defective horn assembly.

Repair or replace horn assembly (TM 55-2210-224-12).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

**MALFUNCTION  
TEST OR INSPECTION  
CORRECTIVE ACTION**

---

**LIGHTS**

**38. HEADLIGHTS WILL NOT FUNCTION PROPERLY.**

Step 1. Check for broken or burned out headlamps.

Replace headlamps (TM 55-2210-224-12).

Step 2. Check for defective headlight switch.

Replace headlight switch (TM 55-2210-224-12).

Step 3. Check for defective headlight setup switch.

Replace headlight setup switch (TM 55-2210-224-12).

Step 4. Check for defective headlight resistors.

Replace headlight resistors (para 3-32).

**39. CAB LIGHTS WILL NOT FUNCTION PROPERLY.**

Step 1. Check for burned out light bulbs.

Replace light bulbs (TM 55-2210-224-12).

Step 2. Check for defective cab lights switch.

Replace cab lights switch (TM 55-2210-224-12).

**40. COWLING LIGHTS WILL NOT FUNCTION PROPERLY.**

Step 1. Check for burned out light bulbs.

Replace light bulbs (TM 55-2210-224-12).

Step 2. Check for defective cowling light switch.

Replace cowling light switch (TM 55-2210-224-12).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>	<b>TEST OR INSPECTION</b>	<b>CORRECTIVE ACTION</b>
--------------------	---------------------------	--------------------------

---

**41. STEP LIGHTS WILL NOT FUNCTION PROPERLY.**

Step 1. Check for burned out light bulbs.

Replace light bulbs (TM 55-2210-224-12).

Step 2. Check for defective step light switch.

Replace step light switch (TM 55-2210-224-12).

**MAIN AIR SYSTEM**

**42. MAIN AIR SYSTEM IS SLOW TO BUILD UP PRESSURE.**

Check for restricted centrifugal air filters.

Remove and replace centrifugal air filter canisters (para 3-61).

**43. MOISTURE IS OBSERVED IN AIR SYSTEM.**

Step 1. Check for defective automatic drain valve.

Replace automatic drain valve (para 3-59).

Step 2. Check for improper operation of timer.

Test and replace timer if defective (para 3-21).

**MAIN GENERATOR**

**44. MAIN GENERATOR ARMATURE OR FIELD COILS ARE GROUNDED.**

Step 1. Check for dirty, oily, or water soaked insulation.

Remove main generator for repair (para 3-37).

Step 2. Check for defective field coils.

Remove main generator for repair (para 3-37).

Step 3. Check for broken insulators.

Replace insulators (para 3-37).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>	<b>TEST OR INSPECTION</b>	<b>CORRECTIVE ACTION</b>
--------------------	---------------------------	--------------------------

---

**44. MAIN GENERATOR ARMATURE OR FIELD COILS ARE GROUNDED. (cont)**

Step 4. Check for dirty or broken commutator bars.

Remove main generator for repair (para 3-37).

Step 5. Check for broken high-voltage leads.

Remove main generator for repair (para 3-37).

Step 6. Check for broken power contactors.

Replace power contactors (para 3-24).

**45. MAIN GENERATOR BEARING FAILS.**

Step 1. Check for unbalanced armature.

Replace armature (para 3-37).

Step 2. Check for no lubrication or contaminated grease.

Lubricate in accordance with LO 55-2210-224-12.

Step 3. Check for loose main generator to diesel engine mounting bolts.

Tighten main generator to diesel engine mounting bolts (para 3-37).

Step 4. Check for improper installation of bearing.

Remove main generator for repair (para 3-37).

**46. MAIN GENERATOR BRUSHES ARE BROKEN.**

Step 1. Check for rough and/or burnt spots, flat spots, or high bars on commutator.

Resurface commutator (para 3-37).

Step 2. Check for low brush spring tension.

Replace springs (para 3-37).

Step 3. Check for vibration caused by defective bearings.

Replace bearings (para 3-37).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**46. MAIN GENERATOR BRUSHES ARE BROKEN. (cont)**

Step 4. Check for out-of-round commutator.

Resurface commutator (para 3-37).

Step 5. Check for high bars on commutator.

Repair or replace commutator (para 3-37).

**47. THERE IS MAIN GENERATOR FLASHOVER.**

Step 1. With generator running, check for eccentric commutator.

Aline main generator (para 3-37).

Step 2. With engine stopped, check for dirt or foreign particles in insulating (mica) spacers between commutator segments.

Undercut or clean out spacers to 3/64 inch (1.2 mm) (para 3-37).

Step 3. Check for brushes broken or worn beyond condemning limits.

Replace brushes (TM 55-2210-224-12).

Step 4. Check for low brush spring tension or sticking brushes.

Adjust spring tension and clean brush holders and brushes (TM 55-2210-224-12).

Step 5. Check for slagged-over commutator bars.

Undercut mica bars (para 3-37).

Step 6. Check for high bars on commutator.

Repair or replace commutator (para 3-37).

Step 7. Check for broken insulators, insulation, or brush shunt wires.

Remove main generator for repair (para 3-37).

Step 8. Check for sudden surges of power from main generator. With brakes applied, reduce to idle before complete stop is made.

Remove main generator for repair (para 3-37).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

**MALFUNCTION  
TEST OR INSPECTION  
CORRECTIVE ACTION**

---

**SANDING SYSTEM**

**48. SANDING SYSTEM WILL NOT FUNCTION.**

- Step 1. Check for obstruction in sandboxes, sander hoses, and/or sand controllers.  
Remove obstructions in sandboxes, sander hoses, and/or sander controller valves.
- Step 2. Check for defective sander control valve.  
Repair or replace sander control valve (para 3-17).
- Step 3. Check for defective sander switch.  
Replace sander switch (TM 55-2210-224-12).

**SPEED-SENSING CIRCUIT**

**49. LOCOMOTIVE DOES NOT TRANSITION OR TRANSITIONS AT WRONG SPEED.**

- Step 1. With locomotive in motion, check for no Hertz at TB1-M.  
Repair or replace speed-sensing alternator (para 3-35).
- Step 2. With locomotive in motion, check for no Hertz at TB1-L.  
Remove transition relay panel and notify intermediate general support personnel (para 4-6).

**THROTTLE CONTROLLER MECHANISM**

**50. THROTTLE CONTROLLER MECHANISM DOES NOT RESPOND.**

- Step 1. Check for improper operation of throttle control valves.  
Repair or replace control valves (TM 5-2815-233-14).
- Step 2. Check for defective controller mechanism.  
Repair or replace controller mechanism (para 3-34).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**51. LOCOMOTIVE WILL NOT MOVE WHEN SHIFTED FORWARD OR REVERSE.**

Step 1. Check for defective reverser relays.

Repair or replace reverser relay (para 3-28).

Step 2. Check for defective controller mechanism.

Repair or replace controller mechanism (para 3-34).

**TRACTION MOTOR**

**52. TRACTION MOTOR ARMATURE OR FIELD COILS ARE GROUNDED.**

Step 1. Check for dirty, oily, or water-soaked insulation.

Remove traction motor for repair (para 3-64).

Step 2. Check for defective field coils.

Remove traction motor for repair (para 3-64).

Step 3. Check for broken insulators.

Replace insulators (para 3-64).

Step 4. Check for dirty or broken commutator bars.

Remove traction motor for repair (para 3-64).

Step 5. Check for broken high-voltage leads.

Remove traction motor for repair (para 3-64).

Step 6. Check for broken power contactors.

Replace power contactors (para 3-24).

Step 7. Check for broken brush shunt wires.

Remove traction motor for repair (para 3-64).

**53. THERE IS TRACTION MOTOR FLASHOVER.**

Refer to main generator flashover (malfunction 47).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT  
TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>	<b>TEST OR INSPECTION</b>	<b>CORRECTIVE ACTION</b>
--------------------	---------------------------	--------------------------

---

**54. TRACTION MOTOR BEARING FAILS.**

Step 1. Check for unbalanced armature.

Replace armature (para 3-64).

Step 2. Check for contaminated grease or no lubrication,

Remove traction motor for repair (para 3-64).

Step 3. Check for improper traction motor alinement.

Aline traction motor (para 3-64).

Step 4. Check for improper installation of bearing.

Remove traction motor for repair (para 3-64).

**55. TRACTION MOTOR BRUSHES ARE BROKEN.**

Step 1. Check for rough and/or burned spots, flat spots, or high bars on commutator.

Resurface commutator (para 3-64).

Step 2. Check for low brush spring tension.

Adjust spring tension (TM 55-2210-24-12).

Step 3. Check for weak or broken suspension pads causing motor vibration.

Replace suspension pads (para 3-63).

Step 4. Check for defective bearings causing motor vibration.

Replace bearings (para 3-64).

Step 5. Check for out-of-round commutator.

Resurface commutator (para 3-64).

Step 6. Check for high bar on commutator.

Repair or replace commutator (para 3-64).

Step 7. Check for dirty or sticking brushes.

Clean brush holder and blow out generator (para 3-64).



**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

---

<b>MALFUNCTION</b>
<b>TEST OR INSPECTION</b>
<b>CORRECTIVE ACTION</b>

---

**56. TRACTION MOTOR SUSPENSION IS LOOSE.**

Step 1. Check for broken or weak suspension pads.

Replace suspension pads (para 3-63).

Step 2. Check for worn motor support axle bearings.

Replace motor support axle bearings (para 3-64).

**TRUCK ASSEMBLY**

**57. LOCOMOTIVE TILTS OR SWAYS BACK AND FORTH WHILE MAKING TURNS OR IF TRACK IS ON AN ANGLE.**

Step 1. Check for excessive side bearing clearance.

Replace side bearings (para 3-63).

Step 2. Check for defective or broken springs.

Replace springs (para 3-63).

Step 3. Check for excessive wear on center casting wear plate and wear ring.

Replace center casting wear plate and/or wear ring (para 3-63).

**58. TRUCKS BIND AND WILL NOT PIVOT WHEN LOCOMOTIVE IS MAKING A TURN.**

Check for zero side bearing clearance.

Replace center casting wear plate and/or wear ring (para 3-63).

**SAFETY WARNING BELL**

**59. SAFETY WARNING BELL WILL NOT SOUND.**

Step 1. Check for defective safety warning bell operating valve.

Replace safety warning bell operating valve (para 3-8).

Step 2. Check for defective bell ringer assembly.

Repair or replace bell ringer assembly (TM 55-2210-224-12).

**Table 3-1. INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT TROUBLESHOOTING (continued)**

**MALFUNCTION  
TEST OR INSPECTION  
CORRECTIVE ACTION**

**WHEELS**

**60. A ROUGH RIDE OR THUMPING IS FELT WHILE OPERATING LOCOMOTIVE.**

Check for flat spots on wheels.

Turn wheels down (para 3-65).

**61. LOCOMOTIVE CONTINUALLY SPLITS SWITCHES.**

Check for thin flanges on the wheels.

Turn wheels down (para 3-65).

**62. LOCOMOTIVE CLIMBS RAIL.**

Check for vertical flanges on the wheels.

Turn wheel down (para 3-65).

**Section III. INTERMEDIATE DIRECT SUPPORT MAINTENANCE INSTRUCTIONS**

**3-5. GENERAL**

This section contains maintenance procedures authorized at the intermediate direct support maintenance category.

**3-6. TASK SUMMARY**

<b>TASK PARA</b>	<b>PROCEDURE</b>	<b>PAGE NO.</b>
3-7	Engine Hood Assembly	3-30
3-8	Safety Warning Bell Operating Valve	3-34
3-9	Horn Assembly Operating Valve	3-36
3-10	Duplex Air Gages	3-38
3-11	Oil Pressure Gages	3-42
3-12	Engine Temperature Gages	3-44
3-13	Load Meter Gages	3-46
3-14	Battery Voltmeter Gage	3-48
3-15	Service Meter Gage	3-50
3-16	Air Compressor Oil Pressure Gage	3-52
3-17	Sander Control Valve	3-53

TASK PARA	PROCEDURE	PAGE NO.
3-18	Emergency Sand Pressure Switch	3-57
3-19	Multiple-Unit Receptacle	3-58
3-20	Engine Heater Receptacle	3-62
3-21	Timer	3-65
3-22	Field Shunt Contactor	3-67
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3-25	Engine Temperature Warning, Motor Kill, Safety, and Field Shunt Transition Relay	3-100
3-26	Ground Relay	3-104
3-27	Wheel Slip Relay	3-110
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3-63	Truck Assembly	3-221
3-64	Traction Motor Assembly	3-233
3-65	Wheel	3-264
3-66	Coupler	3-267

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### 3-7. ENGINE HOOD ASSEMBLY

---

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly |                 |
- 

#### **INITIAL SETUP**

##### Tools

Tool kit SC4940-97-CL-E12  
Suitable lifting device

##### Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
Rubber silicone adhesive (Item 1, Appendix B)

##### Personnel Required

3

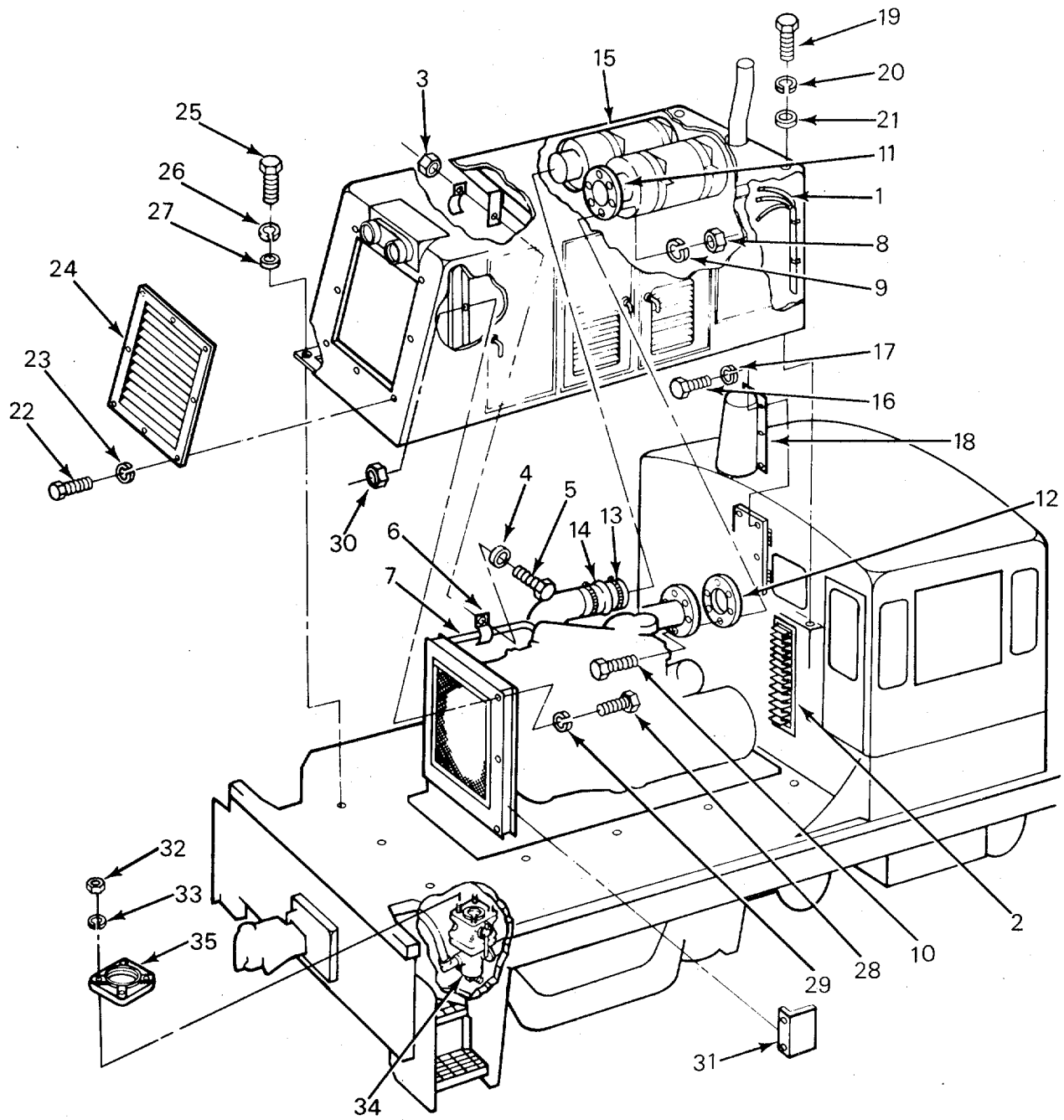
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#### **REMOVAL AND DISASSEMBLY**

1. Tag and disconnect cowling light and headlight wiring (1) from terminal board (2).
2. Remove nut (3), lockwasher (4), and capscrew (5) and remove clamp (6) from water pipe (7).
3. Remove eight nuts (8), lockwashers (9), and capscrews (10) from muffler flange (11). Remove gasket (12).
4. Loosen two hose clamps (13) and remove hose (14) from breather (15).
5. Remove six capscrews (16) and lockwashers (17) from tailpipe guard (18).
6. Remove 25 capscrews (19), lockwashers (20), and flat washers (21).
7. Remove 12 capscrews (22), lockwashers (23), and radiator grille (24).
8. Remove 20 capscrews (25), lockwashers (26), and flat washers (27).
9. Remove 14 capscrews (28), lockwashers (29), and nuts (30). Remove lower radiator flashing (31).
10. Remove eight nuts (32) and lockwashers (33). Position two sand controller (34) out of the way. Remove two pipe nipple and brackets (35) from bottom of sandboxes.
11. Pass lifting cables through hood doors. Attach lifting cables to suitable lifting device.
12. Check that hood is free of interference.
13. Position a person on each side of locomotive to guide lifting operation.

3-7. ENGINE HOOD ASSEMBLY (cont)

REMOVAL AND DISASSEMBLY (cont)



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### 3-7. ENGINE HOOD ASSEMBLY (cont)

---

#### REMOVAL AND DISASSEMBLY (cont)

##### WARNING

Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.

##### CAUTION

Care should be taken when lifting engine hood assembly to prevent binding, uneven balance, or damage to engine components.

14. Use a suitable lifting device and lift engine hood assembly from locomotive.
15. Lower engine hood assembly and place on wooden blocks.
16. Refer to TM 55-2210-224-12 for removal and repair of engine hood door assemblies.

#### CLEANING, INSPECTION, AND REPAIR

##### WARNING

⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.

⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

17. Use drycleaning solvent and clean metal parts. Dry with compressed air.
18. Inspect engine hood assembly and structural parts for cracks, breaks, and damage.
19. Repair engine hood assembly by straightening dents, welding cracks, sanding and painting as required.
20. Refer to TM 55-2210-224-12 for cleaning, inspection, and repair of engine hood door assemblies.

---

### 3-7. ENGINE HOOD ASSEMBLY (cont)

---

#### ASSEMBLY AND INSTALLATION

21. Apply rubber silicone adhesive to cab bulkhead mounting joint.
22. Pass lifting cables through hood doors.
23. Position a person on each side of locomotive to guide installation procedure.

#### WARNING

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

#### CAUTION

**Care should be taken when lifting engine hood assembly to prevent binding, uneven balance, or damage to engine components.**

24. Use a suitable lifting device and raise engine hood assembly over locomotive. Lower hood to deck.
25. Install two pipe nipple and brackets (35) in bottom of sandbox. Position two sand controller (34) and install eight lockwashers (33) and nuts (32).
26. Position lower radiator flashing (31) and install 14 flat washers (30), lockwashers (29), and capscrews (28).
27. Install 20 flat washers (27), lockwashers (26), and capscrews (25).
28. Position radiator grille (24) on engine hood and install 12 lockwashers (23) and capscrews (22).
29. Install 25 flat washers (21), lockwashers (20), and capscrews (19).
30. Position tailpipe guard (18) and install six lockwashers (17) and capscrews (16).
31. Install hose (14) on breather (15) and tighten two hose clamps (13).
32. Position gasket (12) on muffler flange (11) and install eight capscrews (10), lockwashers (9), and nuts (8).
33. Position clamp (6) on water pipe (7) and install capscrew (5), lockwasher (4), and nut (3).
34. Connect cowling light and headlight wiring (1) to terminal board (2) and remove tags.

---

**3-8. SAFETY WARNING BELL OPERATING VALVE**

---

This task covers:

- |         |            |                 |
|---------|------------|-----------------|
| a. Test | b. Removal | c. Installation |
|---------|------------|-----------------|

---

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

**Material/Parts**Antiseize tap (Item 35, Appendix B)

---

**TEST****WARNING**

- ⓘ **Whenever the cutout cock and strainer is removed and installed for any reason, a stationary vehicle airbrake test (para 2-9) must be performed to check that the cutout cock and strainer function properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the cutout cock and strainer. Residual air may escape and cause injury to personnel.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Start locomotive and let air pressure build up.
2. Remove eight screws (1), cover (2), and gasket (3).
3. Operate BELL switch and check the safety warning bell operating valve for proper operation. Inspect the operating valve for air leakage.
4. Shut down locomotive.



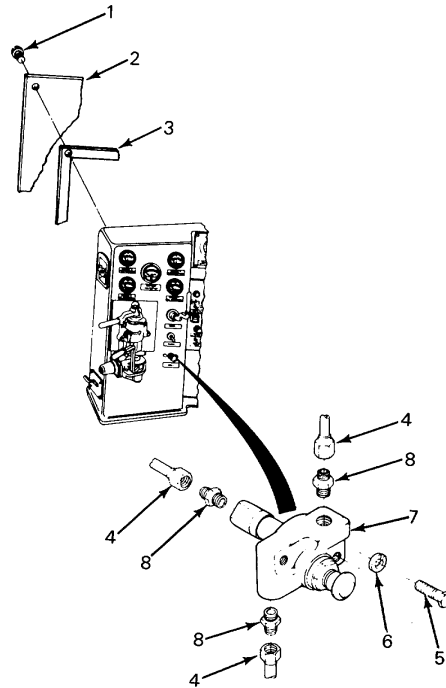
**3-8. SAFETY WARNING BELL OPERATING VALVE (cont)**

**REMOVAL**

5. Disconnect three air line fittings (4).
6. Remove two capscrews (5), lockwashers (6), and operating valve (7).
7. Remove three adapters (8).

**INSTALLATION**

8. Apply antiseize tape to the threads of three adapters (8) and install adapters in operating valve (7).
9. Position operating valve (7) in control cabinet and install two lockwashers (6) and capscrews (5).
10. Connect three air line fittings (4).
11. Perform steps 1, 3 and 4 above.
12. Position gasket (3) and cover (2) on control cabinet and install eight screws (1).



---

**3-9. HORN ASSEMBLY OPERATING VALVE**

---

This task covers:

- a. Test
  - b. Removal
  - c. Installation
- 

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Antiseize tap (Item 35, Appendix B)

---

**TEST**

**WARNING**

- ⓘ **Whenever the cutout cock and strainer is removed and installed for any reason, a stationary vehicle airbrake test (para 2-9) must be performed to check that the cutout cock and strainer function properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the cutout cock and strainer. Residual air may escape and cause injury to personnel.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Start locomotive and let air pressure build up.
2. Remove eight screws (1), cover (2), and gasket (3).
3. Operate horn lever and check horn assembly operating valve for proper operation. Inspect the operating valve for air leakage.
4. Shut down locomotive.

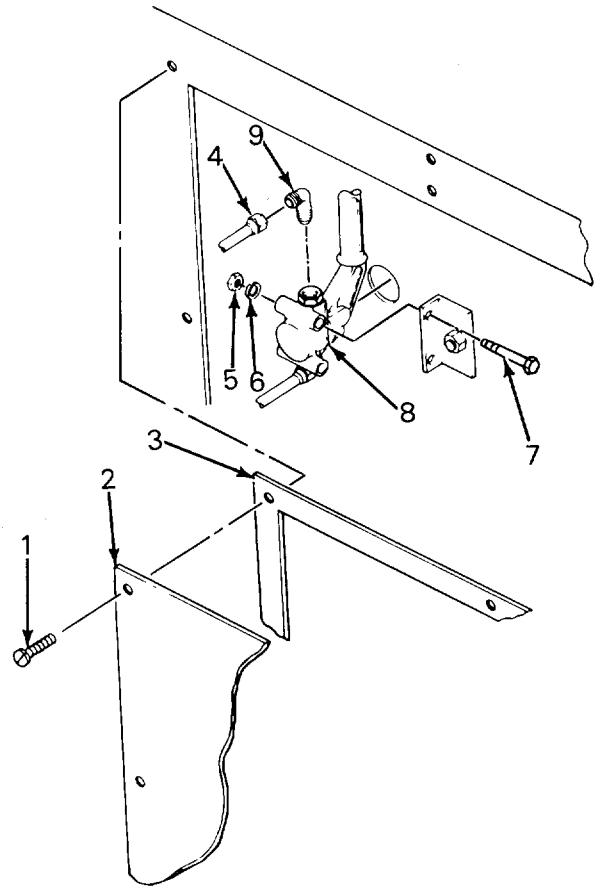
**3-9. HORN ASSEMBLY OPERATING VALVE (cont)****REMOVAL****NOTE**

Handle may have to be removed for disassembly or assembly.

5. Disconnect two air line fittings (4).
6. Remove two nuts (5), lockwashers (6), capscrews (7), and horn assembly operating valve (8).
7. Remove two elbows (9).

**INSTALLATION**

8. Apply antiseize tape on two elbows (9) and install elbows in horn assembly operating valve (8).
9. Position horn assembly operating valve (8) in control cabinet and install two capscrews (7), lockwashers (6), and nuts (5).
10. Connect two air line fittings (4).
11. Perform steps 1, 3 and 4 above.
12. Position gasket (3) and cover (2) on control cabinet and install eight screws (1).



---

### 3-10. DUPLEX AIR GAGES

---

This task covers:

- |                |               |           |                 |
|----------------|---------------|-----------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair | g. Assembly     |
| b. Disassembly | d. Inspection | f. Test   | h. Installation |
- 

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12  
 Pointer puller

##### Material/Parts

Glass cleaner (Item 4, Appendix B)

##### Test Equipment

Portable air gage tester P/N 700-1 (30187)

#### REMOVAL

##### NOTE

- ⓘ **Federal Railroad Administration requires annual testing of duplex air gage or when gage is not operating properly.**
- ⓘ **Duplex air gage can be tested while installed in control stand using a self-contained, portable tester. Refer to step 11 below for testing instructions.**

1. Loosen six thumbscrews (1) and remove front cover (2), two gaskets (3), and gasket (4).
2. Remove five capscrews (5), cover (6), and gasket (7).
3. Disconnect two air line connections (8) from duplex air gage (11).
4. Remove two capscrews (9) and lockwashers (10) and remove duplex air gage (11).

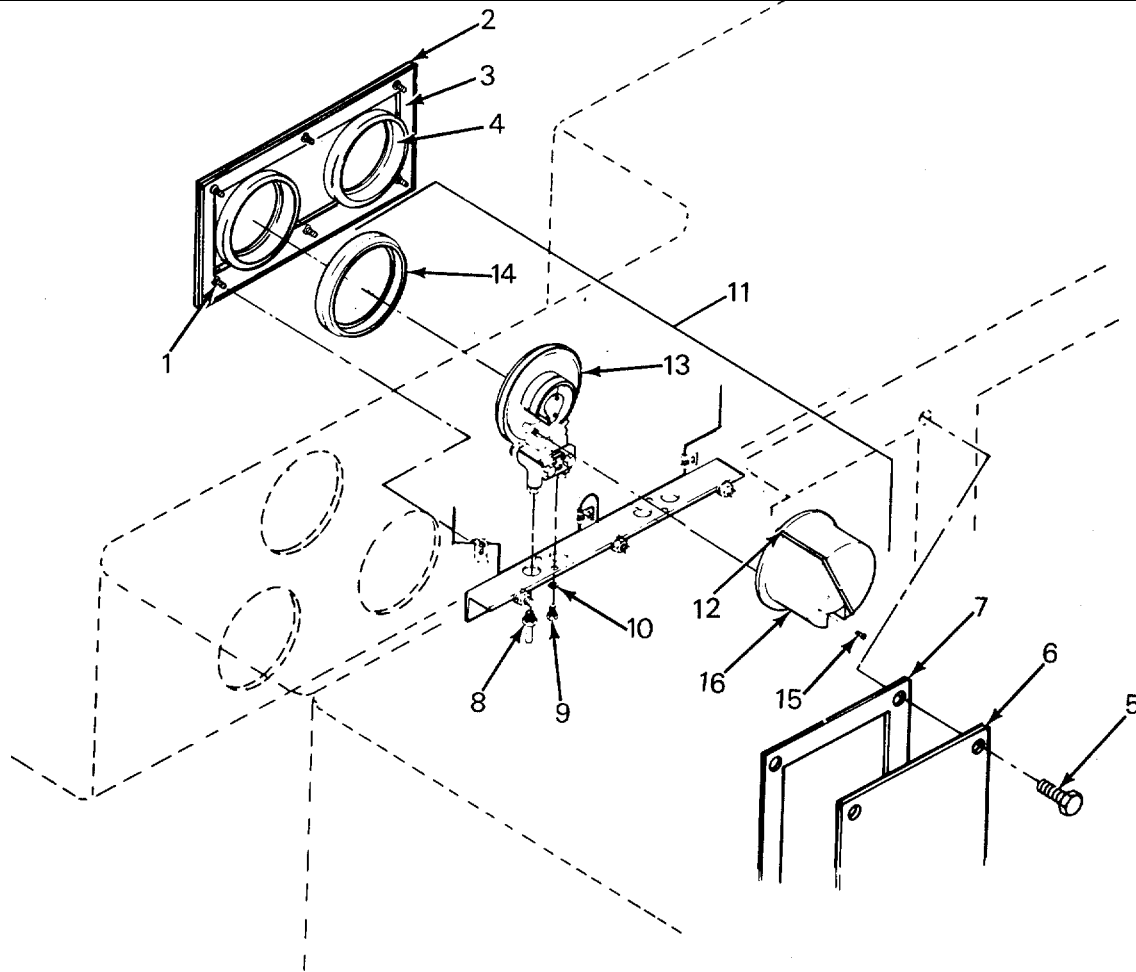
#### DISASSEMBLY

5. Pry copper clasp (12) from gage face (13) and remove glass cover (14).
6. Remove two screws (15) and remove gage face (13) from glass housing (16).

#### CLEANING, INSPECTION, AND REPAIR

7. Use glass cleaner and clean glass cover (14) and glass housing (16).
8. Inspect glass cover (14) and glass housing (16) for cracks or scratches. Replace glass cover or glass housing if damaged.
9. Inspect gage face (13) for damage. Replace if components appear damaged.
10. Repair is limited to the adjustment of pointers. If pointer hands do not set at zero, use pointer puller and remove pointers. Set pointers at zero.

## 3-10. DUPLEX AIR GAGES (cont)

**TEST**

11. If duplex air gage (11) is removed from the locomotive, test by the following:
- a. Use a deadweight tester and test duplex air gage (11) at half scale and full scale. Compare amount of weight applied to the reading shown on gage.
  - b. Adjust pointer as follows:
    - (1) Use a pointer puller and remove pointer.
    - (2) Apply 30 psi (207kPa) test pressure to gage and install pointer. Set pointer on the 30-psi (207 kPa) mark on the dial.
    - (3) Check the accuracy over the entire scale. The gage shall be accurate within 1.5%.
  - c. If duplex air gage (11) is not accurate within 1.5%, further repair is required. Send duplex air gage to a calibration facility.

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**3-10. DUPLEX AIR GAGES (cont)**

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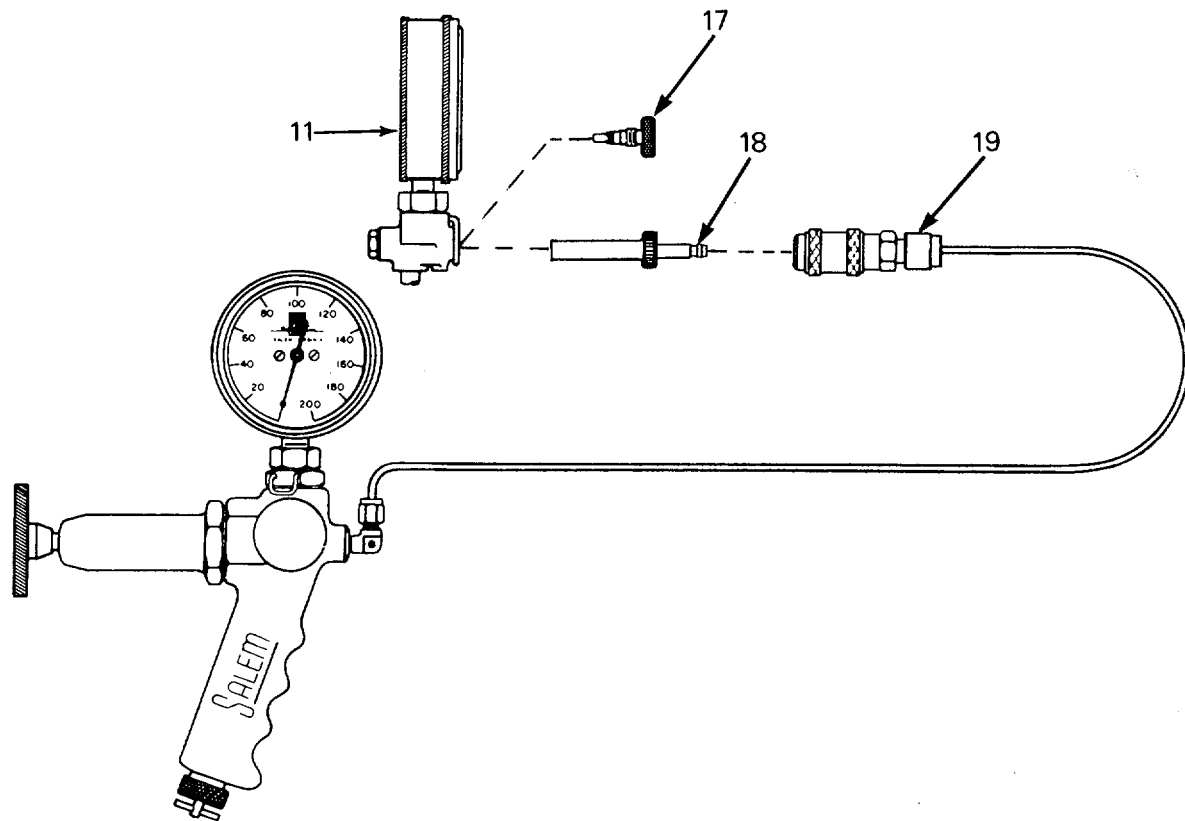
**TEST (cont)**

12. If duplex air gage (11) is not removed from locomotive, use a portable air gage tester and test by the following:
  - a. Perform step 1 above.
  - b. Remove probe plug (17) from duplex air gage (11).
  - c. Install tester probe (18) and female hose connector (19).
  - d. Test at half scale and full scale and compare amount of pressure applied to the reading shown on gage.
  - e. If pointer needs adjusting, perform step 5 above.
  - f. Adjust pointer as needed. Refer to step 11 above.
  - g. If duplex air gage is not accurate within 1.5%, further repair is required. Send duplex air gage to a calibration facility.
  - h. If pointer needed adjusting, perform step 14 below.
  - i. Remove female hose connector (19) and test probe (18).
  - j. Install probe plug (17).
  - k. Perform step 18 below.

---

**3-10. DUPLEX AIR GAGES (cont)**


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**TEST (cont)****ASSEMBLY**

13. Position gage face (13) in glass housing (16) and install two screws (15).
14. Position glass cover (14) on gage face (13) and secure with copper clasp (12).

**INSTALLATION**

15. Position duplex air gage (11) in control cabinet and install two lockwashers (10) and capscrews (9).
16. Connect two air line connections (8) to duplex air gage (11).
17. Position gasket (7) and cover (6) on control cabinet and install five capscrews (5).
18. Install gasket (4), two gaskets (3), and front cover (2) and tighten six thumbscrews (1).

---

### 3-11. OIL PRESSURE GAGES

---

This task covers:

a. Test

b. Removal

c. Installation

---

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

---

#### TEST

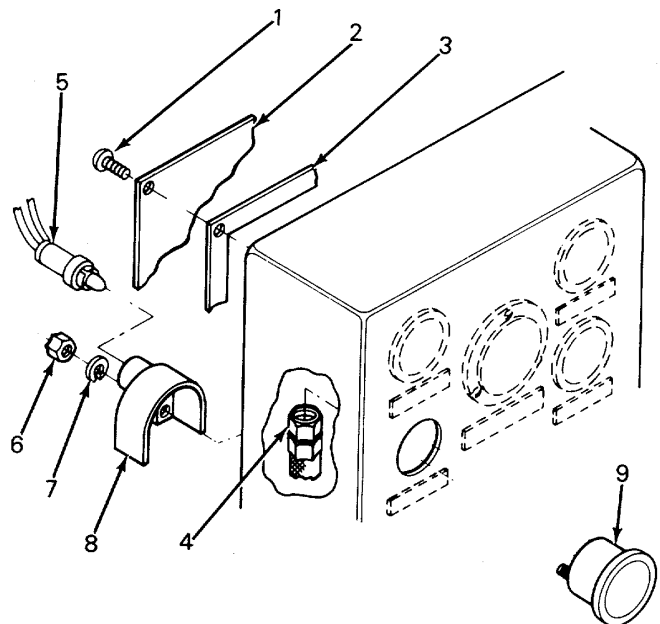
1. If it is suspected that the gage is defective, remove and test with a deadweight tester.

#### NOTE

**Federal Railroad Administration requires annual testing of oil pressure gage or when gage is not operating properly.**

#### REMOVAL

2. Remove four screws (1), rear cover (2), and gasket (3).
3. Disconnect tubing (4) from oil pressure gage (9).
4. Disconnect oil pressure gage light (5).
5. Remove two nuts (6), lockwashers (7), and bracket (8). Remove oil pressure gage (9).





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**3-11. OIL PRESSURE GAGES (cont)**

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**INSTALLATION**

6. Place oil pressure gage (9) in control cabinet and install bracket (8), two lockwashers (7), and nuts (6).
7. Connect oil pressure gage light (5).
8. Connect tubing (4) to oil pressure gage (9).
9. Position gasket (3) and rear cover (2) on control cabinet and install four screws (1).

### 3-12. ENGINE TEMPERATURE GAGES

This task covers:

a. Test

b. Removal

c. Installation

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

#### TEST

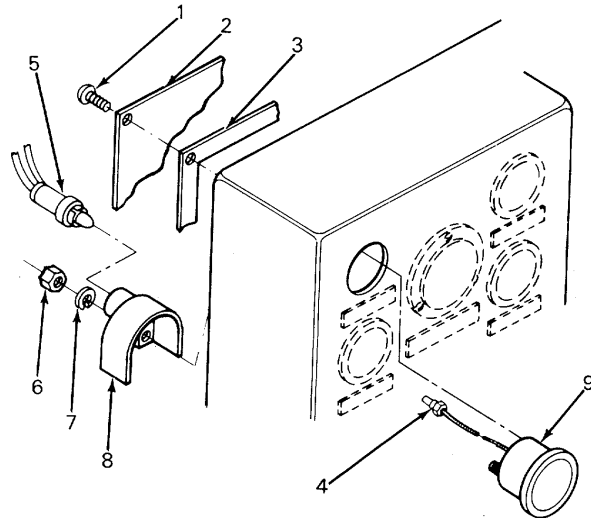
#### NOTE

If it is suspected that gage is defective, remove capillary tube from diesel engine and test gage.

1. Disconnect capillary tubing with heat sensor from diesel engine block.
2. Test gage as follows:
  - a. Heat water in vat to 180°F (82°C). Check with thermometer.
  - b. Place heat sensor in vat. If gage does not indicate 180°F (82°C), replace gage.

#### REMOVAL

3. Remove four screws (1), rear cover (2), and gasket (3).
4. Loosen all capillary tube holddown clamps and remove capillary tubing (4) from clamps.
5. Disconnect engine temperature gage light (5).
6. Remove two nuts (6), lockwashers (7), and bracket (8). Remove engine temperature gage (9).



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**3-12. ENGINE TEMPERATURE GAGES (cont)**

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**INSTALLATION**

7. Place engine temperature gage (9) in control cabinet and install bracket (8), two lockwashers (7), and nuts (6).
8. Connect engine temperature gage light (5).
9. Position capillary tube (4) in all capillary tube holddown clamps and tighten clamps. Connect capillary tubing to diesel engine block.
10. Position gasket (3) and rear cover (2) on control cabinet and install four screws (1).

**3-13. LOAD METER GAGES**

This task covers:

a. Test

b. Removal

c. Installation

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

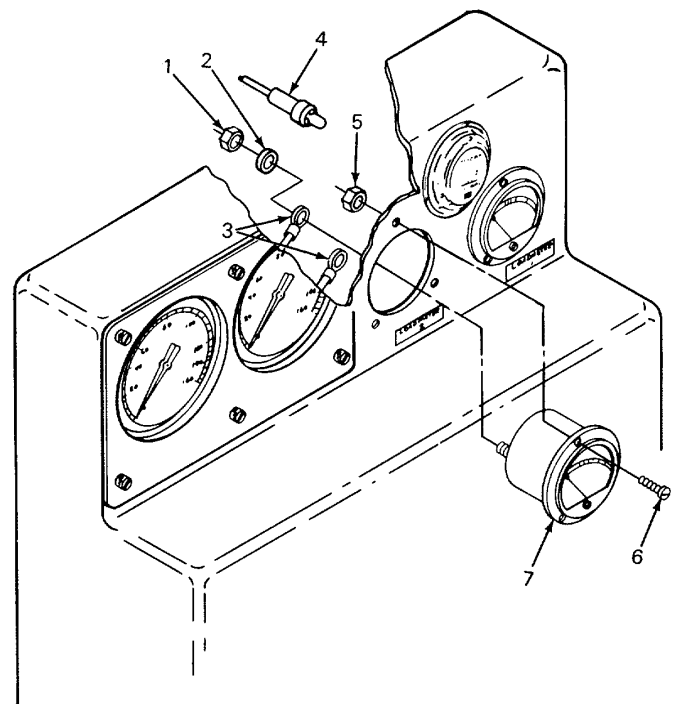
**Test Equipment**

Variable dc voltage supply

**REMOVAL****WARNING**

- ⚠ Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
- ⚠ High voltage is used in the operation of equipment. Do not be misled by the term **LOW VOLTAGE**. Potentials as low as 50 volts may cause death.

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Remove two nuts (1) and flat washers (2). Tag and disconnect two electrical leads (3) from load meter gage (7).
3. Disconnect load meter gage light (4).
4. Remove three nuts (5) and screws (6). Remove load meter gage (7).



---

**3-13. LOAD METER GAGES (cont)**

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**TEST****NOTE**

**The load meter gage can be tested while installed in the locomotive. Attach leads from variable dc voltage tester to rear of gage.**

5. Test load meter gage (7) by the following:
  - a. Use a variable millivolt dc voltage supply and a multimeter and test load meter gage (7). Test at half scale and full scale and compare amount of power supplied to the reading shown on load meter gage.
  - b. If gage is not accurate, further repair is required. Send load meter gage (7) to a calibration facility.

**INSTALLATION**

6. Place load meter gage (7) in control cabinet and install three screws (6) and nuts (5).
7. Connect load meter light (4).
8. Connect two electrical leads (3) to load meter gage (7) and install two flat washers (2) and nuts (1). Remove tags.
9. Close electrical equipment cabinet door.

---

**3-14. BATTERY VOLTMETER GAGE**

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This task covers:

a. Test

b. Removal

c. Installation

---

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E1,2

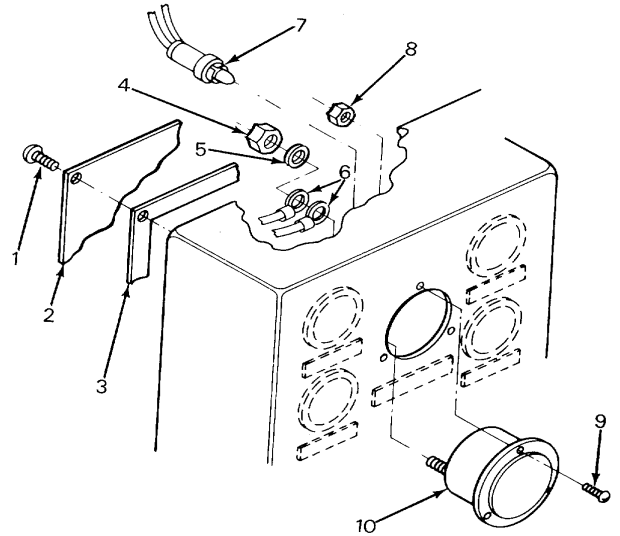
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**TEST****WARNING**

- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**
  - ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
1. Open electrical equipment cabinet door and set battery switch to CLOSED. Start locomotive (TM 55-2210-224-12).
  2. With engine running, use a multimeter and check voltage on engine alternator. Voltage indicated shall be 36 V dc. Stop engines If required, replace defective gage.

**3-14. BATTERY VOLTMETER GAGE (cont)****REMOVAL**

3. Open electrical equipment cabinet door and set battery switch to OPEN.
4. Remove four capscrews (1), rear cover (2), and gasket (3).
5. Remove two nuts (4) and flat washers (5). Tag and disconnect electrical leads (6) from battery voltmeter gage (10).
6. Disconnect battery voltmeter gage light (7).
7. Remove three nuts (8) and screws (9). Remove battery voltmeter gage (10).

**INSTALLATION**

8. Place battery voltmeter gage (10) in control cabinet and install three screws (9) and nuts (8).
9. Connect battery voltmeter gage light (7).
10. Connect electrical leads (6) to battery voltmeter gage (10) and install two flat washers (5) and nuts (4). Remove tags.
11. Position gasket (3) and rear cover (2) on control cabinet and install four screws (1).
12. Close electrical equipment cabinet door.

**3-15. SERVICE METER GAGE**

This task covers:

a. Test

b. Removal

c. Installation

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

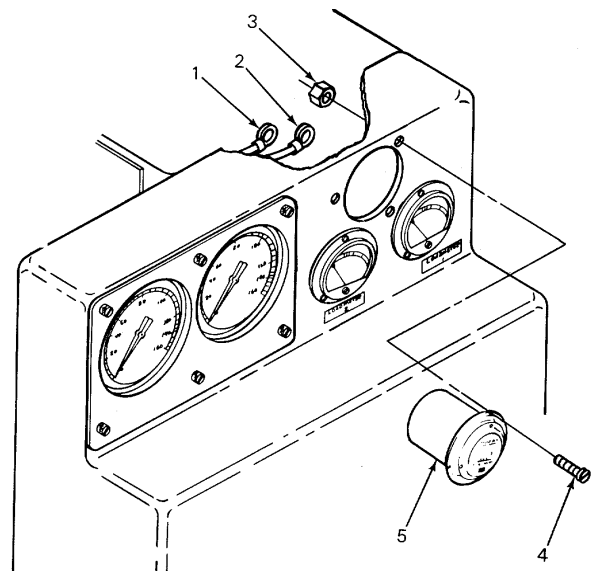
**Test Equipment**

Variable dc voltage supply

**REMOVAL****WARNING**

- ⚠ Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
- ⚠ High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Tag and disconnect wires (1) and (2).
3. Remove three nuts (3) and screws (4).
4. Remove meter (5) from front of meter panel.





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**3-15. SERVICE METER GAGE (cont)**

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**TEST**

5. Connect a variable dc power supply to positive and negative sides of the service meter and apply 32 V dc to meter. Check that time advances on meter face.

**INSTALLATION**

6. Install meter (5) into meter panel.
7. Install three screws (4) and nut(3).
8. Connect wires (1) and (2) to proper terminals and remove tags.
9. Close electrical equipment cabinet door.

---

**3-16. AIR COMPRESSOR OIL PRESSURE GAGE**

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This task covers:

a. Test

b. Removal

c. Installation

---

**INITIAL SETUP**ToolsTool kit SC4940-97-CL-E12

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**REMOVAL**

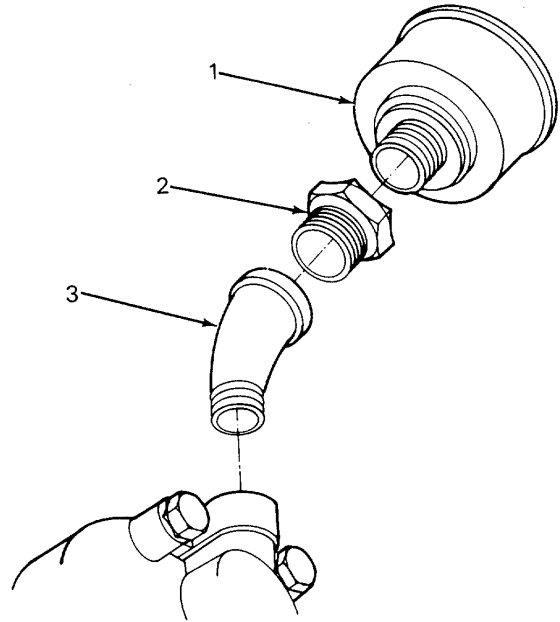
1. Remove air compressor oil pressure gage (1) from reducer (2).
2. If necessary, remove reducer (2) and street elbow (3).

**TEST**

3. Use deadweight tester and test air compressor oil pressure gage (1).

**INSTALLATION**

4. If removed, install street elbow (3) and reducer (2).
5. Install air compressor oil pressure gage (1) into reducer (2).



**3-17. SANDER CONTROL VALVE**

This task covers:

- a. Disassembly
- b. Cleaning
- c. Inspection
- d. Repair
- e. Assembly

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

Equipment Condition

Reference

TM 55-2210-224-12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Wiping rags (Item 32, Appendix B)

Condition Description

Sander control valve removed

**DISASSEMBLY**

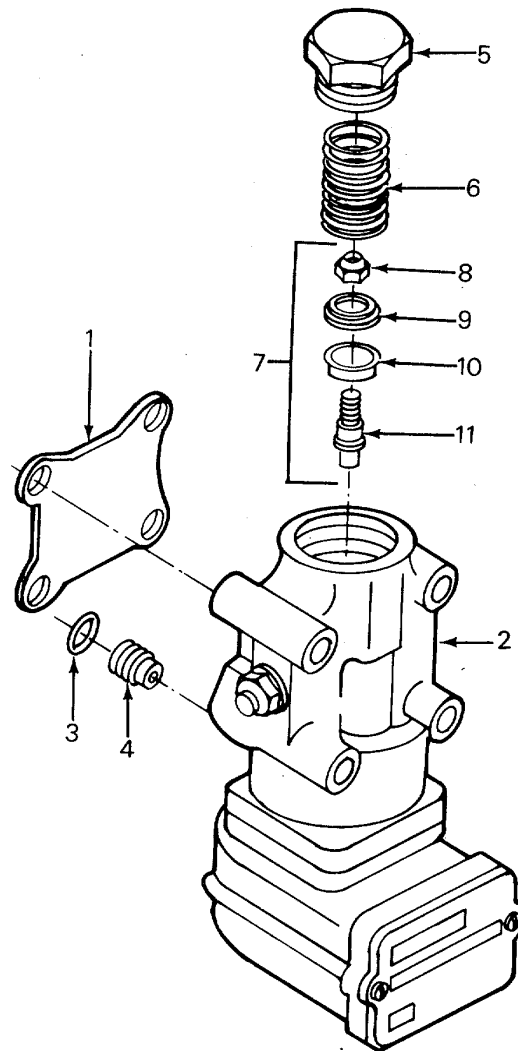
**WARNING**

- ⚠ Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
- ⚠ High voltage is used in the operation of equipment. Do not be misled by the term **LOW VOLTAGE**. Potentials as low as 50 volts may cause death.

**NOTE**

When the sander control valve is completely disassembled, a repair kit should be install. Refer to TM 55-2210-224-24P for the correct repair kit.

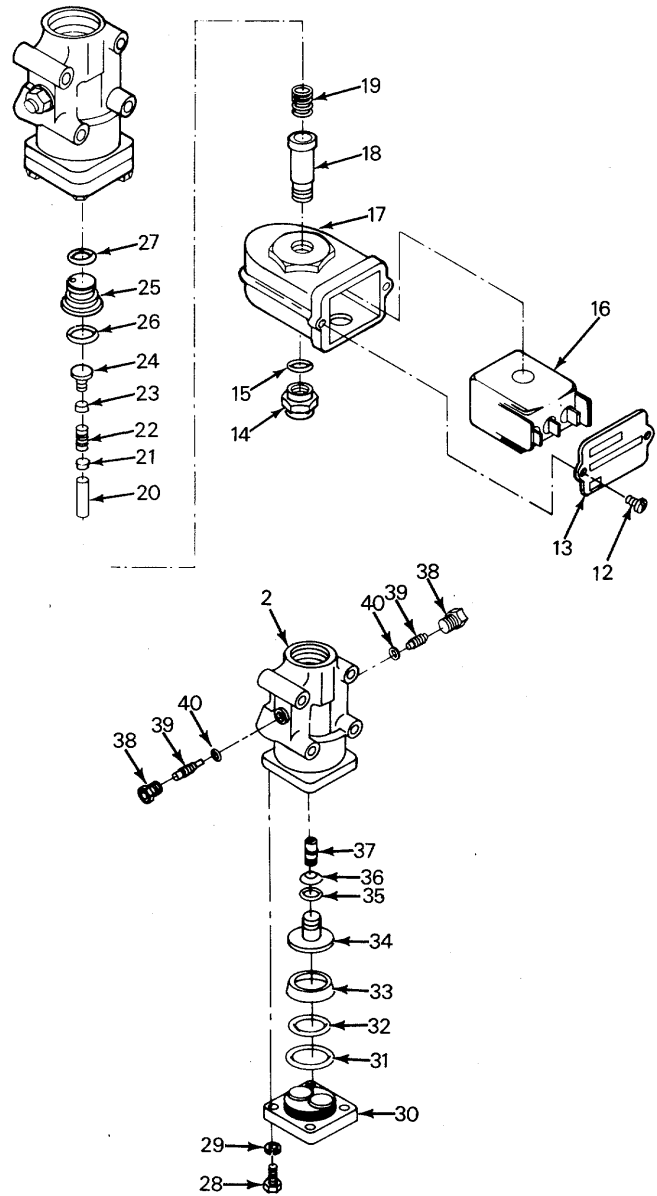
1. Remove gasket (1) from valve body (2). Retain gasket.
2. Remove O-ring (3) and strainer plug (4). Discard O-ring.
3. Remove spring cap (5) and spring (6).
4. Remove valve assembly (7).
5. Remove locknut (8), seat washer (9), and neoprene valve seat (10) from valve stem (11). Discard valve seat.



**3-17. SANDER CONTROL VALVE (cont)**

**DISASSEMBLY (cont)**

6. Remove two screws (12) and cover (13).
7. Remove exhaust nut (14), O-ring (15), field yoke (16), and coil case (17).
8. Remove coil pole (18), spring (19), plunger body (20), and plunger seat (21).
9. Remove plunger spacer (22), plunger seat (23), and plunger cap (24) from solenoid valve body (25). Discard plunger seat.
10. Remove O-rings (26) and (27). Discard O-rings.
11. Remove four screws (28) and lockwashers (29).
12. Remove actuating cap (30), O-rings (31) and (32), and rubber cup (33). Discard O-ring and rubber cup.
13. Remove actuating piston (34), O-ring (35), neoprene valve seat (36), and piston stem (37). Discard O-ring.
14. Remove two plunger bodies (38), plungers (39), and O-rings (40). Discard O-rings.



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**3-17. SANDER CONTROL VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  - ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**
15. Use a cloth dampened in drycleaning solvent and remove grease and oil from exterior and interior of valve body (2).
  16. Use drycleaning solvent and clean metal parts. Dry with compressed air.
  17. Inspect metal parts for cracks, breaks, cuts, or other damage.
  18. Check that springs have not rusted, become distorted, or taken a permanent set.
  19. Measure free height of spring (6). Minimum free height is 1-7/16 inch (36.5 mm).
  20. Measure free height of spring (19). Minimum free height is 31/32 inch (24.6 mm). Replace damaged spring.
  21. Use a multimeter and measure resistance of coil (16). Resistance is 314 to 346.5 ohms.
  22. Repair consists of replacement of damaged parts. Whenever the sander control valve is completely disassembled, the following parts should be replaced from repair kit:
    - a. Gasket (1)
    - b. O-rings (3), (26), (27), (31), (32), (35), and (40)
    - c. Neoprene valve seat (10)
    - d. Plunger seats (21) and (23)
    - e. Rubber cup (33)

**3-17. SANDER CONTROL VALVE (cont)**

---

**ASSEMBLY**

23. Use pneumatic grease and lubricate O-rings (3), (15), (26), (27), (31), (32), (35), and (40), actuating piston (34), and rubber cup (33). Use a clean wiping rag and remove excess grease.
24. Install two O-rings (40), plungers (39), and plunger bodies (38).

**NOTE**

**Dowels must be alined on actuating cap.**

25. Install piston stem (37), neoprene valve seat (36), O-ring (35), actuating piston (34), rubber cup (33), O-rings (32) and (31), and actuating cap (30). Install four lockwashers (29) and screws (28).
26. Install O-rings (27) and (26) on solenoid valve body (25).
27. Install plunger seat (23) in plunger cap (24).
28. Install plunger seat (21) and plunger spacer (22) in plunger body (20). Install plunger cap (23) on plunger body.
29. Install spring (19) on plunger body (20).
30. Install spring (19) and plunger body (20) in coil pole (18).
31. Install solenoid valve body (25).
32. Install field yoke (16) and coil case (17) on coil pole (18). Install O-ring (15) and exhaust nut (14).
33. Position cover (13) and install two screws (12).
34. Assemble valve assembly (7) by the following:
  - a. Install neoprene valve seat (10) and seat washer (9) on valve stem (11).
  - b. Install locknut (8).
35. Install valve assembly (7) and spring (6). Install spring cap (5).
36. Install O-ring (3) and strainer plug (4) in valve body (2).

**NOTE**

**If a repair kit is installed in sander control valve, check that gasket (1) remains with repaired valve for installation procedures.**

37. Install gasket (1).

---

**3-18. EMERGENCY SAND PRESSURE SWITCH**

---

This task covers:

a. Test

b. Removal

c. Installation

---

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

---

**REMOVAL**

1. Disconnect air line fitting (1) from control switch (2).
2. Loosen cover screw (3) and remove cover (4) and gasket (5). Tag and disconnect wires (6).
3. Remove two nuts (7) and lockwashers (8) and remove control switch (2) from mount bracket (9).
4. Remove pipe elbow (10) from control switch (2).

**TEST**

5. Connect a multimeter to switch leads.
6. Apply a regulated air source to switch and check that switch trips at a varied range of pressure from 5 to 75 psi (34.5 to 517 kPa).

**INSTALLATION**

7. Install pipe elbow (10) on control switch (2) and position switch against mount bracket (9).
8. Install two lockwashers (8) and nuts (7).
9. Connect wires (6) and remove tags. Install gasket (5) and cover (4) and tighten with cover screw (3).
10. Connect air line fitting (1) to control switch (2).

---

**3-19. MULTIPLE-UNIT RECEPTACLE**

---

This task covers:

- |                |               |           |                 |
|----------------|---------------|-----------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair | g. Assembly     |
| b. Disassembly | d. Inspection | f. Test   | h. Installation |
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

---

**REMOVAL****WARNING**

- ⓘ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⓘ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**
- ⓘ **Use caution when removing cover hinge shaft. Spring is under pressure and may cause injury to personnel when released from cover hinge shaft.**

1. Open electrical equipment cabinet door and set battery switch to OPEN.



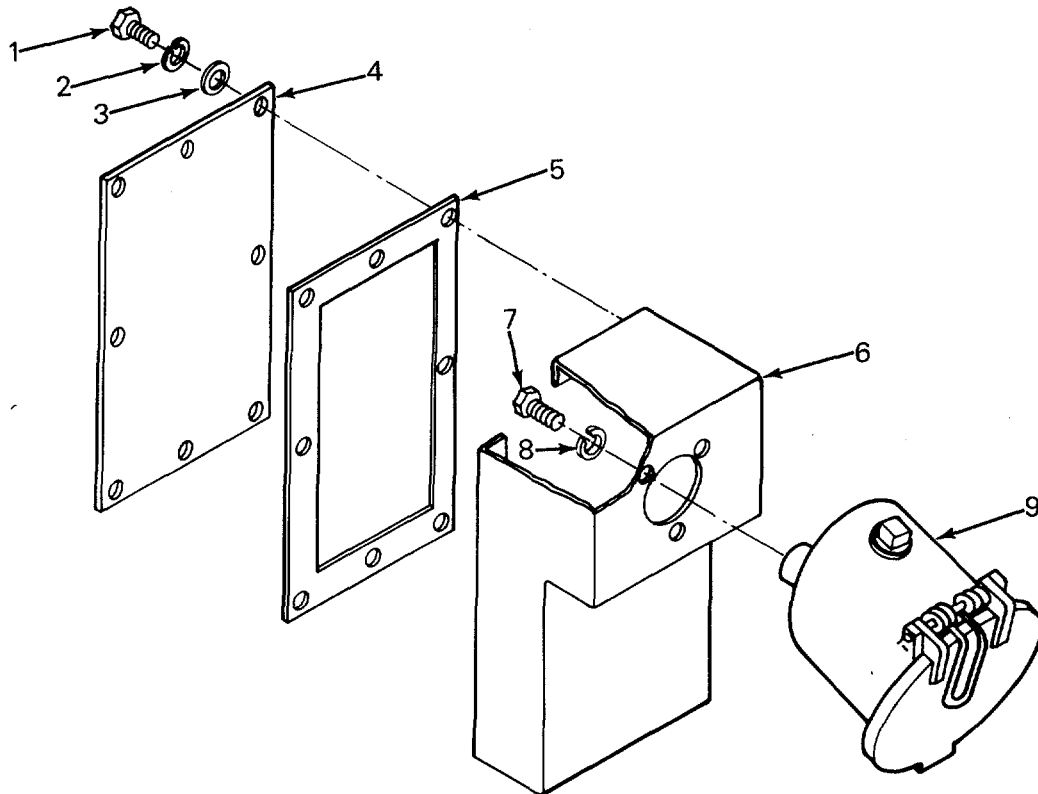
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**3-19. MULTIPLE-UNIT RECEPTACLE (cont)**

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**REMOVAL (cont)**

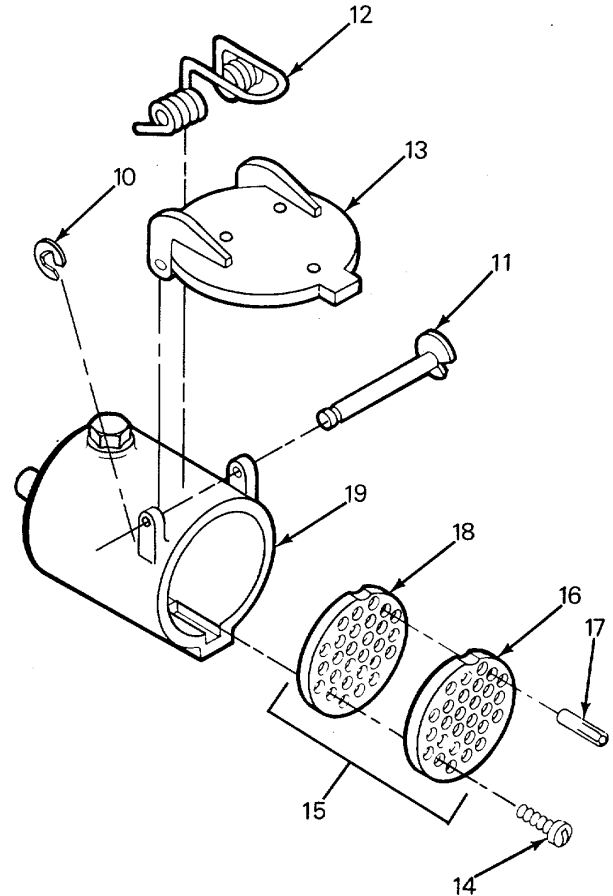
2. Remove eight screws (1), lockwashers (2), and flat washers (3). Remove cover (4) and gasket (5).
3. Tag and disconnect electrical leads from terminal board inside box (6).
4. Remove three capscrews (7), lockwashers (8), and multiple-unit receptacle (9).



**3-19. MULTIPLE-UNIT RECEPTACLE (cont)**

**DISASSEMBLY**

5. Remove external snapping (10), cover hinge shaft (11), spring (12), and housing cover (13).
6. Remove three screws (14) securing pin assembly (15) to receptacle housing (19).
7. Remove pin assembly (15) from receptacle housing (19).
8. Remove insulator plate (16).
9. Tag and disconnect wires from 16 pins (17) and remove pins as required.
10. Remove insulator plate (18), if required, from receptacle housing (19).



**CLEANING, INSPECTION, AND REPAIR**

**WARNING**

- ⊙ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⊙ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

11. Use a cloth dampened in drycleaning solvent and clean parts. Dry with compressed air.

---

**3-19. MULTIPLE-UNIT RECEPTACLE (cont)**

---

**CLEANING, INSPECTION, AND REPAIR (cont)**

12. Inspect pins (17) for pitted or burned areas.
13. Inspect receptacle housing (19) for bends or dents.
14. Inspect for broken or frayed wiring.
15. Inspect for broken or cracked insulation plates.
16. Repair consists of replacement of damaged parts.

**TEST**

17. Use a multimeter and perform a continuity test on the multiple-unit receptacle.
18. Use a megohmmeter and perform a resistance test on the multiple-unit receptacle.

**ASSEMBLY**

19. Install insulator plate (18), if removed, in receptacle housing (19).
20. Install 16 pins (17), connect wires to pins, and remove tags.
21. Install insulator plate (16).
22. Position pin assembly (15) in receptacle housing (19) and install three screws (14).
23. Position housing cover (13) and spring (12) on receptacle housing (19) and install cover hinge shaft (11) and external snapping (10).

**INSTALLATION**

24. Position multiple-unit receptacle (9) on box (6) and install three lockwashers (8) and capscrews (7).
25. Connect electrical leads to terminal board inside box (6) and remove tags.
26. Position gasket (5) and cover (4) on box (6) and install eight flat washers (3), lockwashers (2), capscrews (1).
27. Close electrical equipment cabinet door.

---

**3-20. ENGINE HEATER RECEPTACLE**

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This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Test        | d. Cleaning   | f. Repair   | h. Installation |
| b. Removal     | e. Inspection | g. Assembly | i. Test         |
| c. Disassembly |               |             |                 |
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

---

**TEST****WARNING**

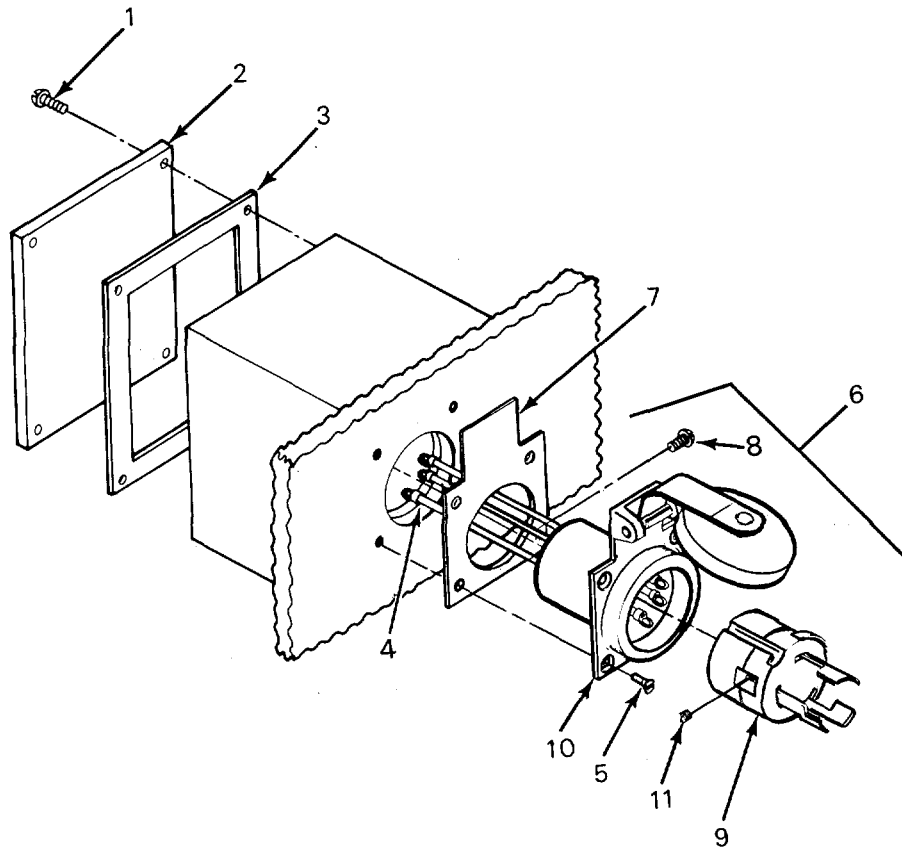
- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Tag and remove electrical connections from jacket water heater.
3. Use a multimeter and perform a continuity test on the engine heater receptacle.

**3-20. ENGINE HEATER RECEPTACLE (cont)**

**REMOVAL**

4. Remove eight screws (1), cover (2), and gasket (3).



5. Tag and disconnect wiring (4) from terminal board.
6. Remove four screws (5) and pull receptacle assembly (6) and gasket (7) from locomotive frame.

**DISASSEMBLY**

7. Remove three screws (8) from back of receptacle assembly (6).
8. Turn receptacle (9) counterclockwise until slots on receptacle housing (10) align with grooves on receptacle. Push receptacle through housing.
9. Remove three setscrews (11).
10. Tag and disconnect wiring (4) from receptacle (9). Remove receptacle.

---

**3-20. ENGINE HEATER RECEPTACLE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⓘ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⓘ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

11. Use a cloth dampened with drycleaning solvent and remove dirt. Dry with compressed air.
12. Inspect contacts for pitted or burned areas. If damaged, replace receptacle.
13. Inspect receptacle housing for bends or dents. If damaged, replace receptacle.
14. Inspect for broken or frayed wiring. Replace damaged wires.

**ASSEMBLY**

15. Insert wiring (4) into proper terminals of receptacle (9) and install three setscrews (11).
16. Align grooves on receptacle (9) with slots in receptacle housing (10) and push receptacle into receptacle housing. Turn receptacle clockwise to lock into place.
17. Install three screws (8).

**INSTALLATION**

18. Position gasket (7) and receptacle assembly (6) in locomotive frame and install four screws (5).
19. Connect wiring (4) to terminal board and remove tags.
20. Position gasket (3) and cover (2) on box and install eight screws (1).

**TEST**

21. Use a multimeter and perform a continuity test on the engine heater receptacle.
22. Replace electrical connections to jacket water heater. Remove tags.

---

**3-21. TIMER**

---

This task covers:

a. Removal

b. Test

c. Installation

---

**INITIAL SETUP****Tools**

Tools SC4940-97-CL-E12

**Test Equipment**

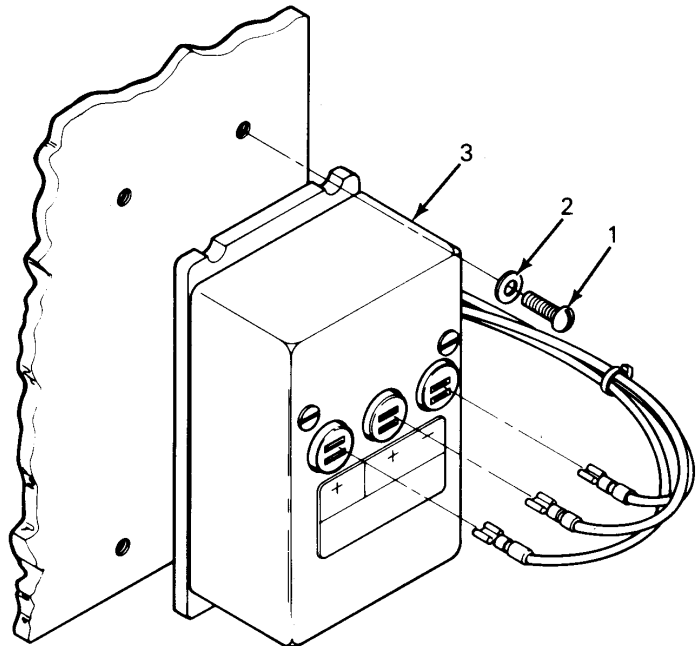
Variable dc voltage supply

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**REMOVAL****WARNING**

- High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.
- Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Tag and disconnect three wires from timer (3).
3. Remove four screws (1), flat washers (2), and timer (3).



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**3-21. TIMER (cont)**

---

**TEST**

4. Connect 36 V dc to positive and negative terminals.
5. Connect multimeter to positive and negative output terminals.
6. Check time from power on to power on or from power off to power off. One complete cycle will be between 2-1/2 and 3-1/2 minutes.

**INSTALLATION**

7. Position timer (3) in electrical equipment cabinet and install four screws (1) and flat washers (2).
8. Connect three wires to timer (3). Remove tags.
9. Close electrical equipment cabinet door.



### 3-22. FIELD SHUNT CONTACTOR

This task covers:

- |                |               |                 |
|----------------|---------------|-----------------|
| a. Removal     | d. Inspection | g. Installation |
| b. Disassembly | e. Repair     | h. Adjustment   |
| c. Cleaning    | f. Assembly   | i. Test         |

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

##### Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
Electrical insulating varnish  
(Item 37, Appendix B)

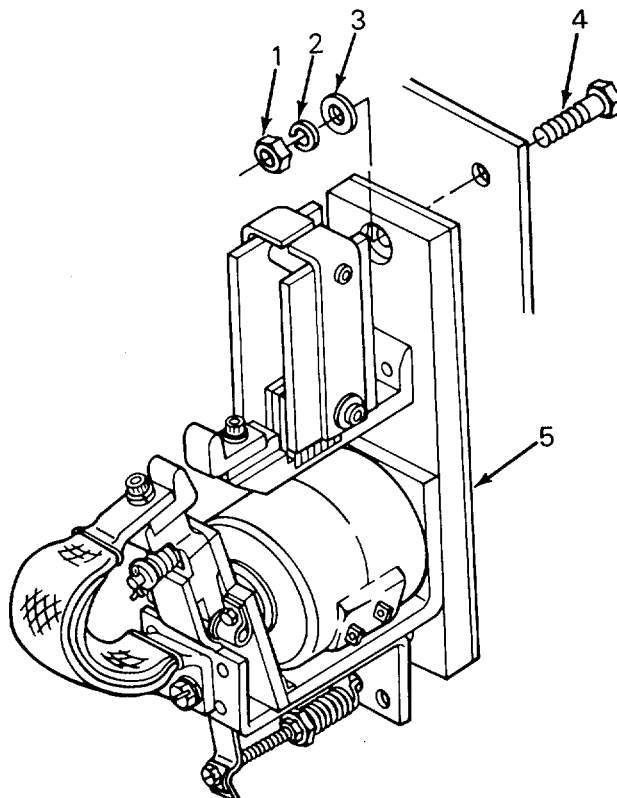
##### Test Equipment

Variable dc voltage supply

#### REMOVAL

##### **WARNING**

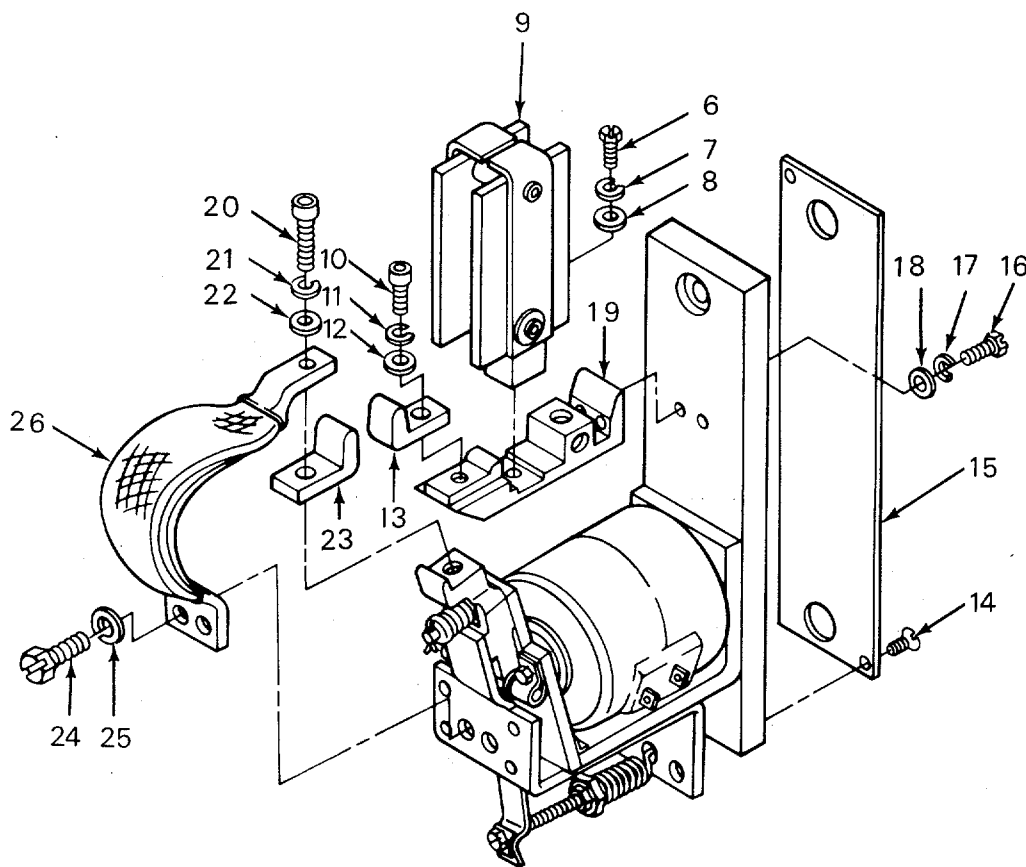
- High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.
  - Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from field shunt contactor assembly (5).
  2. Remove two nuts (1), lockwashers (2), flat washers (3), and capscrews (4). Remove field shunt contactor assembly (5).



**3-22. FIELD SHUNT CONTACTOR (cont)**

## DISASSEMBLY

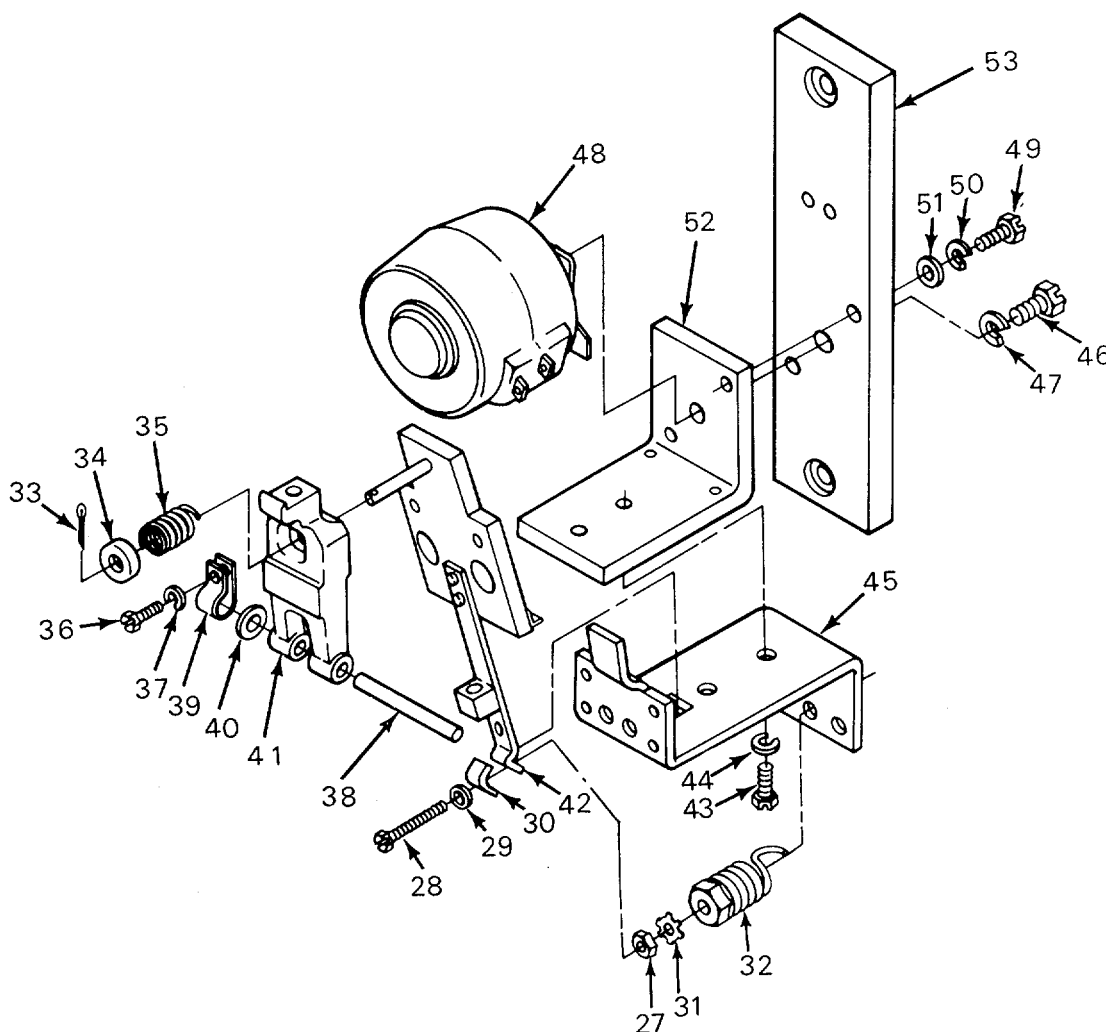
3. Remove capscrew (6), lockwasher (7), and flat washer (8). Remove arc chute (9).
4. Remove allen-head screw (10), lockwasher (11), and flat washer (12). Remove stationary contact tip (13).
5. Remove two screws (14) and cover (15).
6. Remove two capscrews (16), lockwashers (17), and flat washers (18). Remove stationary contact tip support (19).
7. Remove allen-head screw (20), lockwasher (21), and flat washer (22). Remove movable contact tip (23).
8. Remove two capscrews (24) with lockwashers (25). Remove shunt (26).



**3-22. FIELD SHUNT CONTACTOR (cont)**

DISASSEMBLY (cont)

9. Loosen calibrating screw locknut (27) and remove calibrating screw (28), flat washer (29), spacer (30), calibrating screw locknut, star washer (31), and calibrating spring (32).
10. Remove cotter pin (33), spring seat (34), and contact pressure spring (35). Remove two caps (36), lockwasher (37), pins (38), clamps (39), and flat washers (40). Remove contact lever (41) from armature (42). Remove armature from armature stop (45).
11. Remove two capscrews (43) and lockwashers (44). Remove armature stop (45).
12. Remove capscrew (46), lockwasher (47), and operating coil (48). Remove two capscrews (49), lockwashers (50), flat washers (51), and magnet frame (52) from base (53).



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**3-22. FIELD SHUNT CONTACTOR (cont)**

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## CLEANING, INSPECTION, AND REPAIR

**WARNING**

- Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38-59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**NOTE**

Do not file or attempt to clean stationary contact tip (13) and movable contact tip (23). Silver alloy surfaces on contacts may become blackened, pitted, or eroded. These conditions will not hamper the operation of the contactor.

13. Use drycleaning solvent and clean metal parts. Dry with compressed air.
14. Inspect and repair components as follows:
  - a. Arc chute (9). Inspect arc chute and replace plates that are broken or burned three/fourths through. Replace if burned close to the screws.

**CAUTION**

Do not use sandpaper or emery cloth to dress tips.

- b. Inspect stationary contact tip (13) and movable contact tip (23). Replace if worn down 3/32 inch (2.38 mm). Replace silver tips if silver is worn through.

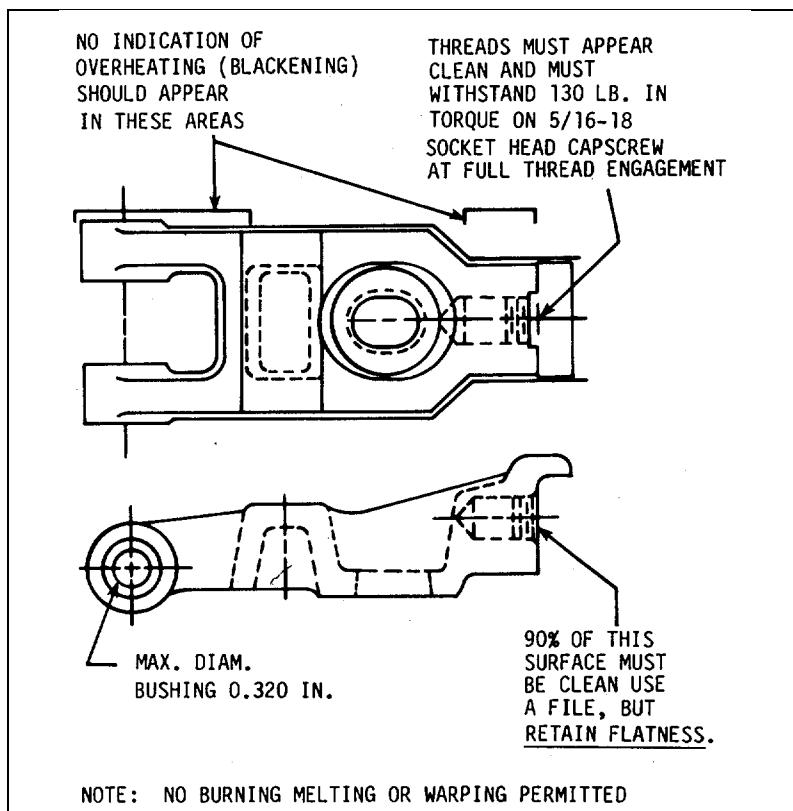
**3-22. FIELD SHUNT CONTACTOR (cont)**

**CLEANING, INSPECTION, AND REPAIR(cont)**

c. Contact lever (41).

(1) Inspect the bushings. If the inside diameter is worn beyond 0.32 inch (8.12 mm), replace lever.

(2) Inspect the hinge pin (38). Replace the pin if scored or burnt.



d. Shunt (26). Inspect the braided copper for wear, fraying, discoloration, or stiffness. Replace the shunt if any of the above conditions exist.

e. Operating coil (48).

(1) Use a multimeter and check coil resistance. Replace the coil if the measured value is not between 34.6 and 42.3 ohms.

(2) Check the coil terminals for damage.

(3) Check the coil for damaged, dry, or brittle insulation. If necessary, insulate by applying electrical insulating varnish. Replace coil if necessary.

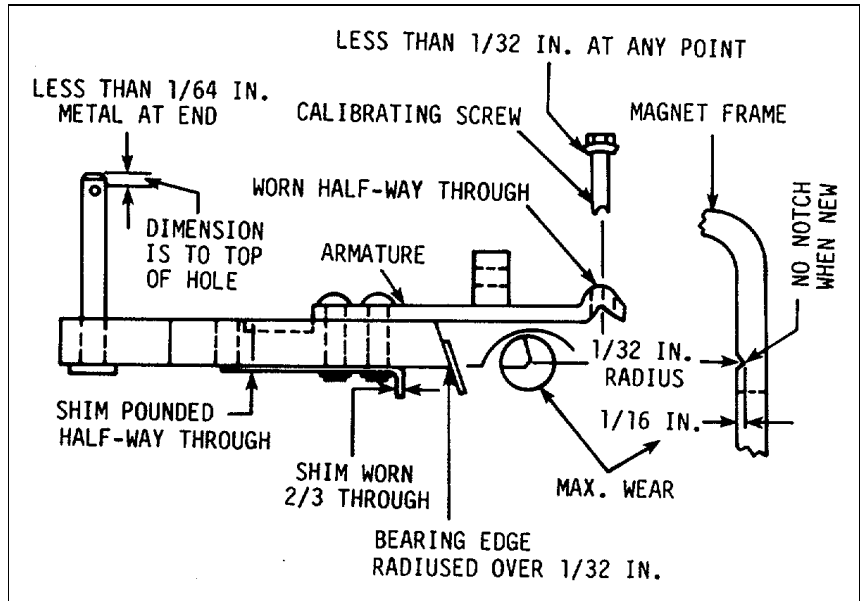
**3-22. FIELD SHUNT CONTACTOR (cont)**

f. Armature (42).

(1) Inspect armature for a rounded bearing edge or uneven wear. If the armature bearing edge is worn beyond 1/32 inch (0.793 mm), replace the armature.

(2) Inspect the armature bracket (extension on the end of the armature to which the calibrating spring is attached).

(3) Inspect the pin over which the contact pressure spring fits. Replace the pin if less than 1/64 inch (0.396 mm) the pin of remains between the hole and the end of the pin.



(4) Inspect the armature shim. Replace shim if the portion between armature and magnet frame is pounded more than halfway through or if the short, bent-up portion is worn more than two-thirds through.

g. Armature stop (45). Inspect the armature stop for grooving and uneven wear. If the armature stop is grooved or worn more than 1/16 inch (1.58 mm) at the bearing edge of the armature, replace the armature stop.

h. Calibrating Spring (32). Inspect calibrating spring and replace spring if it is cracked, corroded, notched on the end hook, or has lost its tension.

i. Contact pressure spring (35). Inspect pressure spring and replace spring if cracked, corroded, notched on end hook, low on tension, annealed, or showing signs of electrical damage.

j. Stationary contact tip support (19).

(1) Inspect contact support for discoloration caused by overheating and for cracks. Replace contact if any of the above conditions are found.

(2) Inspect the tapped hole for signs of burred, stripped, or damaged threads. Replace the contact if tapping of the hole will not restore the threads.

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**3-22. FIELD SHUNT CONTACTOR (cont)**

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## CLEANING, INSPECTION, AND REPAIR (cont)

## k. Base (53).

- (1) Inspect base (53) for soundness. Replace base if it appears to be oil soaked or cracked.
- (2) Paint base (53) with one or two coats of electrical insulating varnish.

## ASSEMBLY

15. Position magnet frame (52) on base (53) and install two flat washers (51), lockwashers (50), and capscrews (49). Position operating coil (48) on magnet frame and install lockwasher (47) and capscrew (46).
16. Position armature stop (45) on magnet frame (52) and install two lockwashers (44) and capscrews (43). Position armature (42) in armature stop.
17. Install two flat washers (40), clamps (39), and pins (38) on contact lever (41). Position contact lever on armature (42). Install two lockwashers (37) and capscrews (36).
18. Install contact pressure spring (35) on pin of contact lever (41) and install spring seat (34) and cotter pin (33).
19. Connect calibrating spring (32) to armature stop (45) and install star washer (31), calibrating screw locknut (27), spacer (30), flat washer (29), and calibrating screw (28). Tighten calibrating screw locknut.
20. Position shunt (26) on armature stop (45) and install two lockwashers (25) and capscrews (24).
21. Position movable contact tip (23) and shunt (26) on contact lever (41) and install flat washer (22), lockwasher (21), and allen-head screw (20).
22. Position stationary contact tip support (19) on base (53) and install two flat washers, (18) lockwashers (17), and capscrews (16).
23. Position cover (15) and install two screws (14).
24. Position stationary contact tip (13) on stationary contact tip support (19) and install flat washer (12), lockwasher (11), and allen-head screw (10).
25. Position arc chute (9) on stationary contact tip support (19). Install flat washer (8), lockwasher (7), and capscrew (6).

**3-22. FIELD SHUNT CONTACTOR (cont)**

**INSTALLATION**

- 26. Install field shunt contactor assembly in electrical equipment cabinet and install two capscrews (4), flat washers (3), lockwashers (2), and nuts (1).

**CAUTION**

Incorrect electrical connections to terminals will result in damage to stationary contact tip (13) and movable contact tip (23), since arc suppression feature will be nullified.

- 27. Connect electrical wires in accordance with wiring diagram and remove tags.

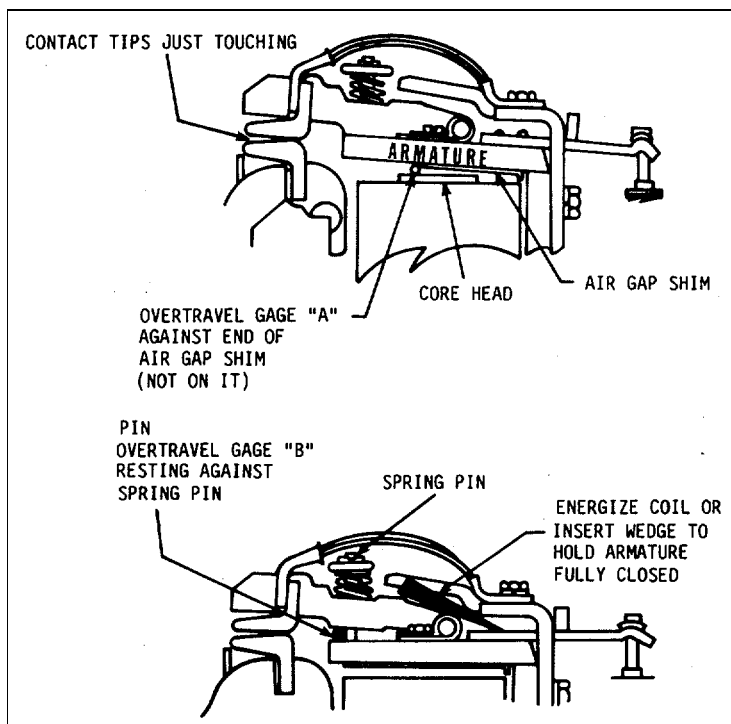
**ADJUSTMENT**

- 28. Measure contact tip overtravel as follows:

**NOTE**

Overtravel is the distance a movable contact tip would travel after touching the stationary tip if the stationary tip were then removed.

- a. Measure overtravel by either method 1, pin at A, or method 2, pin at B. Refer to table 3-1 for amount of overtravel and size of pin required to measure that amount.





**3-22. FIELD SHUNT CONTACTOR (cont)**

**ADJUSTMENT (cont)**

Table 3-1. Measuring Contact Tip Overtravel

Overtravel		Gage Pin		
New Contactor		Status	@A	@B
N E W	10/32	GO	0.176	0.200
	12/32	NO GO	0.207	0.240
T I P S	Old Contactor			
	9/32	GO	0.160	0.180
	13/32	NO GO	0.223	0.260
Low Limit - Old Contactor (Old Tips)				
	7/32	NO GO	0.130	0.140

b. If the overtravel is insufficient, check for the following conditions:

- (1) Badly worn, bent, or incorrect tips
- (2) Bent stationary contact-tip support

c. If the overtravel is too high, check for the following conditions:

- (1) Bent or incorrect tips
- (2) Worn stop on the contact lever
- (3) Bent stationary contact-tip support

29. Measure tip break as follows:

**NOTE**

Make sure the contactor armature is against the stop when making the measurement; otherwise, the reading will be false.

a. Measure the tip break (air gap) at the point of minimum spacing when tips are open.

b. Tip break shall be 14/32 to 19/32 inch (11.11 to 15.08 mm) for worn contactor and 15/32 to 18/32 inch (11.90 to 14.28 mm) for new contactor.

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**3-22. FIELD SHUNT CONTACTOR (cont)**

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**ADJUSTMENT (cont)**

c. If the tip break is not correct, check for the following conditions:

- (1) Worn or bent contact tip
- (2) Bent armature stop
- (3) Worn or bent contact lever

d. Adjust gap by bending the armature stop.

30. Measure tip alinement and adjust as follows:

**NOTE**

The maximum allowable side-to-side misalinement of the contact tips is 3/32 inch (2.88 mm).

a. Check tip for misalinement. If necessary, loosen the screws holding the magnet frame and stationary contact-tip support to the block and move the assembly until tips aline properly.

b. If tip misalinement cannot be corrected, check for the following conditions:

- (1) Grooving or uneven wear of the armature stop.
- (2) Rounded knife edge or uneven wear of the armature pivot point.
- (3) Grooving or uneven wear of the armature guide.

31. Measure tip pressure as follows:

a. Measure initial pressure as follows:

- (1) Block the armature (not the tip lever) so the contacts nearly touch.
- (2) Measure the pull required to just move the contact-tips against the contact pressure spring.
- (3) Check for a pull of 2 to 4 lb (0.907 to 1.814 kg).

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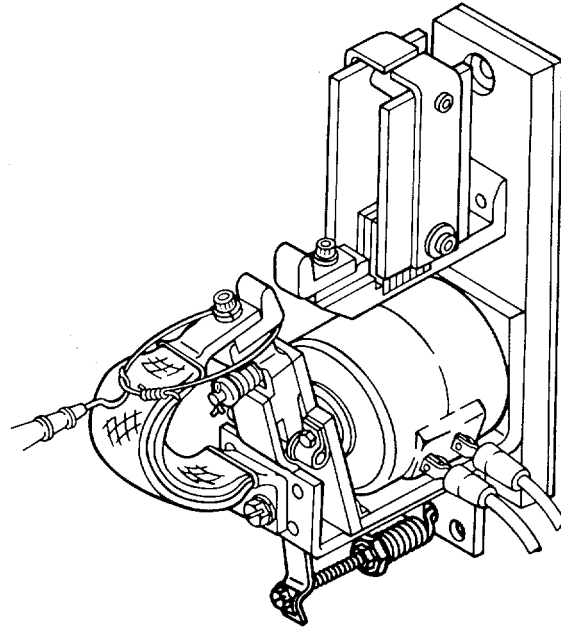
**3-22. FIELD SHUNT CONTACTOR (cont)**

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## ADJUSTMENT (cont)

b. Measure final pressure as follows:

- (1) Block the armature in the closed position.
- (2) Measure the pull required to just separate the contact tips.
- (3) Check for a pull of 5 to 8 lb (2.267 to 3.628 kg).



c. If the pressure measurements are not correct, check for the following conditions:

- (1) Low initial pressure - defective contact pressure spring, worn spring seat or washers, or worn stop.
- (2) Low final pressure - defective pressure spring, low wear allowance, or badly worn tips.

**TEST**

32. Measure and adjust coil operating current as follows:

- a. Use multimeter and measure resistance of coil. The indicator shall be between 34.65 and 42.35 ohms. Replace defective coil.
- b. Connect power supply and ammeter to coil.
- c. Apply current and increase slowly until contactor picks up. Check that the contactor picks up without hesitation, that is, in one quick motion including the contact wipe. The current measured shall be 0.436 to 0.533 amperes.
- d. Adjust calibrating screw until proper value of current is indicated.

33. Manually operate interlock contacts. Use a multimeter and check resistance of contacts for infinity while open and continuity while closed.

**3-23. CRANKING CONTACTOR**

This task covers:

- |                |               |                 |
|----------------|---------------|-----------------|
| a. Removal     | d. Inspection | g. Installation |
| b. Disassembly | e. Repair     | h. Adjustment   |
| c. Cleaning    | f. Assembly   | i. Test         |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Electrical insulating varnish  
 (Item 37, Appendix B)

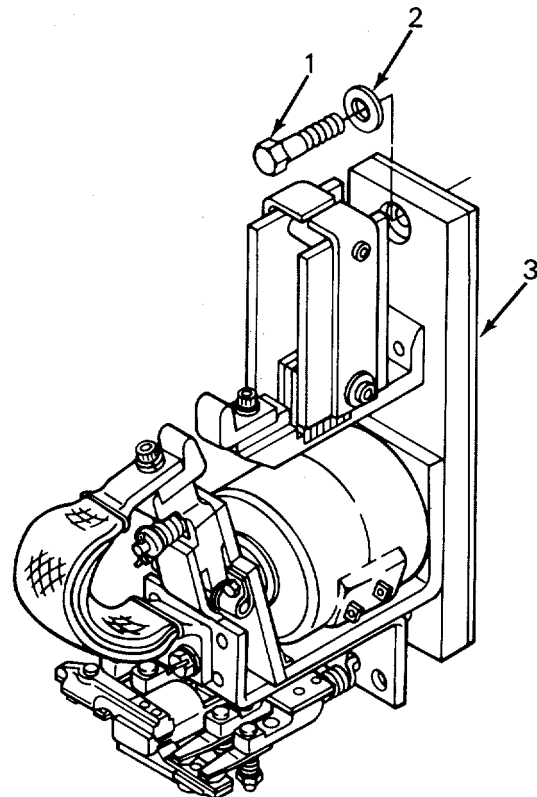
Test Equipment

Variable dc voltage supply

**REMOVAL**

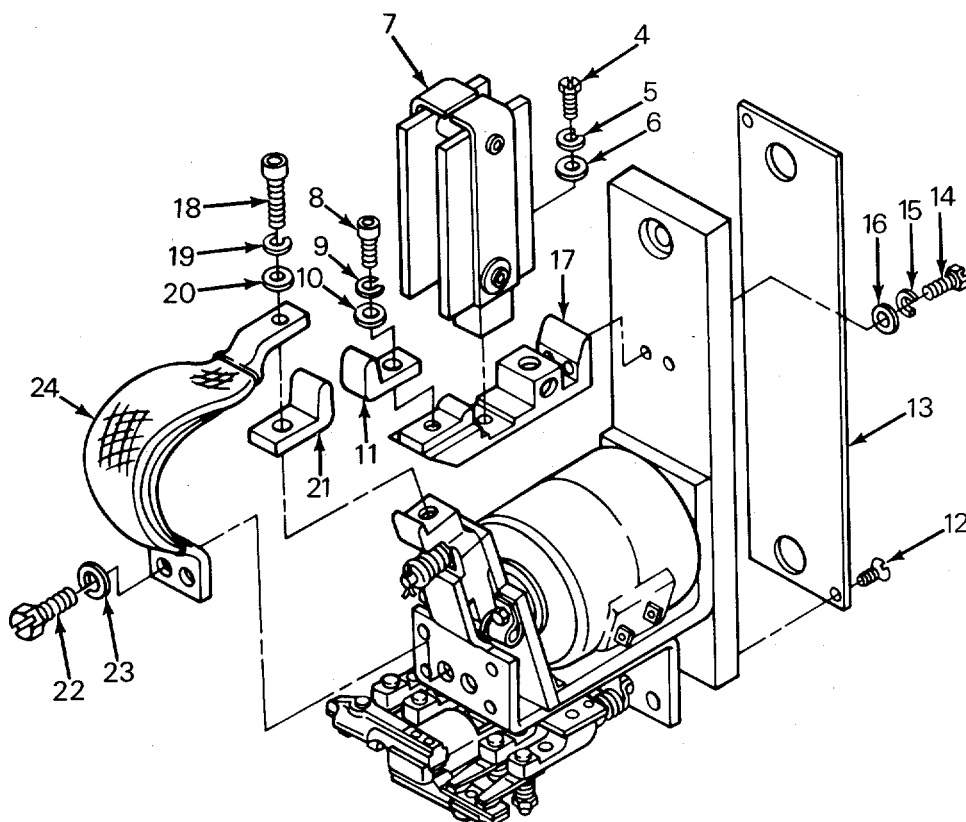
**WARNING**

- High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.
  - Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from cranking contactor assembly (3).
  2. Remove two capscrews (1), lockwashers (2), and cranking contactor assembly (3).



**3-23. CRANKING CONTACTOR (cont)****DISASSEMBLY**

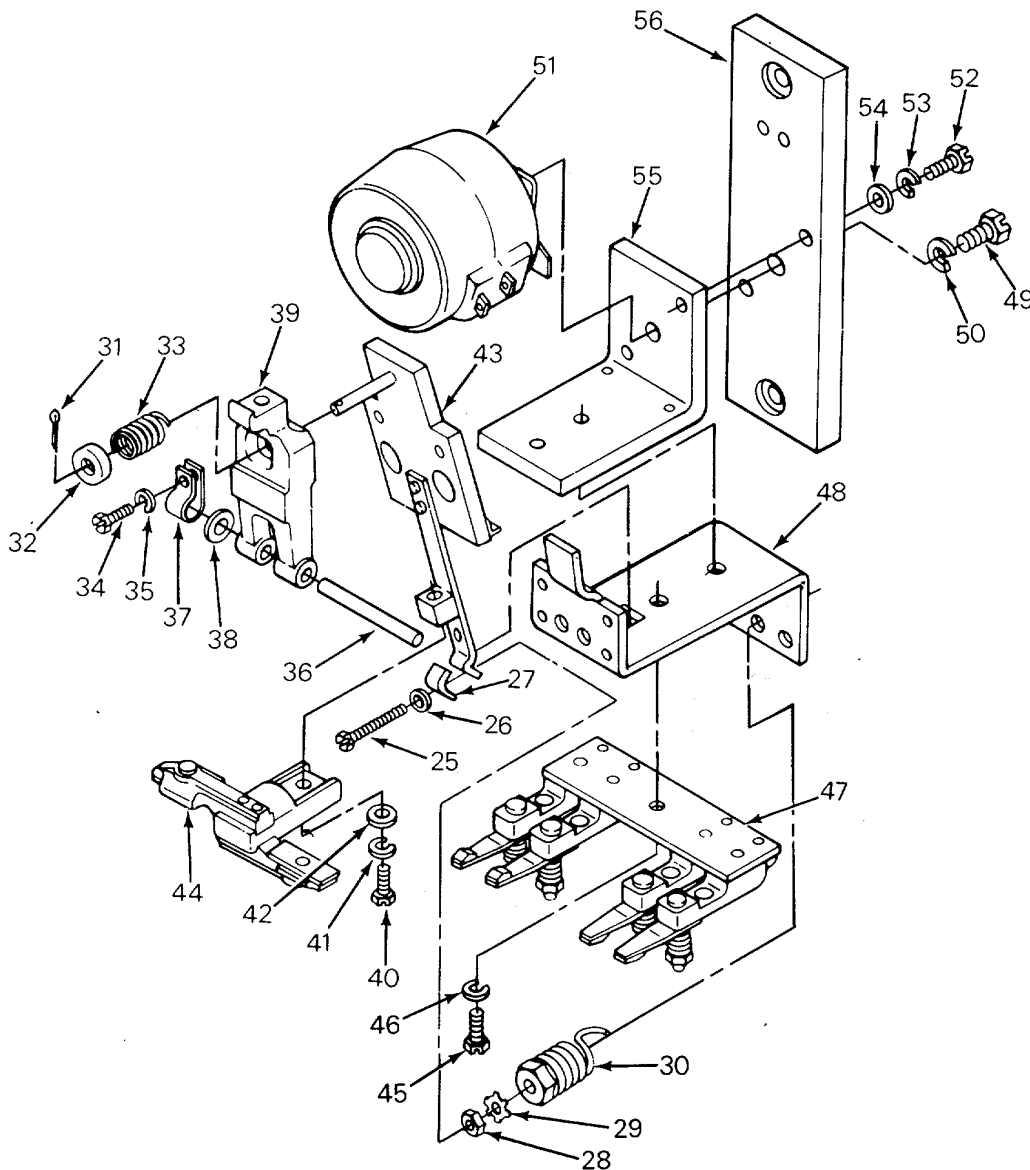
3. Remove capscrew (4), lockwasher (5), and flat washer (6). Remove arc chute (7).
4. Remove allen-head screw (8), lockwasher (9), and flat washer (10). Remove stationary contact tip (11).
5. Remove two capscrews (12) and cover (13).
6. Remove two capscrews (14), lockwashers (15), and flat washers (16). Remove stationary contact tip support (17).
7. Remove allen-head screw (18), lockwasher (19), and flat washer (20). Remove movable contact tip (21).
8. Remove two capscrews (22) and lockwashers (23). Remove shunt (24).



**3-23. CRANKING CONTACTOR (cont)**

**DISASSEMBLY (cont)**

9. Remove calibrating screw locknut (28) and calibrating screw (25), flat washer (26), spacer (27), calibrating screw locknut, star washer (29), and calibrating spring (30).
10. Remove cotter pin (31), spring seat (32), and contact pressure spring (33). Remove two capscrews (34), lockwashers (35), pins (36), clamps (37), and flat washers (38). Remove contact lever (39).
11. Remove capscrew (40), lockwasher (41), and flat washer (42). Remove armature (43) and contact assembly (44).
12. Remove two capscrews (45) and lockwashers (46). Remove interlock (47) and armature stop (48).
13. Remove two capscrews (49), lockwashers (50), and operating coil (51). Remove two capscrews (52), lockwashers (53), flat washers (54), and magnet frame (55) from base (56).



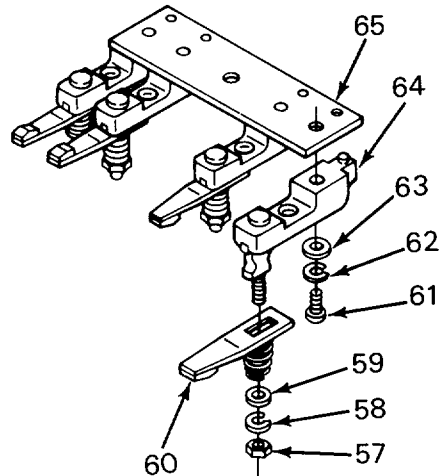
**3-23. CRANKING CONTACTOR (cont)****DISASSEMBLY (cont)**

14. Disassemble interlock (47) by the following:

**NOTE**

All contacts are removed the same way.  
Only one is called out.

- a. Remove nut (57), lockwasher (58), flat washer (59), and contact finger (60).
- b. Remove screw (61), lockwasher (62), flat washer (63), and contact support (64) from base (65).

**CLEANING, INSPECTION, AND REPAIR****WARNING**

- Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**NOTE**

Do not file or attempt to clean stationary contact tip (11) and movable contact tip (21). Silver alloy surfaces on contacts may become blackened, pitted, or eroded. These conditions will not hamper the operation of the contactor.

15. Use drycleaning solvent and clean metal parts. Dry with compressed air.

**3-23. CRANKING CONTACTOR (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

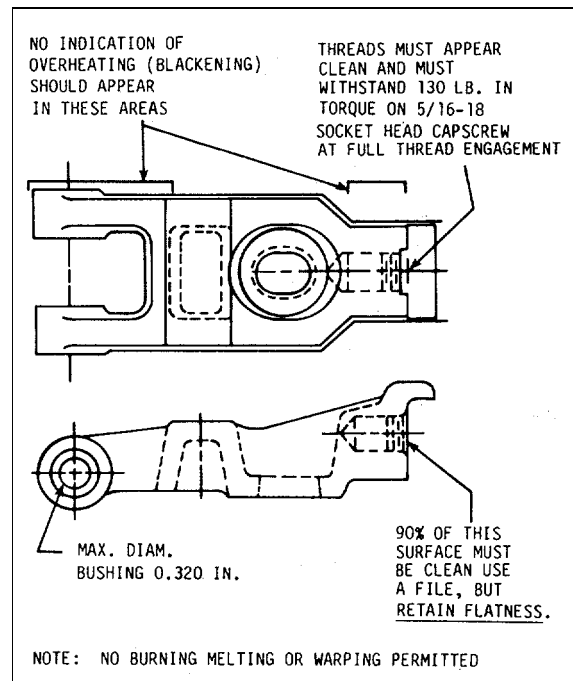
16. Inspect and repair components as follows:

- a. Arc chute (7). Inspect arc chute and replace plates that are broken or burned three-fourths through. Replace if burned close to the screws.

**CAUTION**

Do not use sandpaper or emery cloth to dress tips.

- b. Inspect stationary contact tip (11) and movable contact tip (21). Replace if worn down 3/32 inch - (23.38 mm). Replace silver tips if silver is worn through.
- c. Contact lever (39).
  - (1) Inspect the bushings. If the inside diameter is worn beyond 0.32 inch (8.12 mm), replace lever.
  - (2) Inspect the hinge pin. Replace the pin if scored or burned.
- d. Shunt (24). Inspect the braided copper for wear, fraying, discoloration, or stiffness. Replace the shunt if any of the above conditions exist.



- e. Operating coil (51).
  - (1) Use a multimeter and check coil resistance. Replace the coil if the measured value is not between 5.76 and 7.04 ohms.
  - (2) Check the coil terminals for damage.
  - (3) Check the coil for damaged, dry, or brittle insulation. If necessary, insulate by applying red insulating varnish. Replace coil if necessary.

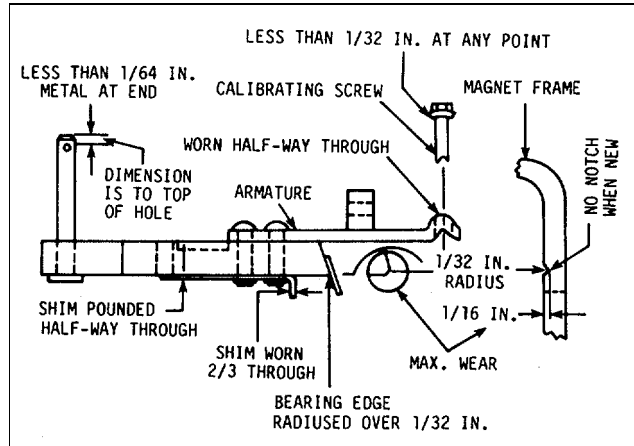


**3-23. CRANKING CONTACTOR (cont)**

CLEANING, INSPECTION, AND REPAIR (cont)

f. Armature (43).

- (1) Inspect the armature for a rounded bearing edge or uneven wear. If the armature bearing edge is worn beyond 1/32 inch (0.793 mm), replace the armature.
- (2) Inspect the armature bracket (extension on the end of the armature to which the calibrating spring is attached).
- (3) Inspect the pin over which the contact pressure spring fits. Replace the pin if less than 1/64 inch (0.396 mm) remains between the hole and the end of the pin.



- (4) Inspect the armature shim. Replace shim if the portion between armature and magnet frame is pounded more than halfway through or if the short, bent-up portion is worn more than two-thirds through.

- g. Armature stop (48). Inspect the armature stop for grooving and uneven wear. If the armature stop is grooved or worn more than 1/16 inch (1.58 mm) at the bearing edge of the armature, replace the armature stop.
- h. Calibrating spring (30). Inspect calibrating spring and replace spring if it is cracked, corroded, notched on the end hook, or has lost its tension.
- i. Contact pressure spring (33). Inspect pressure spring and replace spring if cracked, corroded, notched on end hook, low on tension, annealed, or showing signs of electrical damage.

j. Stationary contact tip support (17).

- (1) Inspect contact support for discoloration caused by overheating and for cracks. Replace contact if any of the above conditions are found.
- (2) Inspect the tapped hole for signs of burred, stripped, or damaged threads. Replace the contact if tapping of the hole will not restore the threads.

k. Base (56).

- (1) Inspect base (56) for soundness. Replace base if it appears to be oil soaked or cracked.
- (2) Paint base (56) with one or two coats of insulating varnish.

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**3-23. CRANKING CONTACTOR (cont)**

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**ASSEMBLY**

17. Assemble interlock (47) by the following:

**NOTE**

All contacts are assembled the same way. Only one is called out.

- a. Position contact support (64) on base (65) and install flat washer (63), lockwasher (62), and screw (61).
  - b. Position contact finger (60) on contact support (64) and install flat washer (59), lockwasher (58), and nut (57).
18. Position magnet frame (55) on base (56) and install two flat washers (54), lockwashers (53), and capscrews (52). Position operating coil (51) on magnet frame and install two lockwashers (50) and capscrews (49).
  19. Position armature stop (48) and interlock (47) on magnet frame (55) and install two lockwashers (46) and capscrews (45).
  20. Position armature (43) and contact assembly (44) on armature stop (48) and install flat washer (42), lockwasher (41), and capscrew (40).
  21. Install two flat washers (38), clamps (37), and pins (36) on contact lever (39). Position contact lever on armature (43) and install two lockwashers (35) and capscrews (34).
  22. Install contact pressure spring (33) on pin of contact lever (39) and install spring seat (32) and spring (31).
  23. Connect calibrating spring (30) to armature stop (48) and install star washer (29), calibrating screw locknut (28), spacer (27), flat washer (26), and calibrating screw (25). Tighten calibrating screw locknut.
  24. Position shunt (24) on armature stop (43) and install two lockwashers (23) and capscrews (22).
  25. Position movable contact tip (21) and shunt (24) on armature stop (43) and install flat washer (20), lockwasher (19), and allen-head screw (18).
  26. Position stationary contact tip support (17) on base (56) and install two flat washers (16), lockwashers (15), and capscrews (14).
  27. Position cover (13) and install two capscrews (12).
  28. Position stationary contact tip (11) on stationary contact tip support (17) and install flat washer (10), lockwasher (9), and allen-head screw (8).
  29. Position arc chute (7) on stationary contact tip support (17). Install flat washer (6), lockwasher (5), and capscrew (4).

**3-23. CRANKING CONTACTOR (cont)**

**INSTALLATION**

- 30. Position cranking contactor assembly (3) in high-voltage cabinet and install two lockwashers (2) and capscrews (1).
- 31. Connect electrical wires in accordance with wiring diagram and remove tags.

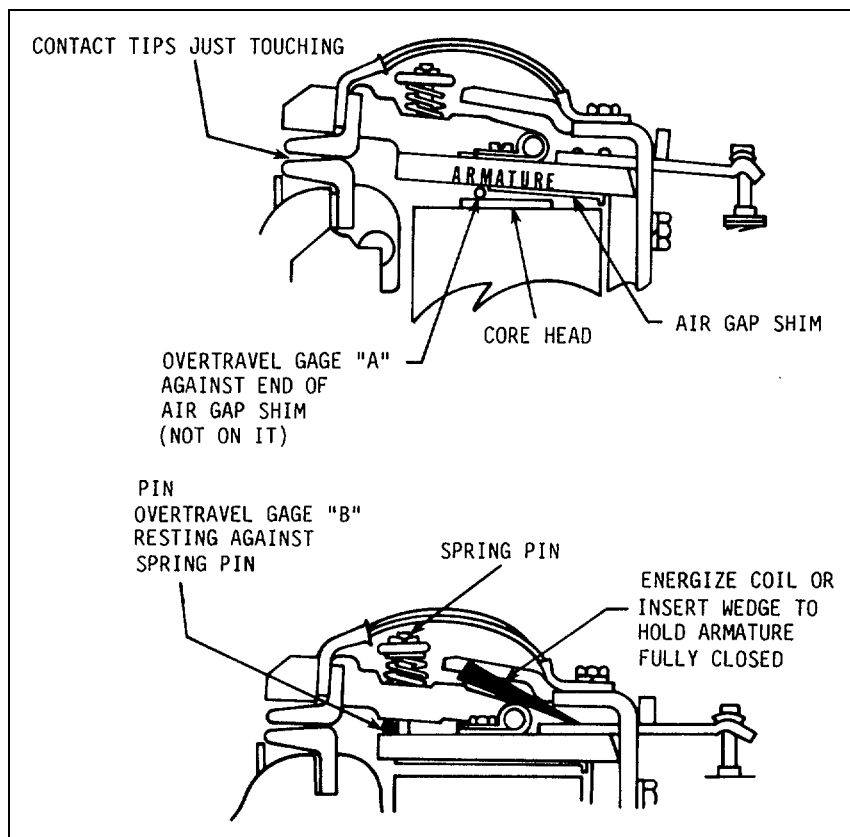
**ADJUSTMENT**

- 32. Measure contact tip overtravel as follows:

**NOTE**

Overtravel is the distance a movable contact tip would travel after touching the stationary tip if the stationary tip were then removed.

- a. Measure overtravel by either method 1, pin at A, or method 2, pin at B. Consult table for amount of overtravel and size of pin required to measure that amount.



**3-23. CRANKING CONTACTOR (cont)**

**ADJUSTMENT (cont)**

Table 3-2. Measuring Contact Tip Overtravel

Overtravel		Gage Pin		
New Contactor		Status	@A	@B
N E W	10/32	GO	0.176	0.200
	12/32	NO GO	0.207	0.240
T I P S	Old Contactor			
	9/32	GO	0.160	0.180
	13/32	NO GO	0.223	0.260
Low Limit - Old Contactor (Old Tips)				
	7/32	NO GO	0.130	0.140

b. If the overtravel is insufficient, check for the following conditions:

- (1) Badly worn, bent, or incorrect tips
- (2) Bent stationary contact-tip support

c. If the overtravel is too high, check for the following conditions:

- (1) Bent or incorrect tip
- (2) Bent armature stop
- (3) Worn or bent contact lever

---

**3-23. CRANKING CONTACTOR (cont)**

---

**ADJUSTMENT (cont)**

33. Measure tip break as follows:

**NOTE**

Check that the contactor armature is against the stop when making the measurement; otherwise, the reading will be false.

- a. Measure the tip break (air gap) at the point of minimum spacing when tips are open.
  - b. Tip break shall be 14/32 to 19/32 inch (11.11 to 15.08 mm) for worn contactor and 15/32 to 18/32 inch (11.09 to 14.28 mm) for new contactor.
  - c. If the tip break is not correct, check for the following conditions:
    - (1) Worn or bent contact tips
    - (2) Bent armature stop
    - (3) Worn or bent contact lever
  - d. Adjust gap by bending the armature stop.
34. Measure tip alignment and adjust as follows:

**NOTE**

The maximum allowable side-to-side misalignment of the contact tip is 3/32 inch (2.38 mm).

- a. Check tip for misalignment. If necessary, loosen the screws holding the magnet frame and stationary contact-tip support to the block and move the assembly until tips align properly.
- b. If tip misalignment cannot be corrected, check for the following conditions:
  - (1) Grooving or uneven wear of the armature stop
  - (2) Rounded knife edge or uneven wear of the armature pivot point
  - (3) Grooving or uneven wear of the armature guide

---

**3-23. CRANKING CONTACTOR (cont)**

---

**ADJUSTMENT (cont)**

35. Measure tip pressure as follows:

a. Measure initial pressure as follows:

- (1) Block the armature (not the tip lever) so the contact nearly touch.
- (2) Measure the pull required to just move the contact-tip arm against the contact pressure spring.
- (3) Check for a pull of 2 to 4 lb (0.908 to 1.816 kg).

b. Measure final pressure as follows:

- (1) Block the armature in the closed position.
- (2) Measure the pull required to just separate the contact tips.
- (3) Check for a pull of 5 to 8 lb (2.267 to 3.632 kg).

c. If the pressure measurements are not correct, check for the following conditions:

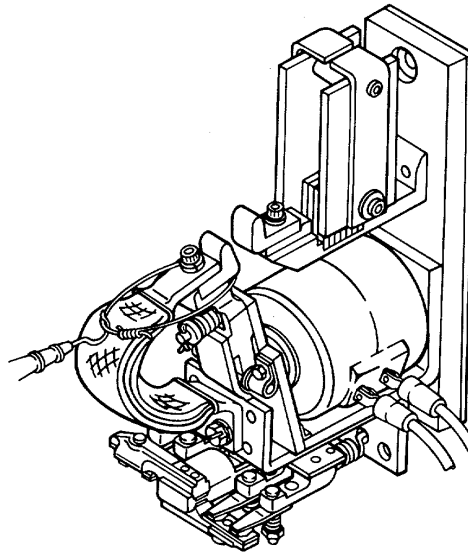
- (1) Low initial pressure defective contact pressure spring, worn spring seat or washers, or worn stop.
- (2) Low final pressure defective pressure spring, low wear allowance, or badly worn tips.

**TEST**

36. Measure and adjust coil operating current as follows:

- a. Use a multimeter and measure resistance of coil. Indication shall be between 5.76 and 7.04 ohms.
- b. Connect power supply and ammeter to coil.
- c. Apply current and increase slowly until contactor picks up. Check that the contactor picks up without hesitation, that is, in one quick motion including the contact wipe. The current measured shall be 1.8 to 2.2 amperes.
- d. Adjust calibrating screw until proper value of current is indicated.

37. Manually operate interlock contacts. Use a multimeter and check resistance of contacts for infinity while open and continuity while closed.



### 3-24. POWER CONTACTOR

This task covers:

- |                |               |                 |
|----------------|---------------|-----------------|
| a. Removal     | d. Inspection | g. Installation |
| b. Disassembly | e. Repair     | h. Adjustment   |
| c. Cleaning    | f. Assembly   | i. Test         |

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

##### Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
Electrical insulating varnish  
(Item 37, Appendix B)

##### Test Equipment

Variable dc voltage supply

#### REMOVAL

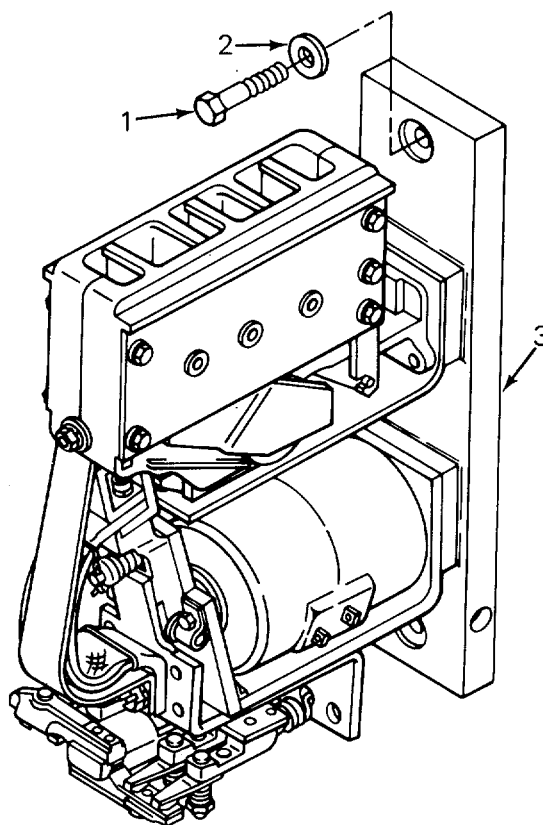
##### **WARNING**

- High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.
- Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.

##### **NOTE**

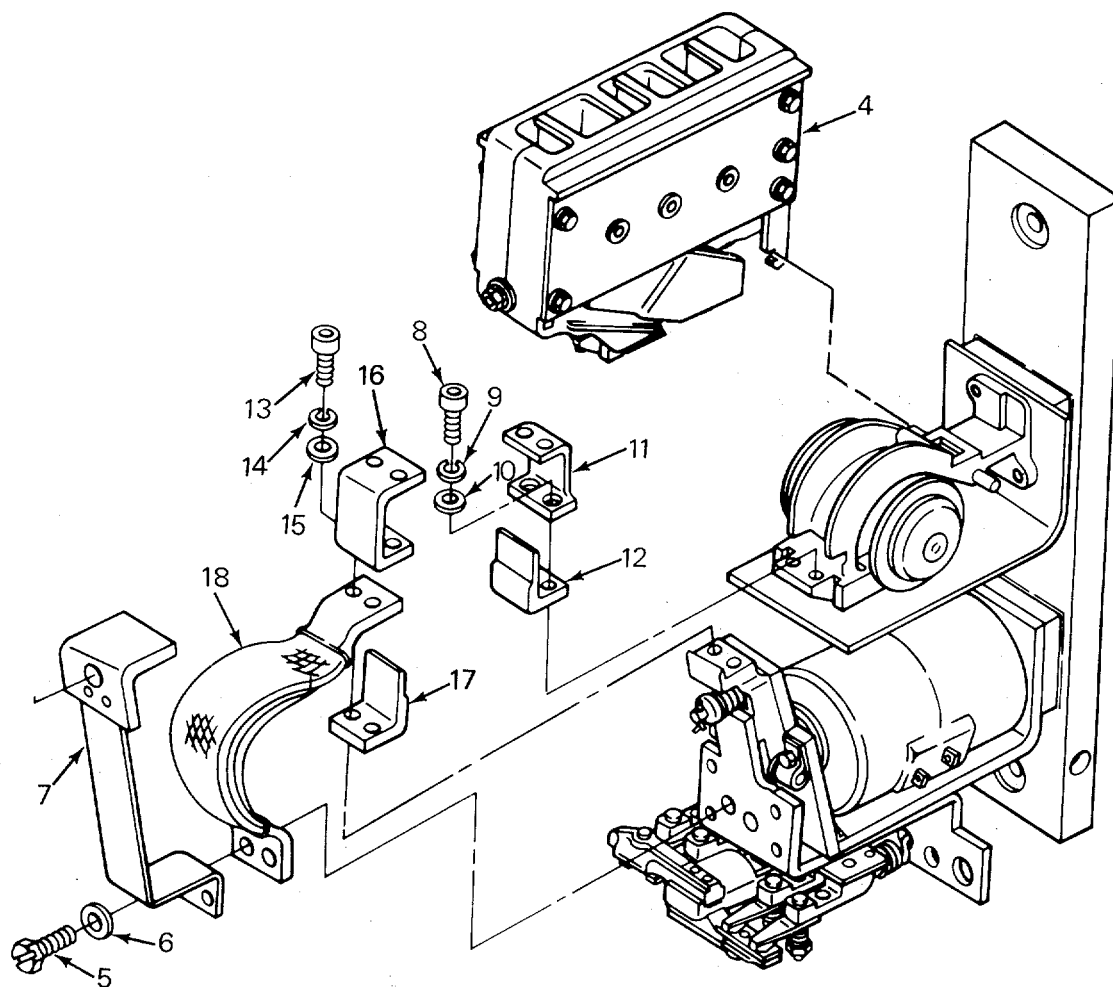
Two of the motor line contactor have interlocks, the other two do not. Except for the interlocks, the maintenance procedures are the same.

1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from power contactor assembly (3).
2. Remove two capscrews (1), flat washers (2), and power contactor assembly (3).



**3-24. POWER CONTACTOR (cont)****DISASSEMBLY**

3. Press support spring (7) and remove arc chute assembly (4). Remove two capscrews (5) and lockwashers (6) and remove support spring.
4. Remove two allen-head screws (8), lockwashers (9), and flat washers (10). Remove arcing horn (11) and stationary contact tip (12).
5. Remove two allen-head screws (13), lockwashers (14), and flat washers (15). Remove arcing horn (16), movable contact tip (17), and shunt (18).



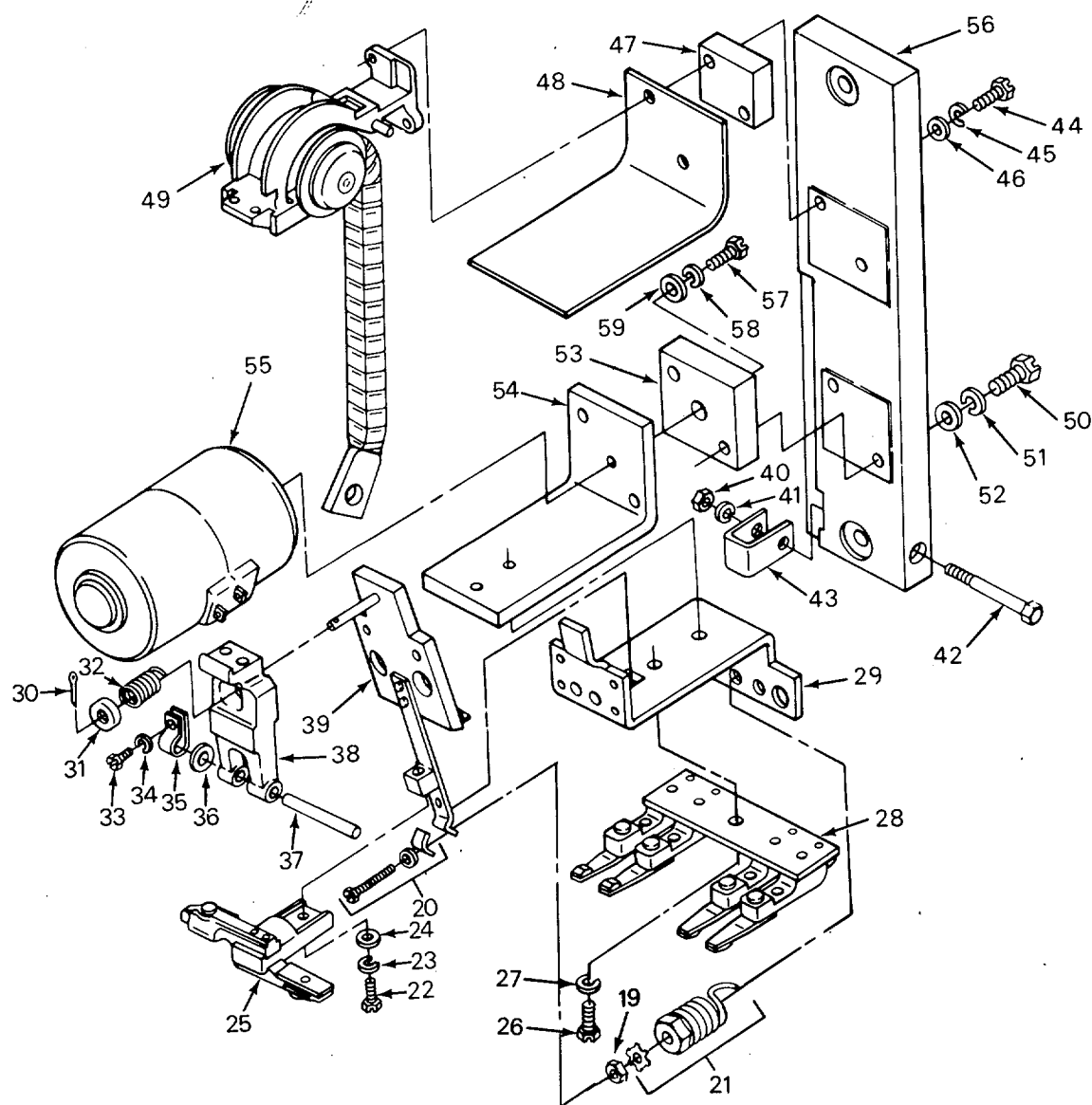
6. Loosen calibrating screw locknut (19) and remove calibrating screw assembly (20) and calibrating spring assembly (21).
7. Remove two capscrew (22), lockwasher (23) flat washers (24), and contact assembly (25). Remove two screws (26), lockwashers (27), and interlock (28) (where applicable). Remove armature stop (29).
8. Remove cotter pin (30), spring retainer (31), and contact pressure spring (32).



3-24 POWER CONTACTOR (cont)

DISASSEMBLY (cont)

9. Remove two capscrews (33), lockwashers (34), clamps (35), flat washers (36), and pin (37). Remove contact lever (38) and armature (39).
10. Remove nut (40), lockwasher (41), capscrew (42), clamp (43), two capscrews (44), lockwashers (45), flat washers (46), insulating block (47), insulator (48), and top contact holder and blowout coil (49).
11. Remove two capscrews (50), lockwashers (51), flat washers (52), insulating block (53), and magnet frame (54) with operating coil (55) from base (56).
12. Remove capscrew (57), lockwasher (58), and flat washer (59) and separate magnet frame (54) and operating coil (55).



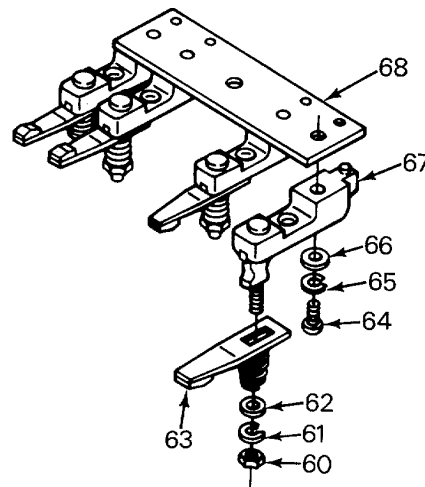
**3-24. POWER CONTACTOR (cont)****DISASSEMBLY (cont)**

13. Disassemble interlock (28) by the following:

**NOTE**

All contacts are removed the same way. Only one is called out.

- a. Remove nut (60), lockwasher (61), flat washer (62), and contact finger (63).
- b. Remove screw (64), lockwasher (65), flat washer (66), and contact support (67) from base (68).

**CLEANING, INSPECTION, AND REPAIR****WARNING**

- Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

14. Thoroughly clean parts with drycleaning solvent. Dry with compressed air.

**3-24. POWER CONTACTOR (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

15. Inspect and repair components as follows:

- a. Arc chute (4). Inspect arc chute and replace plates that are broken or burned three-fourths through. Replace if burned close to the screws.
- b. Contact tips (12) and (17).
  - (1) Inspect tips and replace if worn down 3/32 inch (2.38 mm). Replace silver tips if silver is worn through.

**CAUTION**

Do not use sandpaper or emery cloth.

- (2) Use a file and smooth tips that are slightly corroded or pitted. Do not bend contact in the same surface contour.

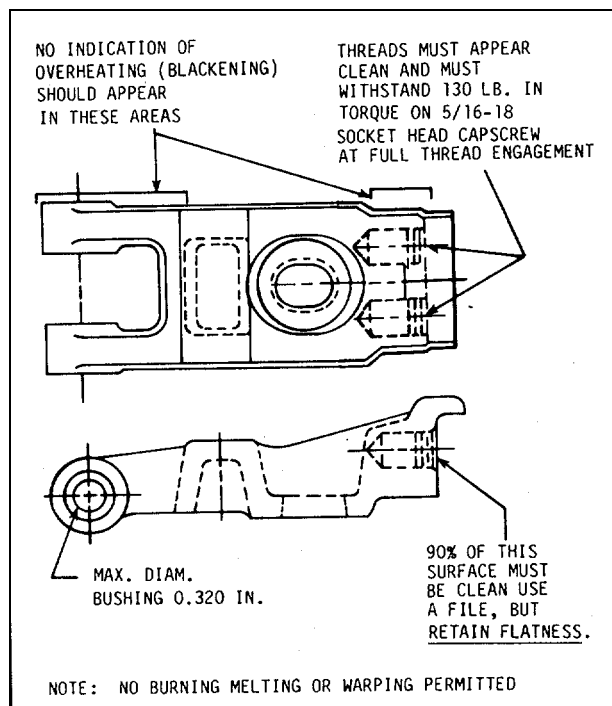
c. Contact lever (38).

- (1) Inspect the bushings. If the inside diameter is worn beyond 0.32 inch (8.12 mm), replace lever.
- (2) Inspect the hinge pin. Replace the pin if scored or burned.

d. Shunt (18). Inspect the braided copper for wear, fraying, discoloration, or stiffness. Replace the shunt if any of the above conditions exist.

e. Operating coil (55).

- (1) Use a multimeter and check coil resistance. Replace the coil if the measured value is not between 24.3 and 29.8 ohms.
- (2) Check the coil terminals for damage.
- (3) Check the coil for damaged, dry, or brittle insulation. If necessary, insulate by applying electrical insulating varnish. Replace coil if necessary.

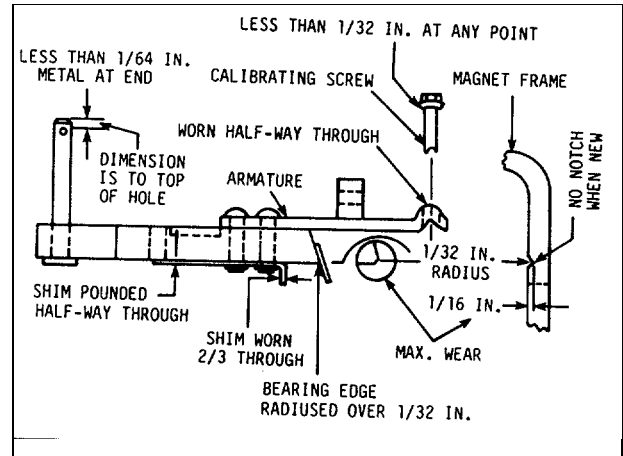


**3-24. POWER CONTACTOR (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

f. Armature (39).

- (1) Inspect armature (39) for a rounded bearing edge or uneven wear. If the armature bearing edge is worn beyond 1/32 inch (0.793 mm), replace the armature).
- (2) Inspect the armature bracket (extension on the end of the armature to which the calibrating spring is attached).
- (3) Inspect the pin over which the contact pressure spring fits. Replace the pin if less than 1/64 inch (0.396 mm) of pin remains between the hole and the end of the pin.



- (4) Inspect the armature shim. Replace shim if the portion between armature and magnet frame is pounded more than halfway through or if the short, bent-up portion is worn more than two-thirds through.

- g. Armature stop (29). Inspect the armature stop for grooving and uneven wear. If the armature stop is grooved or worn more than 1/16 inch (1.58 mm) at the bearing edge of the armature, replace the armature stop.
- h. Calibrating Spring (21). Inspect calibrating spring and replace spring if it is cracked, corroded, notched on the end hook, or has lost its tension.
- i. Contact pressure spring (32). Inspect pressure spring and replace spring if cracked, corroded, notched on end hook, low on tension, annealed, or showing signs of electrical damage.

j. Stationary contact support (49).

- (1) Inspect contact support for discoloration caused by overheating and for cracks. Replace contact if any of the above conditions are found.
- (2) Inspect the tapped hole for signs of burred, stripped, or damaged threads. Replace the contact if tapping of the hole will not restore the threads.

k. Base (56).

- (1) Inspect base (56) for soundness. Replace base if it appears to be oil soaked or cracked.
- (2) Paint base (56) with one or two coats of insulating varnish.

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**3-24. POWER CONTACTOR (cont)**

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**ASSEMBLY**

16. Assemble interlock (28) by the following:

**NOTE**

**All contacts are assembled the same way. Only one of each kind is called out.**

- a. Position contact support (67) on base (68) and install flat washer (63), lockwasher (65), screw (64).
  - b. Position contact finger (63) on contact support (67) and install flat washer (62), lockwasher (61), and nut (60).
17. Position operating coil (55) on magnet frame (54) and install flat washer (59), lockwasher (58), and capscrew (57).
18. Position magnet frame (54) with operating coil (55) and insulating block (53) on base (56) and install two flat washers (52), lockwashers (51), and capscrews (50).
19. Position top contact holder and blow-out coil (49), insulator (48), and insulating block (47) on base (56) and install two flat washers (46), lockwashers (45), and capscrews (44). Position clamp (43) and install capscrew (42), lockwasher (41), and nut (40).
20. Position armature (39) and contact lever (38) together and install pin (37), two flat washers (36), clamps (35), lockwashers (34), and capscrews (33).
21. Install contact pressure spring (32), spring retainer (31), and cotter pin (30).
22. Position armature stop (29) and interlock (28) on magnet frame (54) and install two lockwasher (27) and screws (26) (where applicable). Position contact assembly (25) and install two flat washers (24), lockwashers (23), and capscrews (22).
23. Connect calibrating spring assembly (21) on armature stop (29) and install calibrating screw assembly (20). Tighten calibrating screw locknut (19).
24. Position shunt (18), movable contact tip (17), and arcing horn (16). Install two flat washers (15), lockwashers (14), and allen-head screws (13).
25. Position stationary contact tip (12) and arcing horn (11) and install two flat washers (10), lockwashers (9), and allen-head screws (8).
26. Position support spring (7) and install two lockwashers (6) and capscrews (5). Install arc shute assembly (4).

### 3-24. POWER CONTACTOR (cont)

#### INSTALLATION

27. Position power contactor assembly (3) and install flat washers (2) and capscrews (1).
28. Connect electrical wires in accordance with wiring diagram and remove tags.

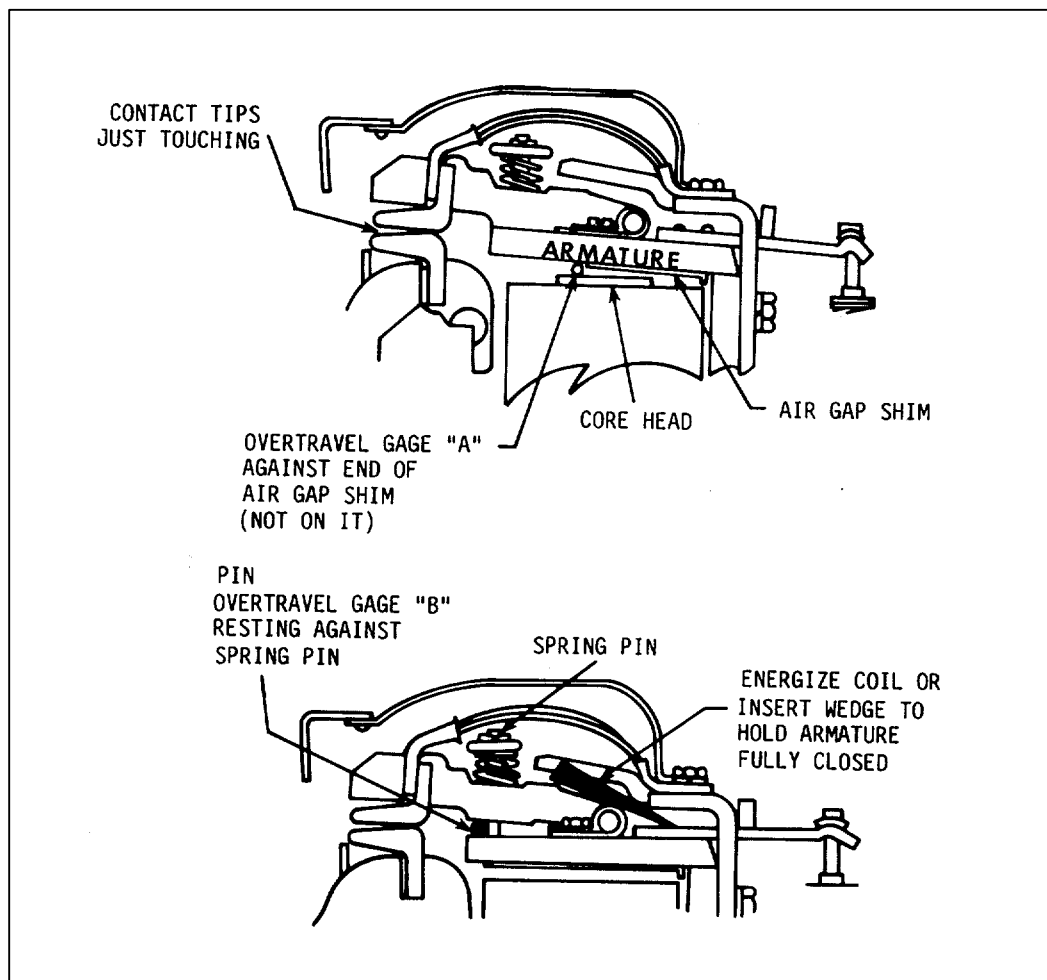
#### ADJUSTMENT

29. Measure contact tip overtravel as follows:

#### NOTE

**Overtravel is the distance a movable contact tip would travel after touching the stationary tip if the stationary tip were then removed.**

- a. Measure overtravel by either method 1, pin at A, or method 2, pin at B. Consult table 3-3 for amount of overtravel and size of pin required to measure that amount.



**3-24. POWER CONTACTOR (cont)**

**ADJUSTMENT (cont)**

**Table 3-3. Measuring Contact Tip Overtravel**

Overtravel		Gage Pin		
New Contactor		Status	@A	@B
N E W	10/32	GO	0.176	0.200
	12/32	NO GO	0.207	0.240
T I P S	Old Contactor			
	9/32	GO	0.160	0.180
	13/32	NO GO	0.223	0.260
Low Limit - Old Contactor (Old Tips)				
	7/32	NO GO	0.130	0.140

b. If the overtravel is insufficient, check for the following conditions:

- (1) Badly worn, bent, or incorrect tips
- (2) Bent stationary contact-tip support

c. If the overtravel is too high, check for the following conditions:

- (1) Bent or incorrect tips
- (2) Worn stop on the contact lever
- (3) Bent stationary contact-tip support

---

**3-24. POWER CONTACTOR (cont)**


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**ADJUSTMENT (cont)**

30. Measure tip break as follows:

**NOTE**

**Make sure the contactor armature is against the stop when making the measurement; otherwise, the reading will be false.**

- a. Measure the tip break (air gap) at the point of minimum spacing when tips are open.
- b. Tip break shall be 14/32 to 19/32 inch (11.11 to 15.08 mm) for worn contactor and 15/32 to 18/32 inch (11.9 to 14.29 mm) for new contactor.
- c. If the tip break is not correct, check for the following conditions:
  - (1) Worn or bent contact tip
  - (2) Bent armature stop
  - (3) Worn or bent contact lever
- d. Adjust gap by bending the armature stop.

31. Measure tip alignment and adjust as follows:

**NOTE**

**The maximum allowable side-to-side misalignment of the contact tips is 3/32 inch (2.38 mm).**

- a. Check tip for misalignment. If necessary, loosen the screws holding the magnet frame stationary contact-tip support to the block and move the assembly until tips aline properly.
- b. If tip misalignment cannot be corrected, check for the following conditions:
  - (1) Grooving or uneven wear of the armature stop
  - (2) Rounded knife edge or uneven wear of the armature pivot point
  - (3) Grooving or uneven wear of the armature guide

32. Measure tip pressure as follows:

a. Measure initial pressure as follows:

- (1) Block the armature (not the tip lever) so the contacts nearly touch.
- (2) Measure the pull required to just move the contact-tip arm against the contact pressure spring.
- (3) Check for a pull of 3.6 to 6.5 lb (1.63 to 2.95 kg).



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**3-24. POWER CONTACTOR (cont)**

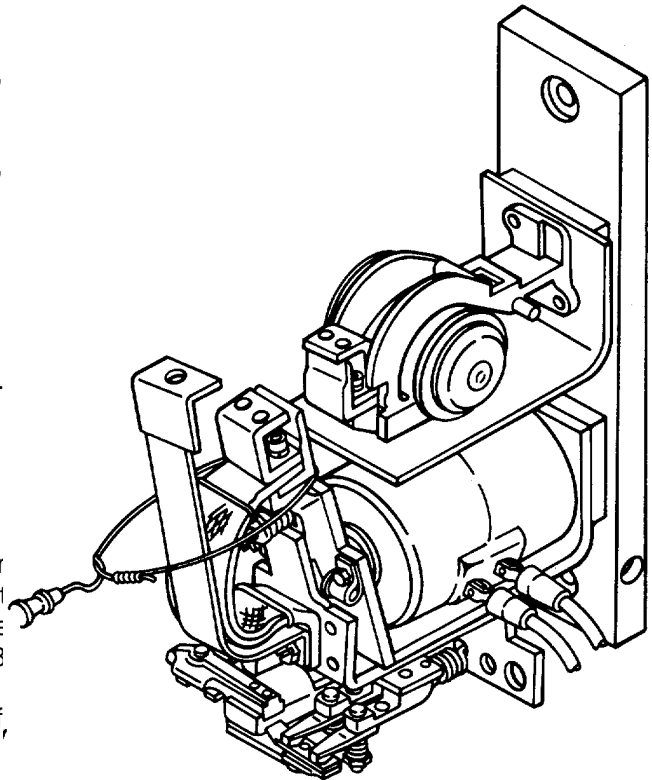
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**ADJUSTMENT (cont)**

- b. Measure final pressure as follows:
  - (1) Block the armature in the closed position.
  - (2) Measure the pull required to just separate the contact tips.
  - (3) Check for a pull of 12 to 16 lb (5.45 to 7.26 kg).
- c. If the pressure measurements are not correct, check for the following conditions:
  - (1) Low initial pressure defective contact pressure spring, worn spring seat or washers, or worn stop.
  - (2) Low final pressure defective pressure spring, low wear allowance, or badly worn tips.

**TEST**

- 33. Measure and adjust coil operating current as follows:
  - a. Use a multimeter and measure resistance of coil. Resistance shall be between 24.39 and 29.81 ohms. Replace defective coil.
  - b. Connect power supply and ammeter to core.
  - c. Apply current and increase slowly until contactor picks up. Check that the contactor picks up without hesitation, that is, in one quick motion including the contact wipe. The current measured shall be 0.638 to 0.775 amperes.
  - d. Adjust calibrating screw until proper valve of current is indicated.
- 34. Manually operate interlock contacts. Use a multimeter and check resistance of contacts for infinity while open and continuity while closed.



**3-25. ENGINE TEMPERATURE WARNING, MOTOR KILL, SAFETY, AND FIELD SHUNT TRANSITION RELAYS**

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly | h. Test         |

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

Test Equipment

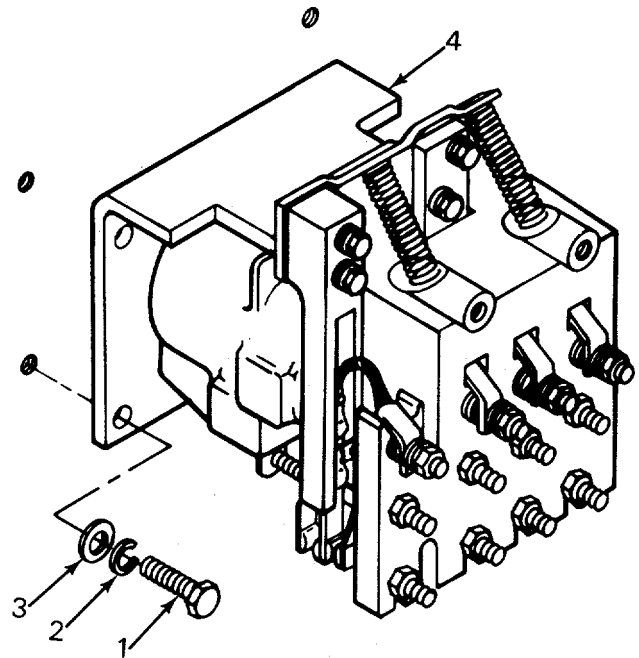
Variable dc voltage supply

**REMOVAL**

**WARNING**

- ⌚ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⌚ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from relay assembly.
2. Remove four capscrews (1), lockwashers (2), flat washers (3), and relay assembly (4).



**3-25. ENGINE TEMPERATURE WARNING, MOTOR KILL, SAFETY, AND FIELD SHUNT TRANSITION RELAYS  
(Cont)**

**DISASSEMBLY**

3. Remove two capscrews (5), lockwashers (6), and flat washers (7). Remove support block assembly (8).
4. Remove two capscrews (9), lockwashers (10), and flat washers (11). Remove two capscrews (12), lockwashers (13), and spring seat and springs (14). Remove armature assembly (15).
5. Remove nut (16), lockwasher (17), and flat washer (18). Separate finger base (19) and support block assembly (8).
6. Disassemble support block assembly (8) by the following:

**NOTE**

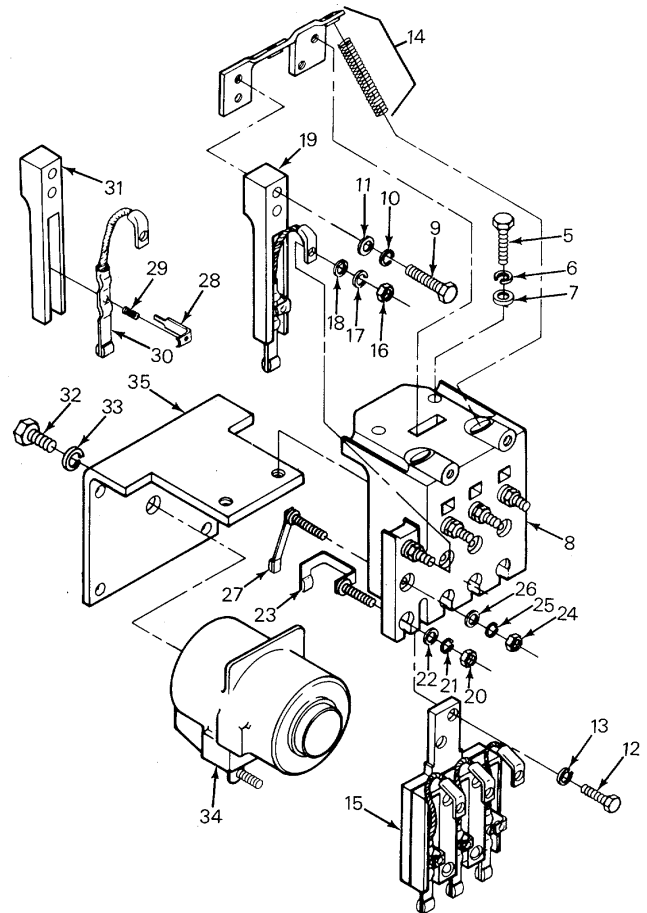
**All fingers are removed the same way.  
Only one is shown.**

- a. Remove nut (20), lockwasher (21), and flat washer (22). Remove normally open finger (23).
- b. Remove nut (24), lockwasher (25), and flat washer (26). Remove normally closed finger (27).

**NOTE**

**All movable contact fingers are removed the same way, only one contact finger is shown.**

7. Remove spring retainer (28), wire spring (29), and movable contact finger (30) from support (31).
8. Remove screw (32) and lockwasher (33). Separate operating coil (34) and magnet frame (35).



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**3-25. ENGINE TEMPERATURE WARNING, MOTOR KILL, SAFETY, AND FIELD SHUNT TRANSITION RELAYS**  
**(Cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

**NOTE**

**Do not file or attempt to clean contacts. Silver alloy surfaces on contacts may become blackened, pitted, or eroded. These conditions will not hamper the operation of the contactor.**

9. Use dry-cleaning solvent and clean metal parts. Dry with compressed air.
10. Inspect molded parts for warpage, breaks, and cracks.
11. Inspect operating coil (34) for damaged insulation.
12. Use a multimeter and measure resistance of operating coil (34). If resistance is not 69.8 to 77.1 ohms, replace coil.
13. Repair consists of replacing defective parts.

**ASSEMBLY**

14. Position operating coil (34) on magnet frame (35) and install lockwasher (33) and screw (32).
15. Position movable contact finger (30) in support (31) and install wire spring (29) and spring retainer (28).

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**3-25. ENGINE TEMPERATURE WARNING, MOTOR KILL, SAFETY, AND FIELD SHUNT TRANSITION RELAYS**  
**(Cont)**

---

**ASSEMBLY (cont)**

16. Assemble support block assembly (8) by the following:
  - a. Position normally closed finger (27) and normally open finger (23) in support block assembly (8).
  - b. Install flat washers (26) and (22), lockwashers (25) and (21), and nuts (24) and (20).
17. Position finger base (19) on support block assembly (8) and install flat washer (18), lockwasher (17), and nut (16).
18. Position armature (15) and support block assembly (8) and install spring seat and springs (14), lockwashers (13), capscrews (12), flat washers (11), lockwashers (10), and capscrews (9).
19. Position support block assembly (8) on magnet frame (35) and install two flat washers (7), lockwashers (6), and capscrews (5).

**INSTALLATION**

20. Position relay assembly (4) and install four flat washers (3), lockwashers (2), and capscrews (1).
21. Connect electrical wires in accordance with wiring diagram. Remove tags.

**TEST**

22. Energize and deenergize relay and check that there is no hesitation during pickup or dropout.

### 3-26. GROUND RELAY

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly | h. Test         |

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

##### Test Equipment

Variable dc voltage supply

##### Material/Parts

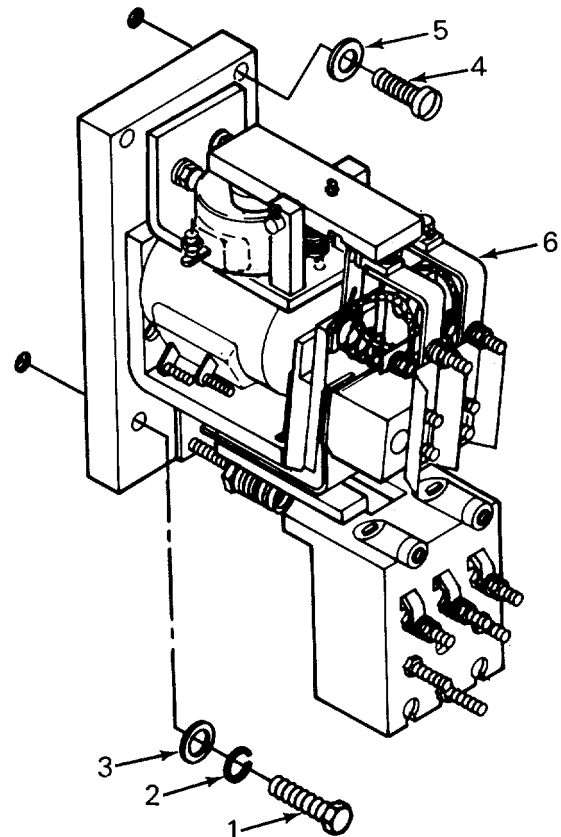
Drycleaning solvent (Item 34, Appendix B)

#### REMOVAL

##### WARNING

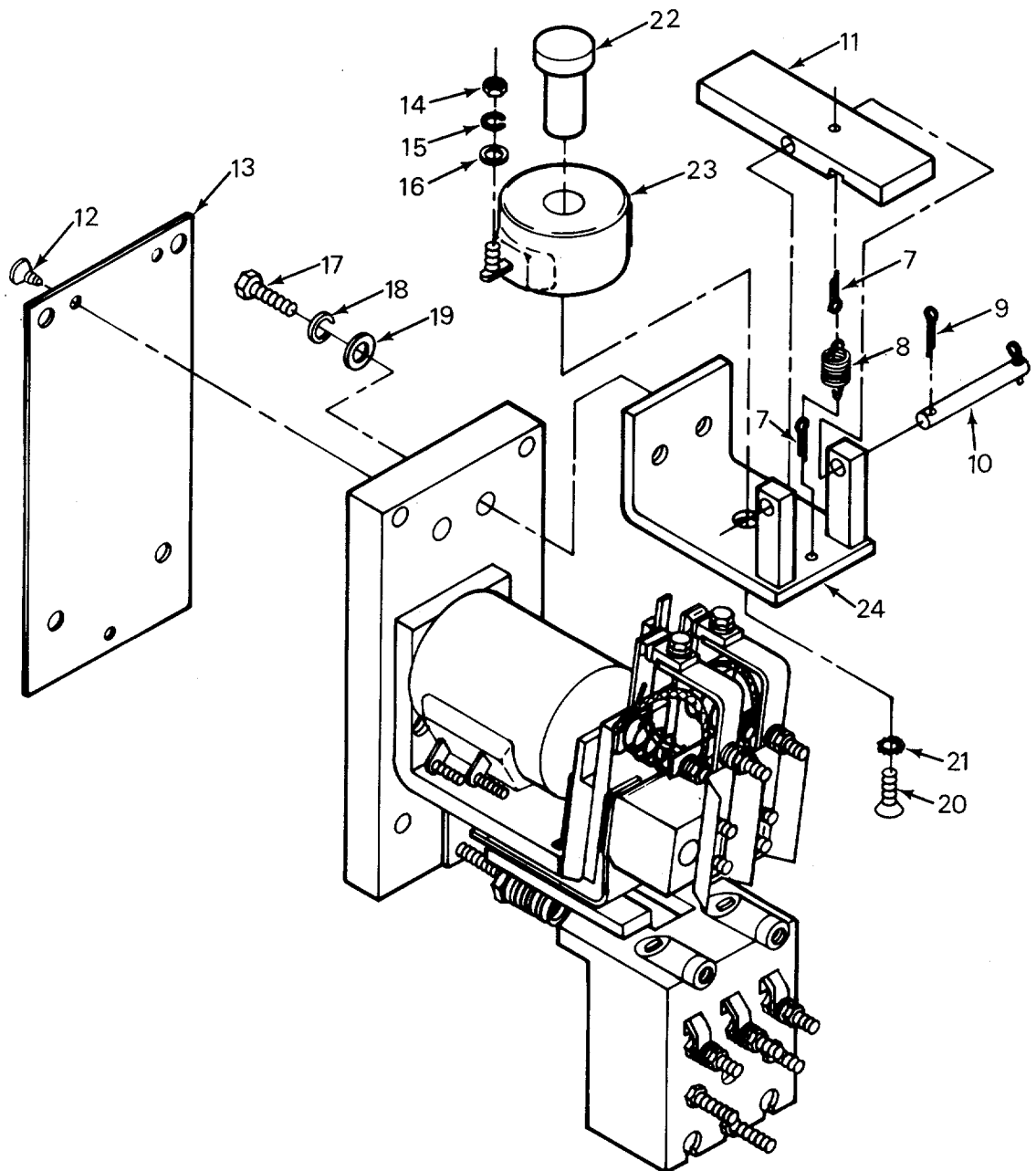
- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from relay assembly.
2. Remove two capscrews (1), lockwashers (2), and flat washers (3).
3. Remove two machine screws (4), flat washers (5), and ground relay (6).



**3-26. GROUND RELAY (Cont)****DISASSEMBLY**

4. Remove two cotter pins (7) and spring (8). Remove cotter pin (9), pin (10), and armature (11).
5. Remove three machine screws (12) and rear cover (13). Remove nut (14), lockwasher (15), and flat washer (16).
6. Remove two screws (17), lockwashers (18), and flat washers (19). Remove screw (20), lockwasher (21), magnet core (22), operating coil (23), and magnet frame (24).

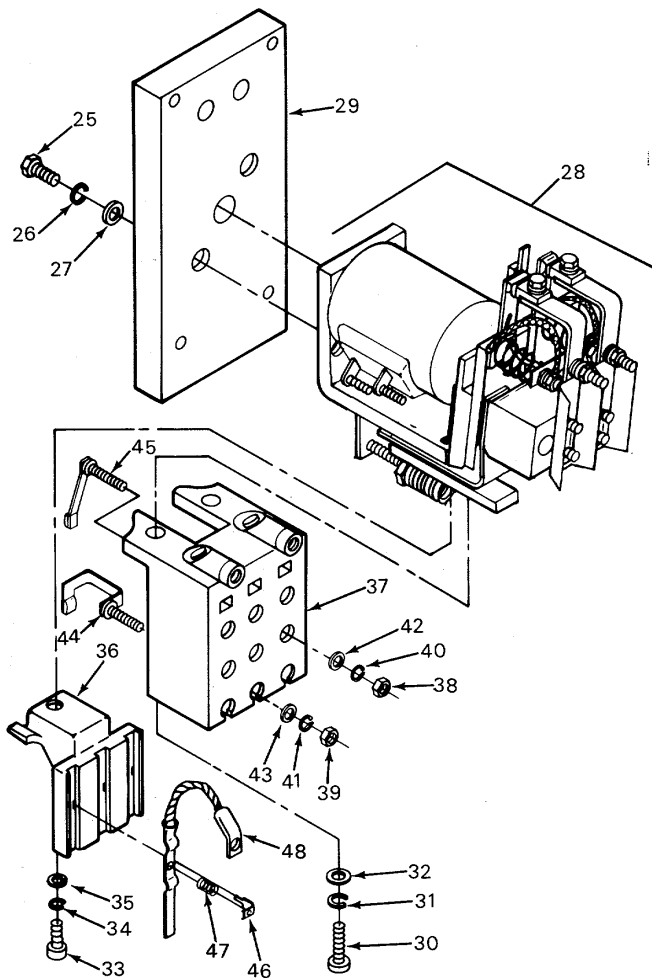


3-26. GROUND RELAY (Cont)

DISASSEMBLY (cont)

7. Remove two capscrews (25), lockwashers (26), and flat washers (27). Remove contactor (28) from base (29).

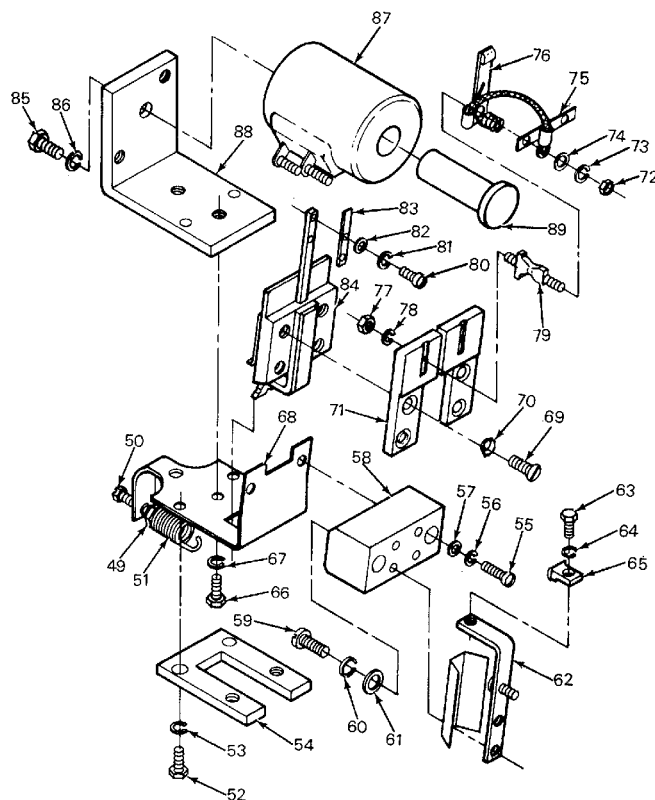
8. Remove two allenhead screws (30), lockwashers (31), and flat washers (32). Remove allen-head screw (33), lockwasher (34), and flat washer (35). Remove support blocks (36) and (37). Remove nuts (38) and (39), lockwashers (40) and (41), flat washers (42) and (43), normally open contact (44), and normally closed contact (45). Remove spring retainer (46), spring (47), and movable contact finger (48).





**3-26. GROUND RELAY (Cont)****DISASSEMBLY (cont)**

9. Loosen calibrating screw locknut (49) and calibrating screw (50) and unlock calibrating spring (51) from 8, armature (84).
10. Remove two capscrews (52) and lockwashers (53). Remove interlock frame (54).
11. Remove two machine screws (55), lockwashers (56), and flat washers (57). Remove outer contact block (58). Remove two screws (59), lockwashers (60), flat washers (61), and finger (62). Remove screws (63), lockwashers (64), and contact (65).
12. Remove two capscrews (66) and lockwashers (67) and remove armature stop (68).
13. Remove four screws (69), lockwashers (70), and support (71). Remove nut (72), lockwasher (73), flat washer (74), spacer (75), contact (76), nut (77), lockwasher (78), and stud (79).
14. Remove two screws (80), lockwasher (81), and flat washers (82). Remove contact (83) from armature (84).
15. Remove capscrew (85) and lockwasher (86). Remove operating coil (87) from magnet frame (88). Remove magnet core (89).



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**3-26. GROUND RELAY (Cont)**

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**CLEANING, INSPECTION AND REPAIR****WARNING**

- Ⓢ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100-138°F (38-59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- Ⓢ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

16. Use dry-cleaning solvent and clean metal parts. Dry with compressed air.
17. Inspect molded parts for warpage, breaks, and cracks.
18. Use a multimeter and measure resistance of operating coil (23). If resistance is not 54 to 66 ohms, replace coil.
19. Use a multimeter and measure resistance of operating coil (87). If resistance is not 65. 25 to 79. 75 ohms, replace coil.

**ASSEMBLY**

20. Install magnet core (89) in operating coil (87). Position operating coil on magnetic frame (88) and install lockwasher (86) and capscrew (85).
21. Position contact (83) on armature (84) and install two flat washers (82), lockwashers (81), and screws (80).
22. Position stud (79), on support (71) and install lockwasher (78), nut (77), contact (76), spacer (75), flat washer (74), lockwasher (73), and nut (72).
23. Position support (71) on armature (84) and install four lockwashers (70) and screws (69).
24. Position armature stop (68) and install two lockwashers (67) and capscrews (66).
25. Position contact (65) and install lockwashers (64) and screws (63). Position finger (62) and install two flat washers (61), lockwashers (60), and screws (59). Position outer contact block (58) and install two flat washers (57), lockwashers (56), and machine screws (55).

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**3-26. GROUND RELAY (Cont)**


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**ASSEMBLY (cont)**

26. Position interlock frame (54) and install lockwashers (53) and capscrews (52).
27. Hook calibrating spring (51) on armature (84) and tighten calibrating screw (50) and calibrating screw locknut (49).
28. Position movable contact finger (48) and install spring (47) and retainer (46). Position normally closed contact (45) and normally open contact (44), and install flat washers (43) and (42), lockwashers (41) and (40), and nuts (39) and (38).
29. Position support blocks (37) and (36), and install flat washer (35), lockwasher (34), and allen-head screw (33). Install two flat washers (32), lockwashers (31), and allen-head screws (30).
30. Position contact (28) on base (29) and install two flat washers (27), lockwashers (26), and capscrews (25).
31. Position magnet frame (24), operating coil (23), and magnet core (22) on base (29) and install lockwasher (21), screw (20), two flat washers (19), lockwashers (18), and screws (17). Install flat washer (16), lockwasher (15), and nut (14).
32. Position rear cover (13) on base (29) and install three machine screws (12).
33. Position armature (11) and install pin (10) and cotter pin (9). Install spring (8) and two cotter pins (7).

**INSTALLATION**

34. Position ground relay (6) and install two flat washers (5) and machine screws (4).
35. Install two flat washers (3), lockwashers (2), and capscrews (1).
36. Connect electrical wires in accordance with wiring diagram and remove tags.

**TEST**

37. Connect a variable dc voltage supply and multimeter to operating coil (28). Check that operating coil maximum pickup current is 0.255 amp, minimum pickup current is 0.250 amp, and drop away current is 0.075 amp.
38. Connect a variable dc voltage supply to unlatching assembly (23). Use a multimeter and check that unlatching coil maximum pickup voltage is 48 V dc and minimum drop away voltage is 2 to 18 V dc.

### 3-27. WHEEL SLIP RELAY

This task covers:

- |                |               |                 |
|----------------|---------------|-----------------|
| a. Removal     | d. Inspection | g. Installation |
| b. Disassembly | e. Repair     | h. Test         |
| c. Cleaning    | f. Assembly   |                 |

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

##### Test Equipment

Variable dc voltage supply

##### Material/Parts

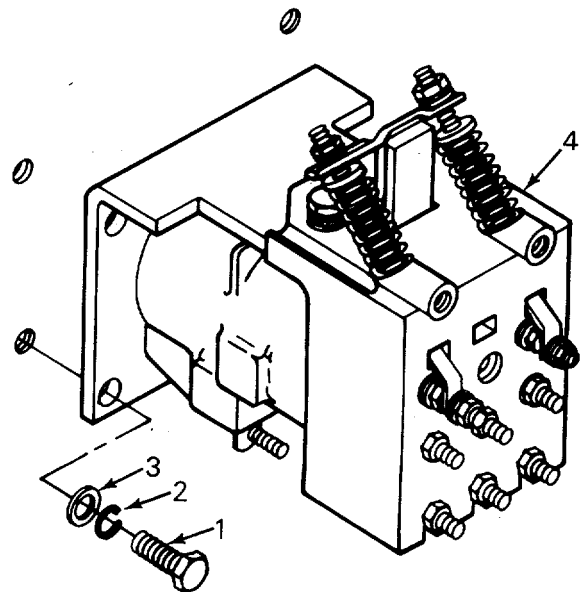
Drycleaning solvent (Item 34, Appendix B)

#### REMOVAL

#### WARNING

- ⌚ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⌚ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

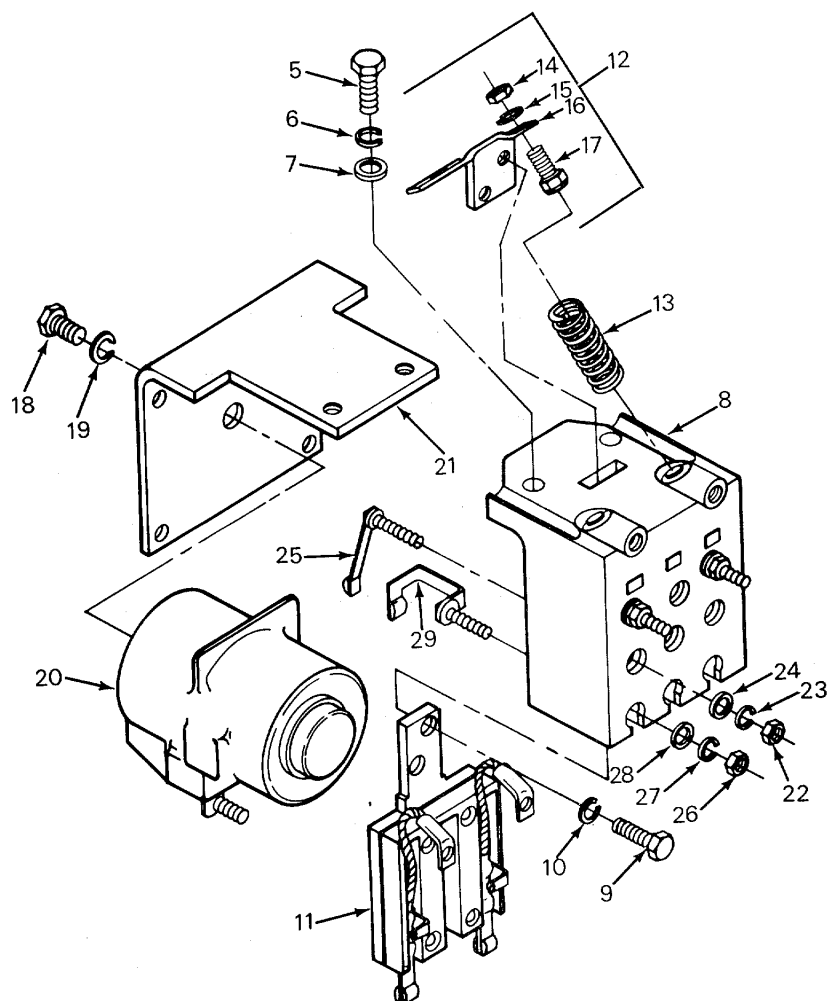
1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure electrical wires are labeled with wire numbers or polarity signs. Tag and disconnect wires from wheel slip relay (4).
2. Remove two capscrews (1), lockwashers (2), and flat washers (3). Remove wheel slip relay (4).



### 3-27. WHEEL SLIP RELAY(Cont)

#### DISASSEMBLY

3. Remove two capscrews (5), lockwashers (6), and flat washer (7). Remove support block assembly (8).
4. Remove two capscrews (9), lockwashers (10), armature (11), spring seat assembly (12), and springs (13). Remove nut (14), lockwasher (15), and stud (16) from spring seat (17).
5. Remove capscrew (18) and lockwasher (19). Separate operating coil (20) and magnet frame (21).
6. Disassemble support block assembly (8) by the following:
  - a. Remove three nuts (22), lockwashers (23), and flat washers (24). Remove normally closed finger (25).
  - b. Remove three nuts (26), lockwashers (27), and flat washers (28). Remove normally open finger (29).



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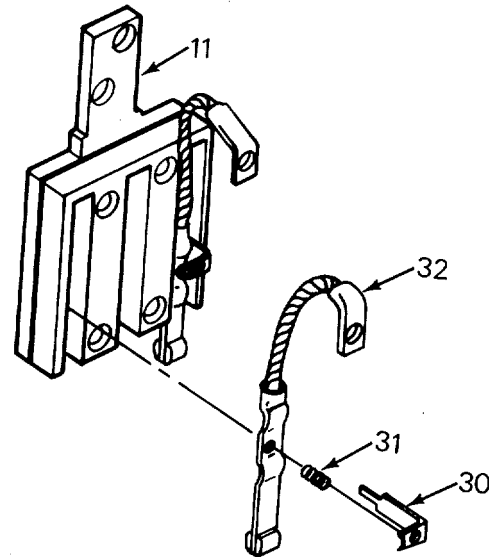
**3-27. WHEEL SLIP RELAY(Cont)**


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**DISASSEMBLY (cont)****NOTE**

All movable fingers are removed the same way. Only one contact finger is shown.

7. Remove spring retainer (30), wire spring (31), and movable contact finger (32) from armature (11).

**CLEANING, INSPECTION, AND REPAIR WARNING****WARNING**

- ⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100-138°F (38-60°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**NOTE**

**Do not file or attempt to clean contacts. Silver alloy surfaces on contacts may become blackened, pitted, or eroded. These conditions will not hamper the operation of the contactor.**

8. Use dry-cleaning solvent and clean metal parts. ~~Do not~~ use compressed air.
9. Inspect molded parts for warpage, breaks, and cracks.
10. Use a multimeter and measure resistance of operating coil (20). If resistance is not 1.03 ohms ±5%, replace coil.
11. Repair consists of replacement of damaged parts.

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**3-27. WHEEL SLIP RELAY(Cont)**

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**ASSEMBLY**

12. Position movable contact finger (32) in armature (11) and install wire spring (31) and spring retainer (30).
13. Assemble support block assembly (8) by the following:
  - a. Position normally closed finger (29) in support block (8) and install three flat washers (28), lockwashers (27), and nuts (26).
  - b. Position normally closed finger (25) in support block (8) and install three flat washers (24), lockwashers (23), and nuts (22).
14. Position operating coil (20) on magnet frame (21) and install lockwasher (19) and capscrew (18).
15. Install stud (16) in spring seat (17) and install two lockwashers (16) and nuts (15).
16. Position armature (11) in support block assembly (8) and position two springs (13) and spring seat (12), and install two lockwashers (10) and capscrews (9).
17. Position support block assembly (8) on magnet frame (21) and install two flat washers (7), lockwashers (6), and capscrews (5).

**INSTALLATION**

18. Position wheel slip relay (4) in high-voltage cabinet and install two flat washers (3), lockwashers (2), and capscrews (1).
19. Connect electrical wires in accordance with wiring diagram and remove tags.

**TEST**

20. Energize and deenergize relay and check that there is no hesitation during pickup and dropout.

**3-28. REVERSER**

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly | h. Test         |

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

**Test Equipment**

Variable dc voltage supply

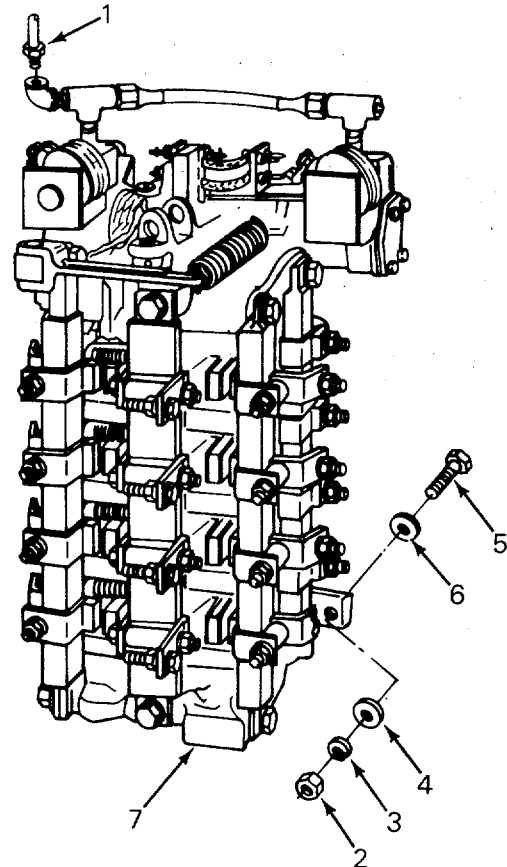
**Material/Parts**

Drycleaning solvent (Item 34, Appendix B)

**REMOVAL****WARNING**

- ⚠ **High voltage is use in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN. Make sure that electrical wires are labeled with wire numbers or polarity signs. Disconnect wires from reverser (7).
2. Disconnect air line fittings (1).
3. Remove four nuts (2), lockwashers (3), flat washers (4), capscrews (5), flat washers (6), and reverser (7).





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**3-28. REVERSER (Cont)**

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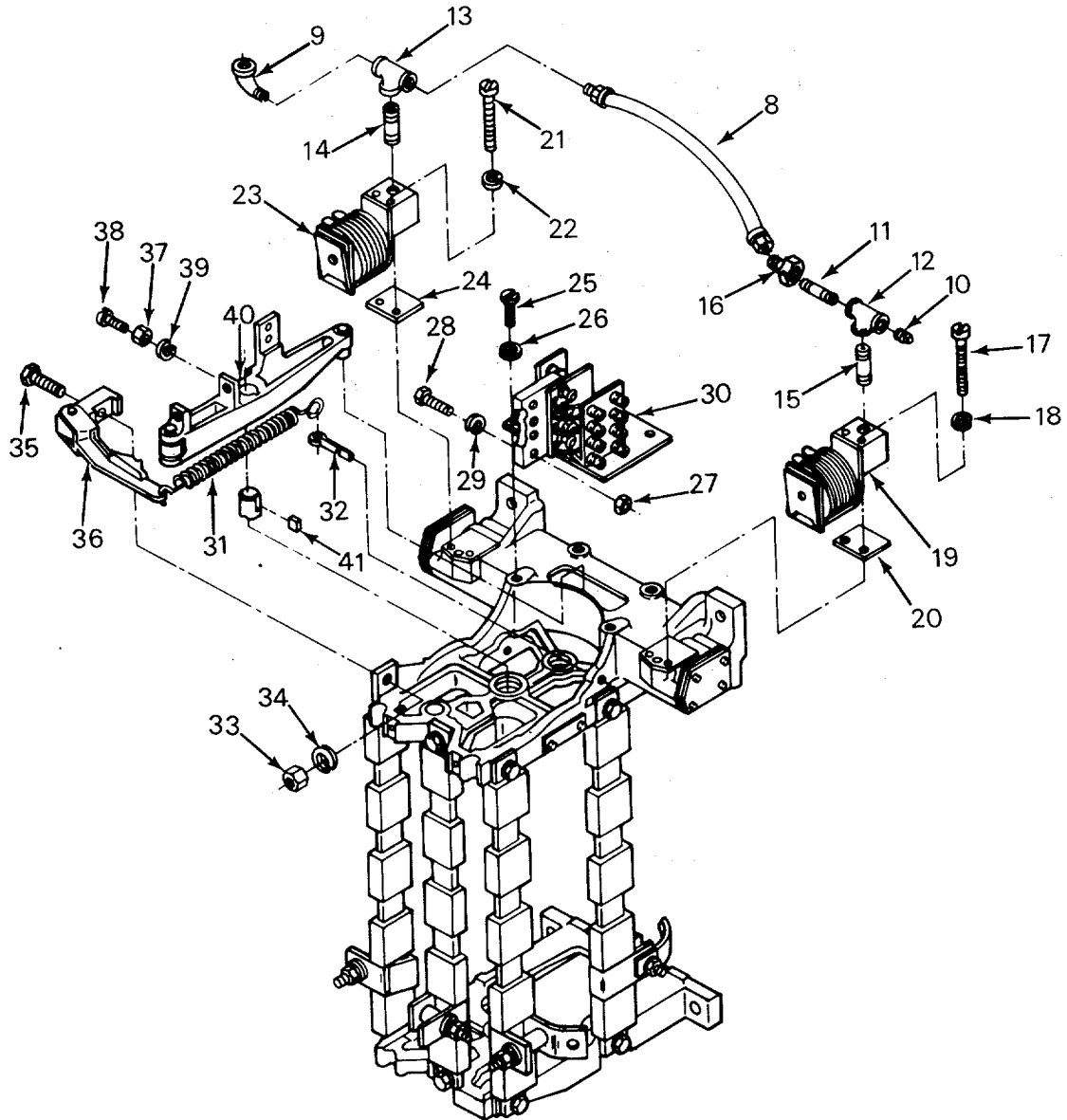
**DISASSEMBLY****CAUTION**

**All bus bars, cables, and contact mounting rods must be marked for proper installation before removal from the reverser to prevent misapplication and subsequent electrical damage. Care must be exercised in handling and storing the bus bars to prevent bending the copper.**

4. Remove hose (8), elbow (9), pipe plug (10), nipple (11), tees (12) and (13), and nipples (14) and (15), and adapter (16).
5. Remove two bolts (17), lockwashers (18), magnet valve assembly (19), and gasket (20). Refer to step 26 below for disassembly of magnet valve assembly.
6. Remove two bolts (21), lockwashers (22), magnet valve assembly (23), and gasket (24). Refer to step 26 for disassembly of magnet valve assembly.
7. Remove three screws (25), lockwashers (26), two nuts (27), lockwashers (28), capscrews (29), and interlock (30).
8. Remove tension spring (31) and cotter pin (32). Remove nut (33), lockwasher (34), bolt (35), and pawl assembly (36).
9. Loosen locknut (37) and remove setscrew (38) with locknut and lockwasher (39).
10. Remove operating lever assembly (40) and woodruff key (41).

3-28. REVERSER (Cont)

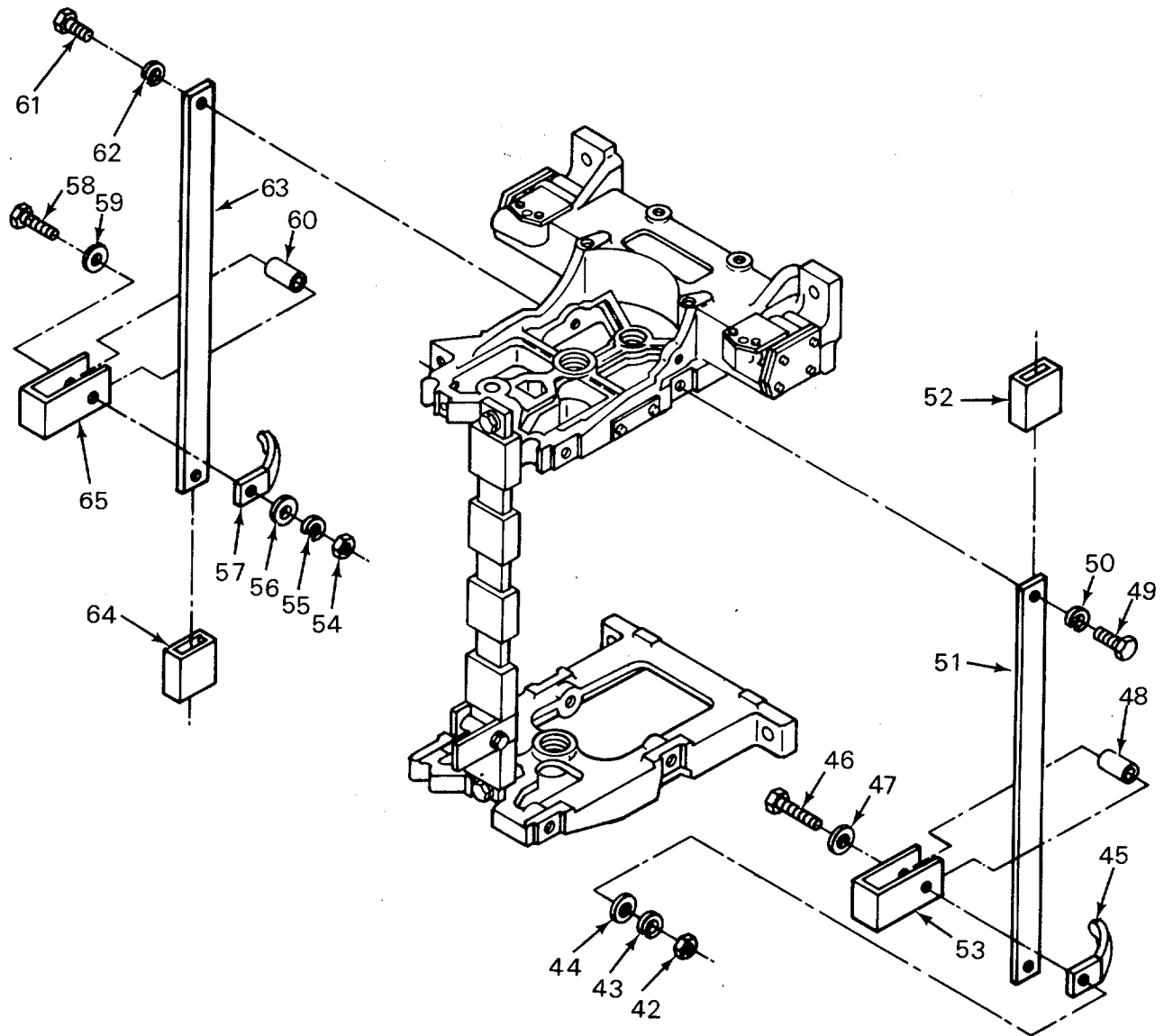
DISASSEMBLY (cont)



3-28. REVERSER (Cont)

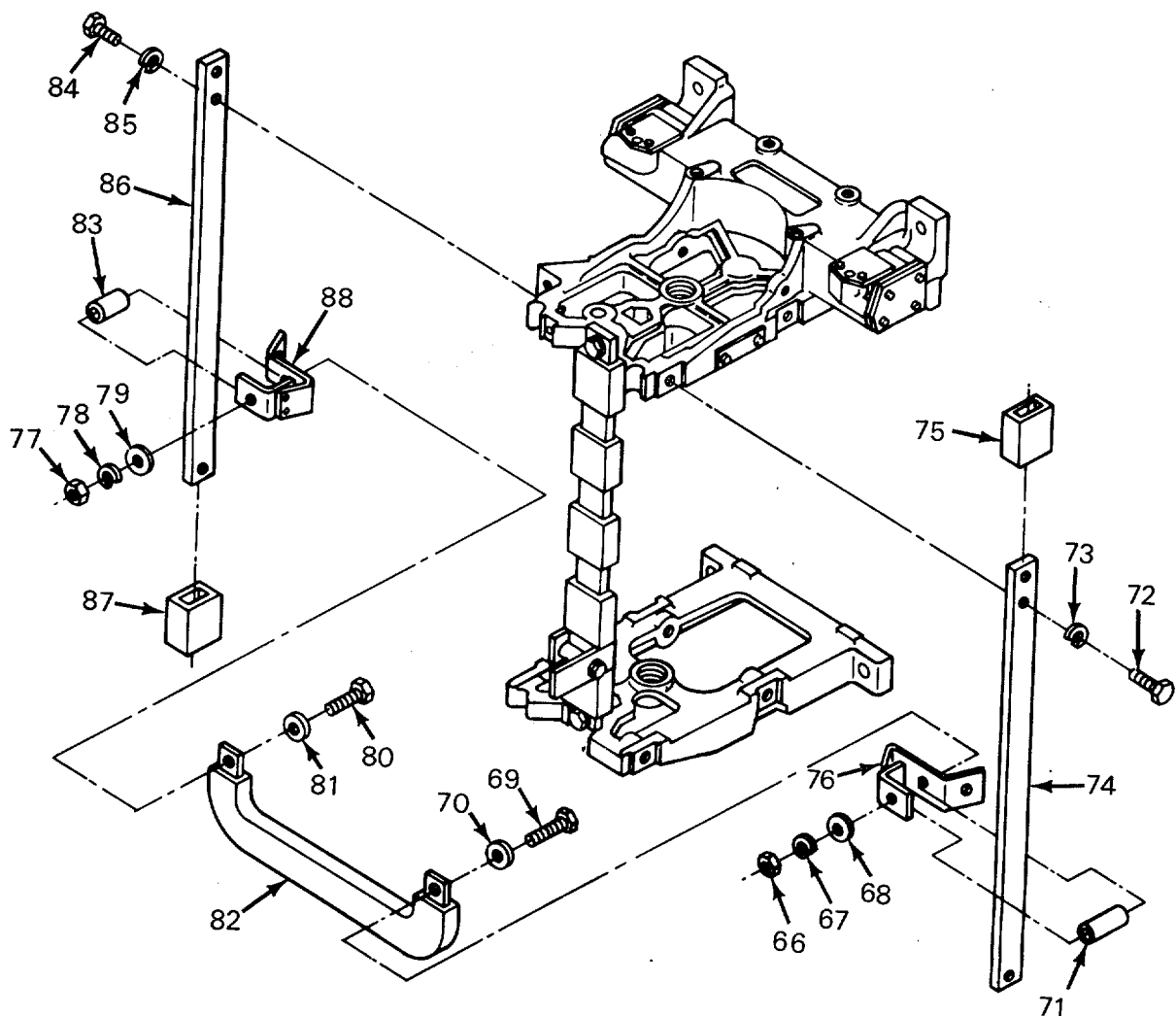
DISASSEMBLY (cont)

11. Remove four nuts (42), lockwashers (43), and flat washers (44). Disconnect four fingers (45). Remove four carriage bolts (46), flat washers (47), and spacers (48).
12. Remove two bolts (49), lockwashers (50), and rod (51). Remove five sleeves (52) and four supports (53).
13. Remove four nuts (54), lockwashers (55), and flat washers (56). Disconnect four fingers (57). Remove four carriage bolts (58), flat washers (59), and spacers (60).
14. Remove two bolts (61), lockwashers (62), and rod (63). Remove five sleeves (64) and four supports (65).



**3-28. REVERSER (Cont)****DISASSEMBLY (cont)**

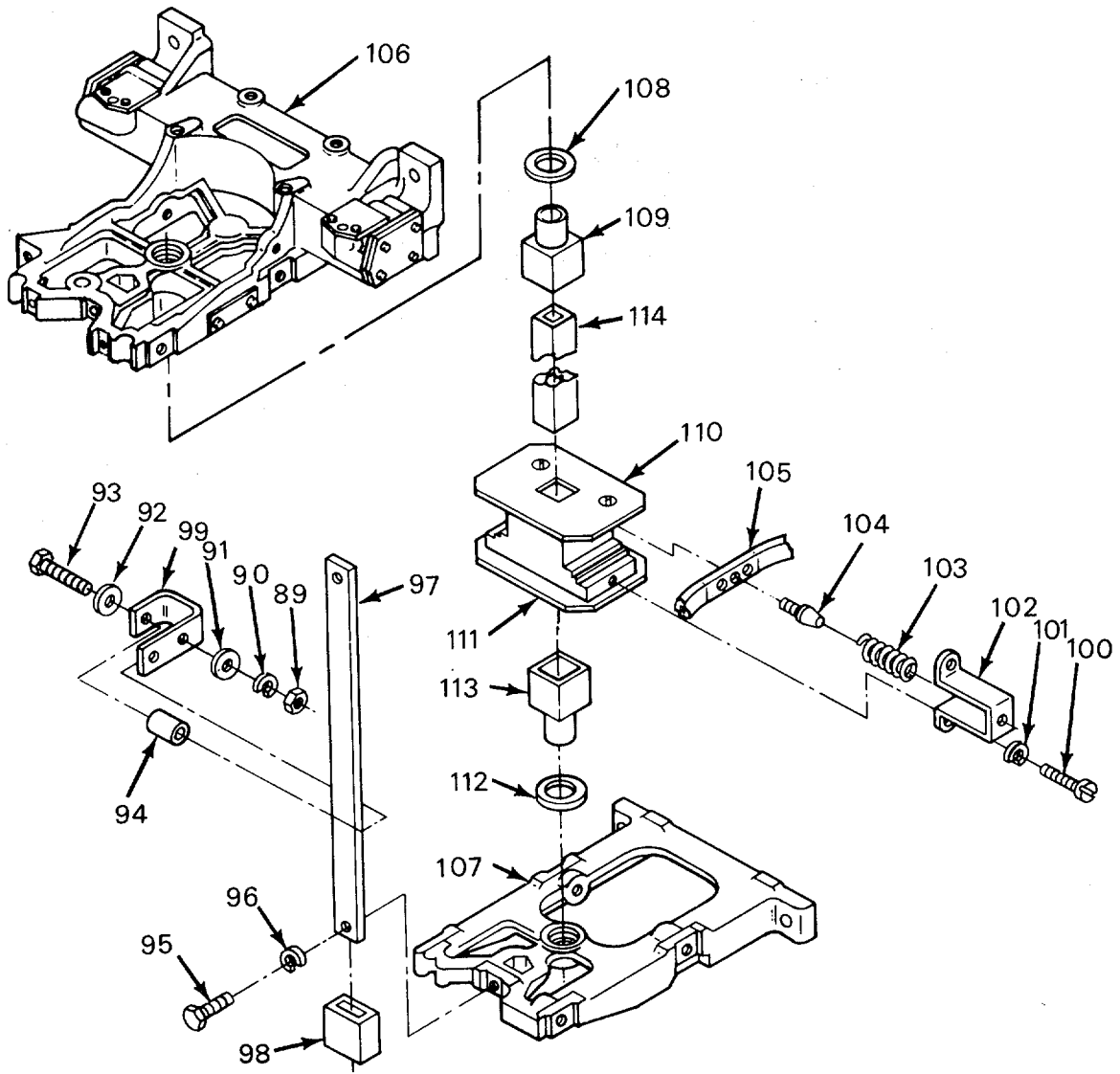
15. Remove four nuts (66), lockwashers (67), and flat washers (68). Remove four carriage bolts (69), flat washers (70), and spacers (71). One end of four bus bar (82) are disconnected at this time.
16. Remove two bolts (72), lockwashers (73), and rod (74). Remove five sleeves (75) and four supports (76).
17. Remove four nuts (77), lockwashers (78), and flat washers (79). Remove four carriage bolts (80), flat washers (81), bus bars (82), and spacers (83).
18. Remove two bolts (84), lockwashers, (85), and rod (86). Remove five sleeves (87) and four supports (88).



3-28. REVERSER (Cont)

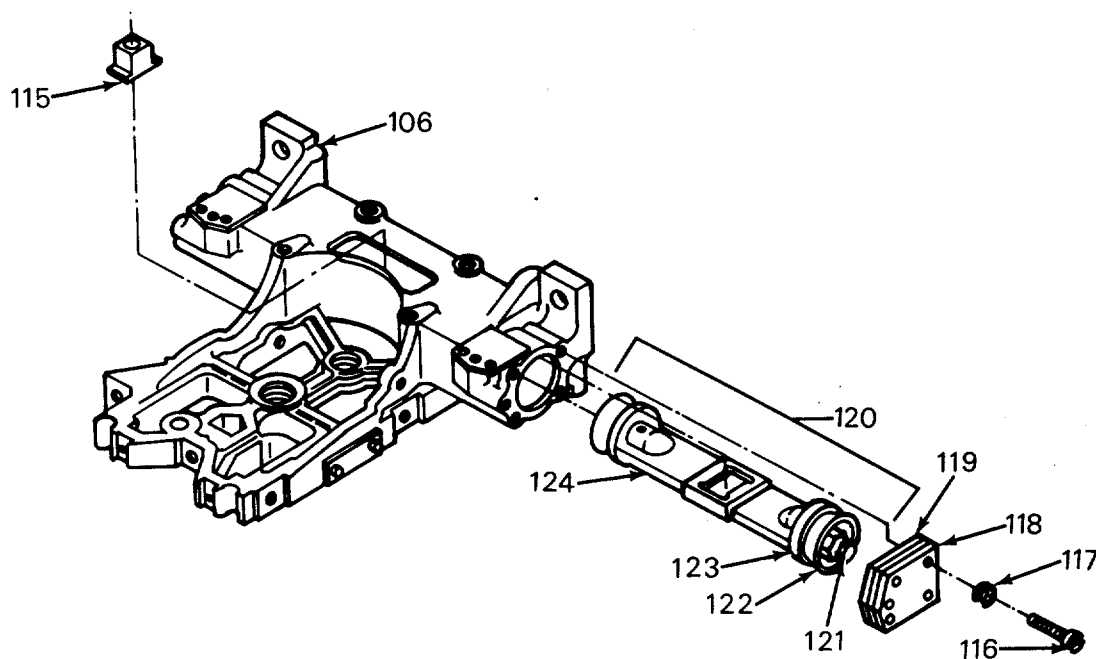
DISASSEMBLY (cont)

19. Remove four nuts (89), lockwashers (90), flat washers (91), flat washers (92), bolts (93), and spacers (94).
20. Remove two bolts (95), lockwashers (96), rod (97), five sleeves (98), and four supports (99).
21. Remove 16 screws (100), lockwashers (101), 8 supports (102), springs (103), seats (104), and fingers (105) from support barriers (110).
22. Remove top end frame (106) and bottom end frame (107) from shaft (114).
23. Remove thrust bearing (108), sleeve (109), four support barriers (110), three insulators (111), spacer (112), and sleeve (113) from shaft (114).



**3-28. REVERSER (Cont)****DISASSEMBLY (cont)**

24. Turn guide block (115) 90 degrees and remove from top end frame (106). Remove eight bolts (116), lockwashers (117), cylinder head (118), and gasket (119). Remove piston assembly (120).
25. Remove two self-locking nuts (121), followers (122), and packings (123) from piston (124).



3-28. REVERSER (Cont)

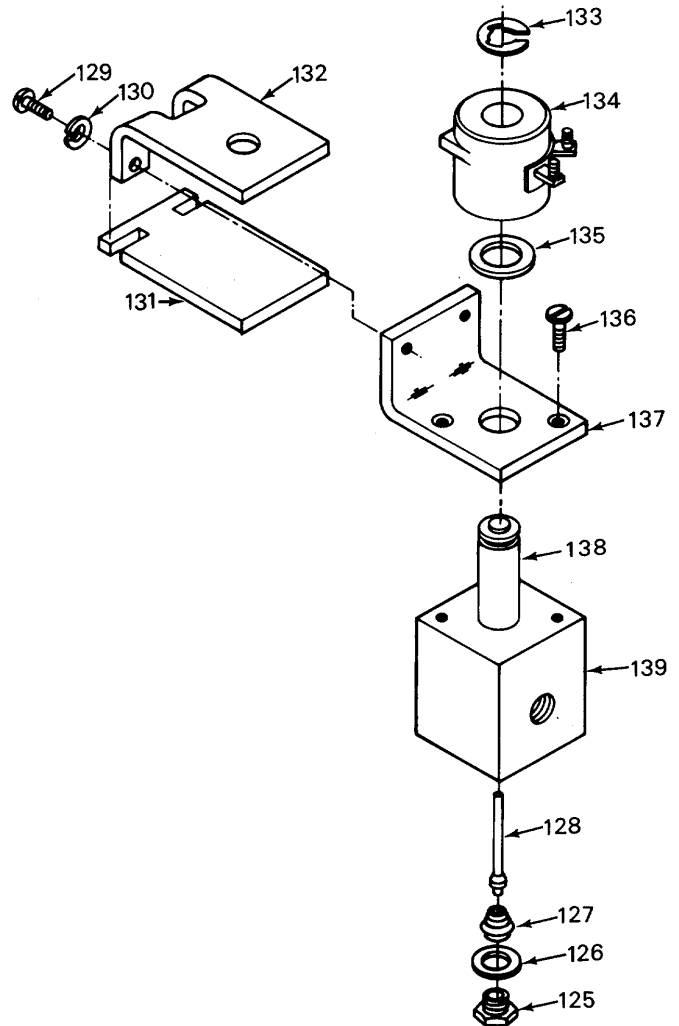
DISASSEMBLY (cont)

26. Disassemble magnet valve assemblies (19) and (23) by the following:

NOTE

Magnet valve assemblies are identical and are disassembled in the same manner.

- a. Remove cap plug (125), gasket (126), spring (127), and inlet valve (128).
- b. Remove two screws (129), lockwasher (130), armature guide (131), and armature (132).
- c. Remove retaining ring (133) ½ coil (134), and rubber washer (135) from valve stem (138).
- d. Remove two screws (136), magnet frame (137), and valve stem (138) from valve body (139).



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**3-28. REVERSER (Cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100-138°F (38-59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

27. Use dry-cleaning solvent and clean metal parts. Dry with compressed air.
28. Inspect molded parts for warpage, breaks, and cracks.
29. Inspect fingers (45) and (57). If alloy material is worn through to base metal, replace fingers.
30. Inspect seat in valve body (139). If valve stem (138) does not seat properly, lap in the valve stem with graphite and oil. After the valve stem has been properly seated, clean ports to remove the compound. If valve seats are excessively scored or worn, replace the seats.
31. Inspect coil (134) for damaged insulation.
32. Use a multimeter and measure resistance of coil (134). If resistance is not between 72.5 and 93.3 ohms, replace coil.
33. Repair consists of replacing defective parts.



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**3-28. REVERSER (Cont)**

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**ASSEMBLY**

34. Assemble magnet valve assemblies (19) and (23) by the following:

**NOTE**

**Magnetic valve assemblies are identical and are assembled in the same manner.**

- a. Install valve stem (138) in valve body (139). Position magnet frame (137), on valve body and install two screws (136).
  - b. Position rubber washer (135) and coil (134) on valve stem (138) install retaining ring (133).
  - c. Position armature (132) and armature guide (131) on valve stem (138) and install two lockwashers (130) and screws (129).
  - d. Install inlet valve (128), spring (127), gasket (126), and cap plug (125).
35. Position packings (123) and followers (122) in piston (124) and install two self-locking nuts (121).
36. Install piston assembly (120) in top end frame (106) and install gasket (119), cylinder head (118), eight lockwashers (117), and bolts (116). Install guide block (115) and rotate 90 degrees.
37. Position shaft (114) and install sleeve (113), spacer (112), three insulators (111), four support barriers (110), sleeve (109), and thrust bearing (108).
38. Install bottom end frame (107) and top end frame (106) on shaft (114).
39. Position 8 fingers (105), seats (104), springs (103), and supports (102) on support barrier (109) and install 16 lockwashers (101) and screws (100).
40. Position four supports (99), five sleeves (98), and rod (97), and install two lockwashers (96) and bolts (95).
41. Install four spacers (94), bolts (93), flat washers (92), flat washers (91), lockwashers (90), and nuts (89).
42. Position four supports (88) and five sleeves (87). Install rod (86), two lockwashers (85), and bolts (86).
43. Position four spacers (83) and bus bar (82) and install four flat washers (81) and carriage bolts (80), flat washers (79), lockwashers (78), and nuts (77).
44. Position four supports (76) and five sleeves (75). Install rod (74), two lockwashers (73), and bolts (72).

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**3-28. REVERSER (Cont)**

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**ASSEMBLY (cont)**

45. Install four spacers (71), flat washers (70), and carriage bolts (69). Install four flat washers (68), lockwashers (67), and nuts (66).
46. Position four supports (65) and five sleeves (64). Install rod (63), two lockwashers (62), and bolts (61).
47. Install four spacers (60), flat washers (59), and carriage bolts (58). Connect four fingers (57) and install four flat washers (56), lockwashers (55), and nuts (54).
48. Position four supports (53) and five sleeves (52). Position rod (51) and install two lockwashers (50) and bolts (49).
49. Position four spacers (48) and install four flat washers (47) and carriage bolts (46). Connect four fingers (45) and install four flat washers (44), lockwashers (43), and nuts (42).
50. Install woodruff key (41) and operating lever assembly (40) and install setscrew (38) with locknut (37) and lockwasher (39).
51. Install pawl assembly (36), bolt (35), lockwasher (34), nut (33), cotter pin (32), and tension spring (31).
52. Position interlock (30) and install two capscrews (29), lockwashers (28), nuts (27), three lockwashers (26), and screws (25).
53. Position gasket (24) and magnet valve assembly (23) and install two lockwashers (22) and bolts (21).
54. Position gasket (20) and magnet valve assembly (19) and install two lockwashers (18) and bolts (17).
55. Install adapter (16), nipples (15) and (14), tees (12) and (13), adapter (11), pipe plug (10), elbow (9), and hose (8).

**INSTALLATION**

56. Position reverser (7) and install four flat washers (6), capscrews (5), flat washers (4), lockwashers (3), and nuts (2). Connect air line fittings (1).
57. Install electrical wires in accordance with wiring diagram.

**TEST**

58. Manually operate interlock contacts. Use a multimeter and check resistance of fingers for infinity while open and continuity while closed.
59. Set battery switch to CLOSE and close equipment cabinet door. Start locomotive and build up air pressure and set reverser to forward and reverse while checking reverser for proper operation.

**3-29. LOAD METER SHUNT**

This task covers:

a. Removal

b. Test

c. Installation

INITIAL SETUP

Tools

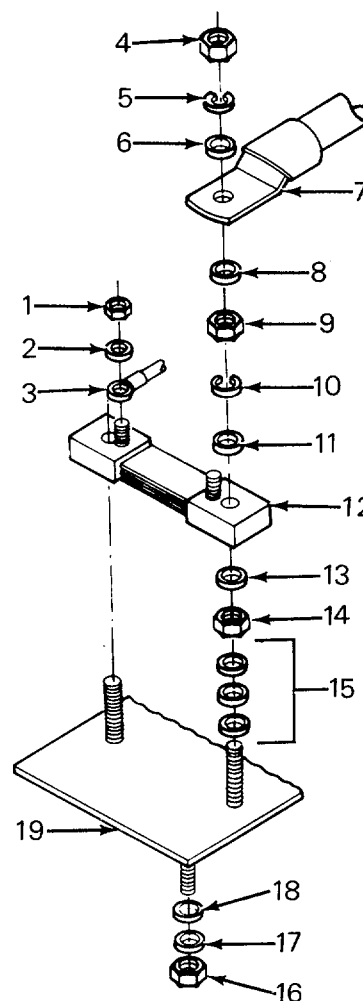
Tool kit SC4940-97-CL-E12

**REMOVAL**

**WARNING**

- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wrist-watches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Remove two nuts (1).
3. Remove spacer (2). Tag and disconnect two wires (3).
4. Remove two nuts (4), lockwashers (5), and flat washers (6). Tag and disconnect wires (7).
5. Remove two flat washers (8), nuts (9), lockwashers (10), and flat washers (11).
6. Remove shunt (12).
7. Remove two flat washers (13), nuts (14), six flat washers (15).
8. Remove four nuts (16), lockwashers (17), and flat washers (18). Remove shunt base (19).



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**3-29. LOAD METER SHUNT (cont)**

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**TEST**

9. Use a multimeter and perform a continuity test on the load meter shunt. Replace defective unit.

**INSTALLATION**

10. Position shunt base (19) and install four flat washers (18), lockwashers (17), and nuts (16).

11. Install six flat washers (15), two nuts (14), and flat washers (13). Install shunt (12) on shunt base (19).

12. Install two flat washers (11), lockwashers (10), nuts (9), and flat washers (8) on shunt (12). Connect two wires (7) and install two flat washers (6), lockwashers (5), and nuts (4). Remove tags.

13. Connect two wires (3) and install spacer (2) and two nuts (1). Remove tags.

14. Close electrical equipment cabinet door.

### 3-30 GENERATOR FIELD (SELF) RESISTOR

This task covers:

a. Removal

b. Test

c. Installation

#### INITIAL SETUP

#### Tools

Tool kit SC4940-97-CL-E12

#### REMOVAL

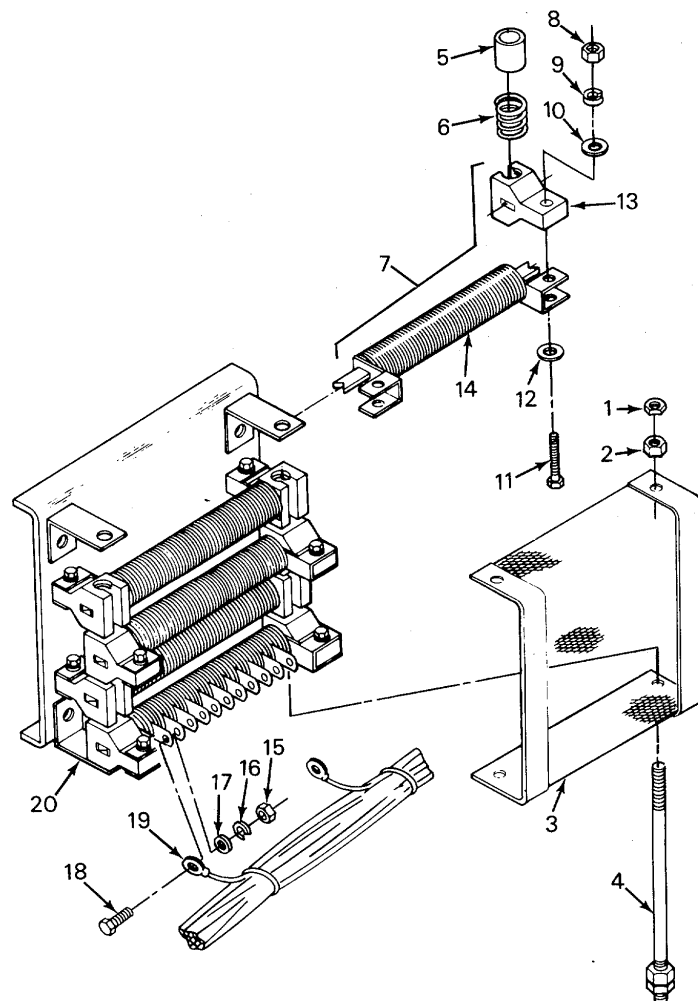
##### **WARNING**

- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Remove two locknuts (1), nuts (2), screen (3), two studs (4), four spacers (5), and springs (6). Remove resistor and insulator assembly (7).

##### **NOTE**

**All insulator and resistor assemblies are disassembled in the same manner.**



3. Remove two nuts (8), lockwashers (9), flat washers (10), capscrews (11), and flat washers (12). Remove two insulators (13) from resistor (14).

---

**3-30 GENERATOR FIELD (SELF) RESISTOR (cont)**

---

**REMOVAL (cont)****NOTE**

**If the bottom resistor is to be removed perform step 4.**

4. Tag electrical leads (19) and remove two nuts (15), lockwashers (16), flat washers (17), capscrews (18) and electrical leads. Remove resistor and insulator assembly (20). Repeat step 3 for disassembly of insulator and resistor assembly.

**TEST**

5. Use a multimeter and perform a resistance test on the generator field (self) resistor. The resistor value should be 6 ohms. If this reading is not obtained, replace defective resistor.

**INSTALLATION****NOTE**

**All insulator and resistor assemblies are assembled in the same manner.**

6. Insert resistor (14) in two insulators (13) and install two flat washers (12), capscrews (11), flat washers (10), lockwashers (9), and nuts (8).
7. Position resistor and insulator assembly (20) and install two electrical leads (19), capscrews (18), flat washers (17), lockwashers (16), and nuts (15). Remove tags.
8. Position resistor and insulator assembly (7) and install four springs (7), spacers (6), screen (5), two studs (4), four nuts (3), and locknuts (2).
9. Set battery switch to CLOSE and close electrical equipment cabinet door.

**3-31. FIELD SHUNT RESISTOR**

This task covers:

a. Removal

b. Test

c. Installation

**INITIAL SETUP****Tools**

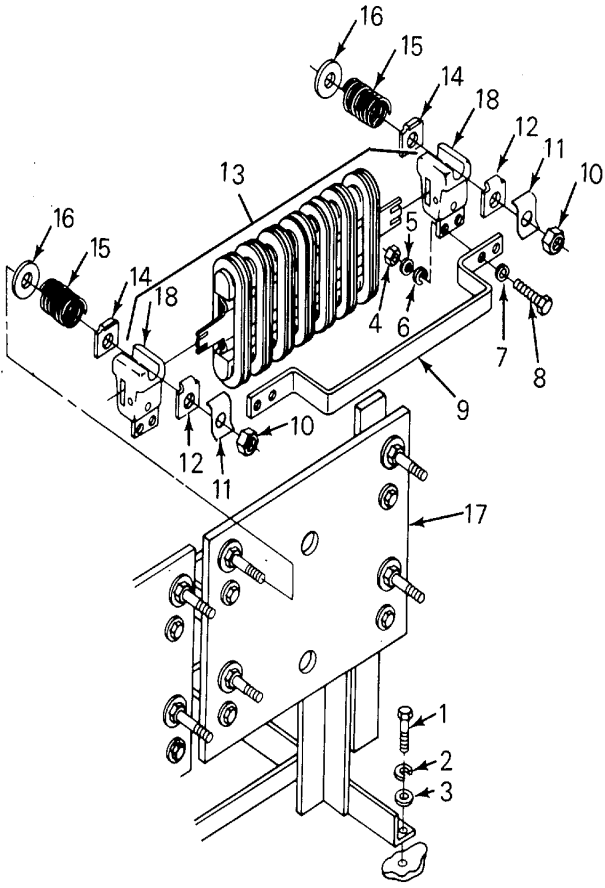
Tool kit SC4940-97-CL-E12

**REMOVAL****WARNING**

- ⌚ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⌚ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

**NOTE**

The six resistors are removed and installed in a similar manner.

1. Open electrical equipment cabinet door and set battery switch to OPEN.
- 
2. Tag and disconnect electrical leads.
  3. Remove four capscrews (1), flat washers (2), and lockwashers (3). Remove reverser frame from locomotive.
  4. Remove four nuts (4), flat washers (5), lockwashers (6), flat washers (7), and capscrews (8) and remove shunt (9).
  5. Remove two nuts (10), spacers (11) and (12), insulator-resistor assembly (13), two spacers (14), springs (15), and flat washers (16) from mounting board (17). Separate two insulators (18) from resistor (19).

---

**3-31. FIELD SHUNT RESISTOR (cont)**

---

**TEST**

6. Use a multimeter and perform a resistance test on the field shunt resistors. The six 12-inch resistors are 0.0186 ohm. If these readings are not obtained, replace defective resistors.

**INSTALLATION**

7. Insert resistor (19) in two insulators (18). Install two flat washers (16), springs (15), and spacers (14) on mounting board (17). Position insulator-resistor assembly (13), two spacers (12), and two spacers (11) and install two nuts (10).
8. Position shunt (9) and install four capscrews (8), flat washers (7), lockwashers (6), flat washers (5), and nuts (4).
9. Position reverser frame in locomotive and install four flat washers (3), lockwashers (2), and capscrews (1).
10. Connect electrical leads and remove tags.
11. Close electrical equipment cabinet door.



**3-32. HEADLIGHT RESISTOR AND GENERATOR FIELD (SEPARATE) RESISTOR**

This task covers:

a. Removal

b. Test

c. Installation

**INITIAL SETUP****Tools**

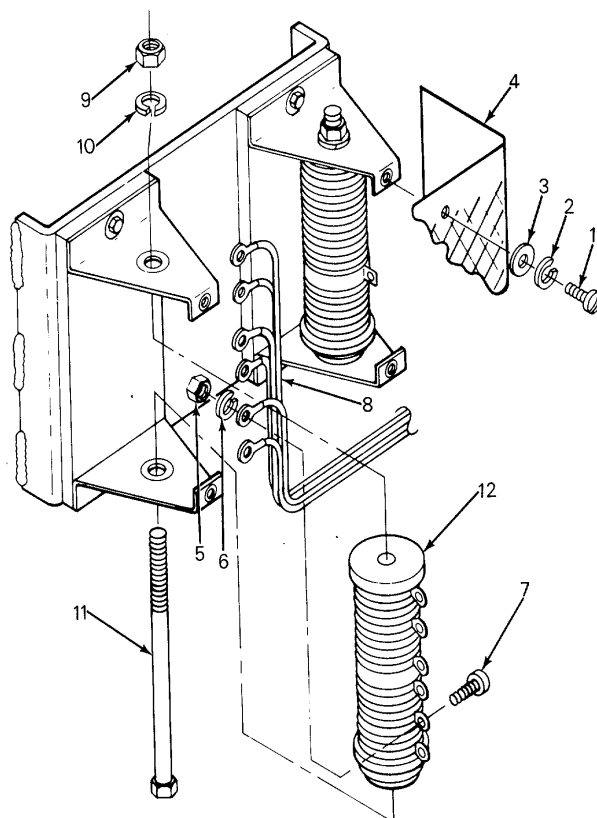
Tool kit SC4940-97-CL-E12

**REMOVAL****WARNING**

- ⓘ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⓘ **Remove rings, bracelets, wrist-watches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

**NOTE**

Both resistors are removed and installed the same way.



1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Remove four screws (1), lockwashers (2), flat washers (3), and screen (4).
3. Tag electrical leads (8) and remove six nuts (5), lockwashers (6), and screws (7). Disconnect electrical leads.
4. Remove nut (9), lockwasher (10), and capscrew (11). Remove resistor (12).

---

**3-32. HEADLIGHT RESISTOR AND GENERATOR FIELD (SEPARATE) RESISTOR (cont)**

---

**TEST**

5. Use a multimeter and perform a resistance test on the headlight resistors and generator field (separate) resistor. The headlight resistors are 5.5 ohms  $\pm 5\%$  and the generator field (separate) resistor is 27 ohms  $\pm 10\%$ . If these readings are not obtained, replace defective resistors.

**INSTALLATION**

6. Position resistor (12) in frame and install capscrew (11), lockwasher (10), and nut (9).
7. Position electrical leads (8) and install six screws (7), lockwashers (6), and nuts (5). Remove tags.
8. Position screen (4) and install four flat washers (3), lockwashers (2), and screws (1).
9. Close electrical equipment cabinet door.

**3-33. GAGE LIGHT RESISTOR AND WHEEL-SLIP RELAY RESISTOR**

This task covers:

a. Removal

b. Test

c. Installation

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

**REMOVAL**

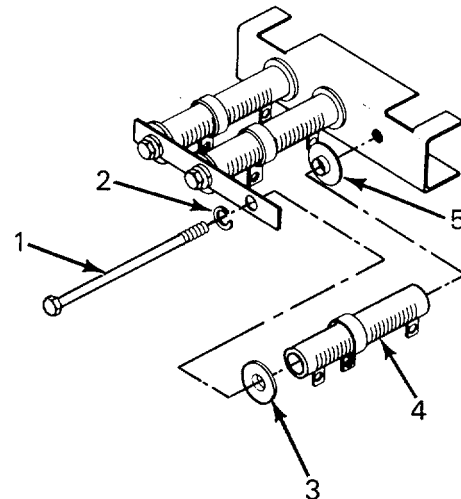
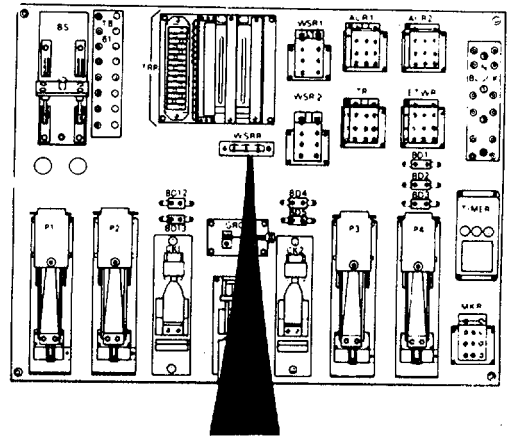
**WARNING**

- ⌚ High voltage is used in the operation of equipment. Do not be misled by the term **LOW VOLTAGE**. Potentials as low as 50 volts may cause death.
- ⌚ Remove rings, bracelets, wrist-watches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.

**NOTE**

Resistors are removed and installed in a similar manner. Only one of each is called out.

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Tag and disconnect electrical leads to the wheel slip relay resistor.
3. Remove screw (1), lockwasher (2), insulator (3), wheel slip relay resistor (4), and insulator (5).



**3-33. GAGE LIGHT RESISTOR AND WHEEL-SLIP RELAY RESISTOR (cont)**

**REMOVAL (cont)**

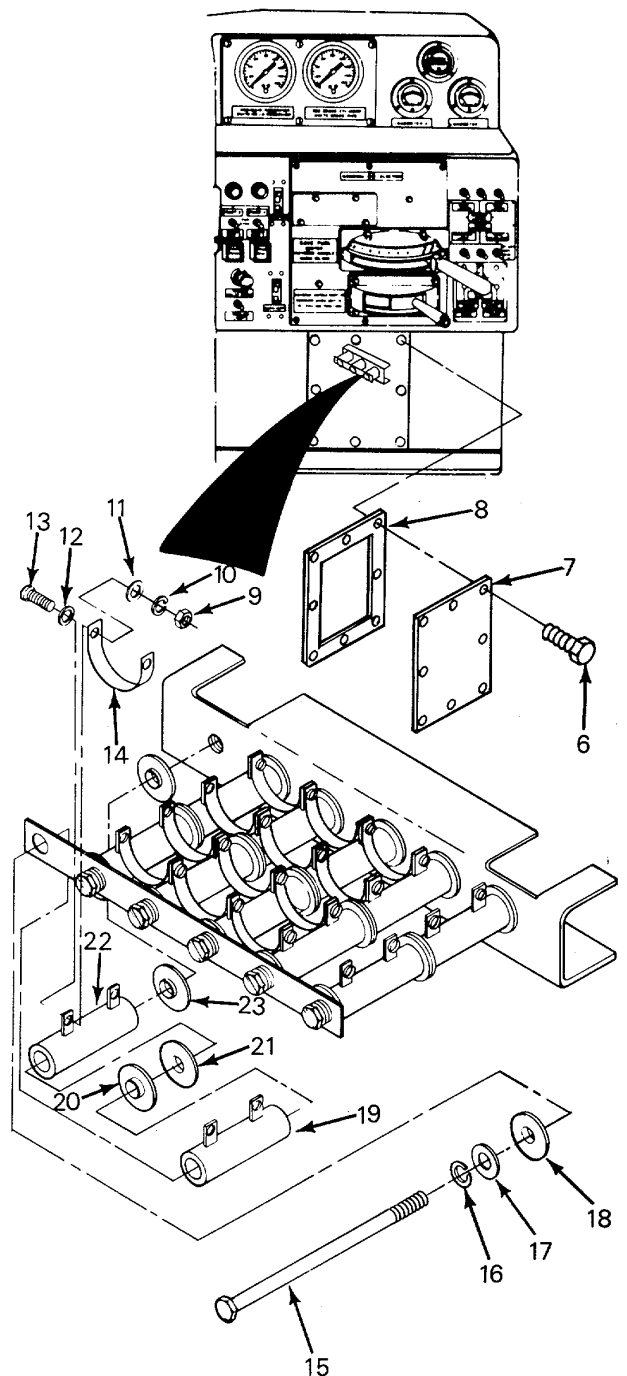
4. Tag and remove electrical leads from gage light resistors.
5. Remove eight screws (6), cover (7), and gasket (8).
6. Remove two nuts (9), lockwashers (10), flat washers (11), flat washers (12), capscrews (13) and jumper (14).
7. Remove capscrew (15), lockwasher (16), flat washer (17), insulator (18), gage light resistor (19) insulators (20), and (21), gage light resistor (22), and insulator (23).

**TEST**

8. Use a multimeter and perform a resistance tests on the resistors. Gage light resistors (19) and (22) are 150 ohms  $\pm 5\%$ . Wheel slip relay resistor (4) is 1 ohm. If these reading are not obtained, replace defective resistors.

**INSTALLATION**

9. Position insulator (23), gage light resistor (22), insulators (21) and (20), gage light resistor (19), insulator (18), flat washer (17), lockwasher (16), and capscrew (15).
10. Position jumper (14) and install two capscrew (13), flat washer (12) and (11), lockwasher (10), and nuts (9).
11. Position gasket (8) and cover (7) and install eight screws (6).
12. Connect electrical leads to gage.
13. Position insulator (5), wheel slip relay resistor (4), insulator (3), lockwasher (2), and capscrew (1).
14. Close electrical equipment cabinet door.



### 3-34. CONTROLLER MECHANISM

This task covers:

- |                |               |           |                 |
|----------------|---------------|-----------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair | g. Assembly     |
| b. Disassembly | d. Inspection | f. Test   | h. Installation |

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12

##### Material/Parts

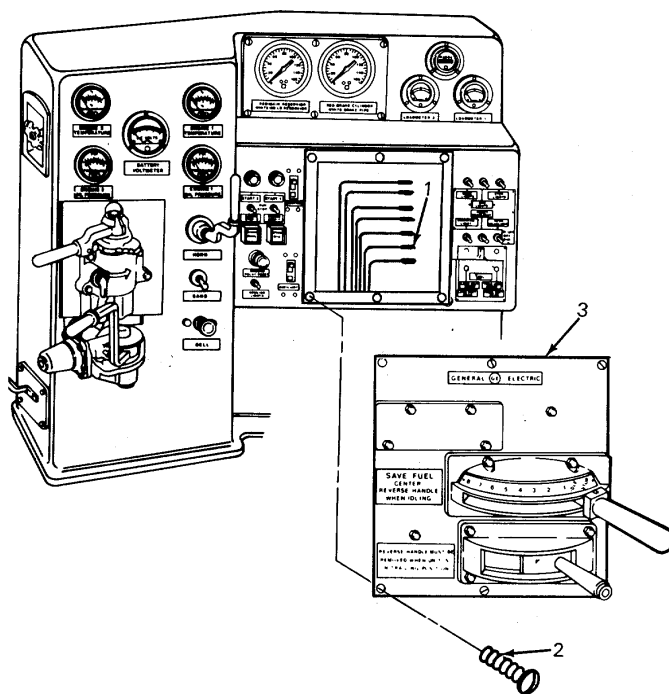
Drycleaning solvent (Item 34, Appendix D)

#### REMOVAL

##### WARNING

- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

1. Open electrical equipment cabinet door and set battery switch to OPEN.
2. Gain access to rear of controller through high-voltage cabinet door.
3. Tag and disconnect wire harness leads (1) from controller mechanism (3).
4. Remove six mounting screws (2) from top and bottom of controller mechanism (3).
5. Remove controller mechanism (3).



**3-34. CONTROLLER MECHANISM (cont)**

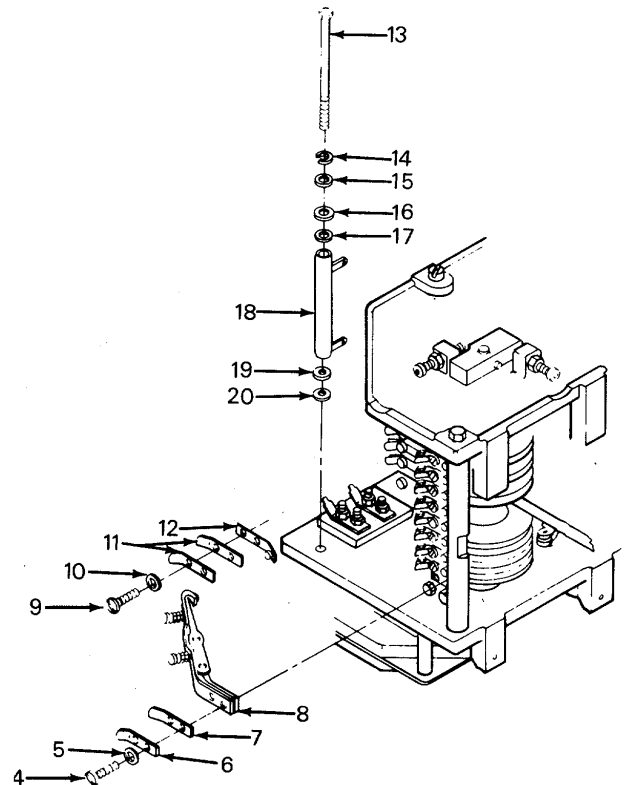
**DISASSEMBLY**

6. Remove two screws (4), lockwashers (5), spacers (6), and connectors (7). Remove finger assembly (8).
7. Remove two screws (9), lockwashers (10), and connectors (11). Remove contact (12).
8. Repeat step 7 and disassemble remaining contacts.
9. Tag and disconnect wire from resistor (18). Remove screw (13), lockwasher (14), flat washer (15), spacer (16), mica washer (17), resistor (18), mica washer (19), and spacer (20).

**CLEANING, INSPECTION, AND REPAIR**

**WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 1380F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**



**NOTE**

**Repair consists of adjusting or replacing defective contacts and/or fingers and/or replacing resistor.**

10. Use drycleaning solvent and clean parts. Dry with compressed air.

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**3-34. CONTROLLER MECHANISM (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

11. Inspect contact surfaces for burning or wear.
12. Check contact finger pressure as follows:
  - a. Use spring scale connect to contact loop.
  - b. Insert a strip of paper between the closed stationary contact and movable fingers.
  - c. Pull on the spring scale until the finger separates enough to allow the paper to move. Scale value should be 3/4 to 1 inch (19 to 25 mm).
13. Inspect resistor for cracks, breaks, and signs of burning.

**CAUTION**

**Do not use sandpaper or emery cloth to file contacts.**

14. Replace damaged resistor or badly worn, burned, or pulled contacts. Contacts may be filed smooth with a fine file.

**TEST**

15. Use multimeter and check the contacts and fingers individually. Make a resistance test to check that the contacts and fingers open and close while moving the throttle from STOP to THROTTLE 8 position.
16. Use multimeter and test resistor (18). Make a resistance test to check that the resistance is 300 ohms  $\pm 5\%$ .

**ASSEMBLY**

17. Install spacer (20), mica washer (19), resistor (18), mica washer (17), spacer (16), flat washer (15), lockwasher (14), and screw (13). Connect wires and remove tags.
18. Position contact (12) in controller and install two connectors (11), lockwashers (10), and screws (9).
19. Repeat step 18 and assemble remaining contacts.
20. Position finger assembly (8) in controller and install two connectors (7), spacers (6), lockwashers (5), and screws (4).

---

**3-34. CONTROLLER MECHANISM (cont)**

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**INSTALLATION**

21. Install controller mechanism (3) in control stand and secure with six mounting screws (2).
22. Connect wire harness leads (1) to controller mechanism (3) and remove tags.
23. Close electrical equipment cabinet door.



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**3-35. SPEED-SENSING ALTERNATOR**

---

This task covers:

- |            |                |               |                 |
|------------|----------------|---------------|-----------------|
| a. Test    | c. Disassembly | e. Inspection | g. Assembly     |
| b. Removal | d. Cleaning    | f. Repair     | h. Installation |
- 

**INITIAL SETUP****Tools****Material/Parts**

Tool kit SC4940-97-CL-E12

Drycleaning solvent (Item 34, Appendix B)

---

**TEST**

1. If the locomotive does not transition before removing speed-sensing alternator, perform the following:
  - a. Connect positive lead of multimeter to TB1-M and negative lead to TB1-K.
  - b. Operate the locomotive to the speed where transition should take place (approximately 10 to 15 mph).
  - c. The indication on the multimeter should be 10 V ac or more.
  - d. If a 10 V ac signal is present on TB1-M, transition relay panel is probably defective. If no signal is present, speed-sensing alternator is probably defective.

**REMOVAL****WARNING**

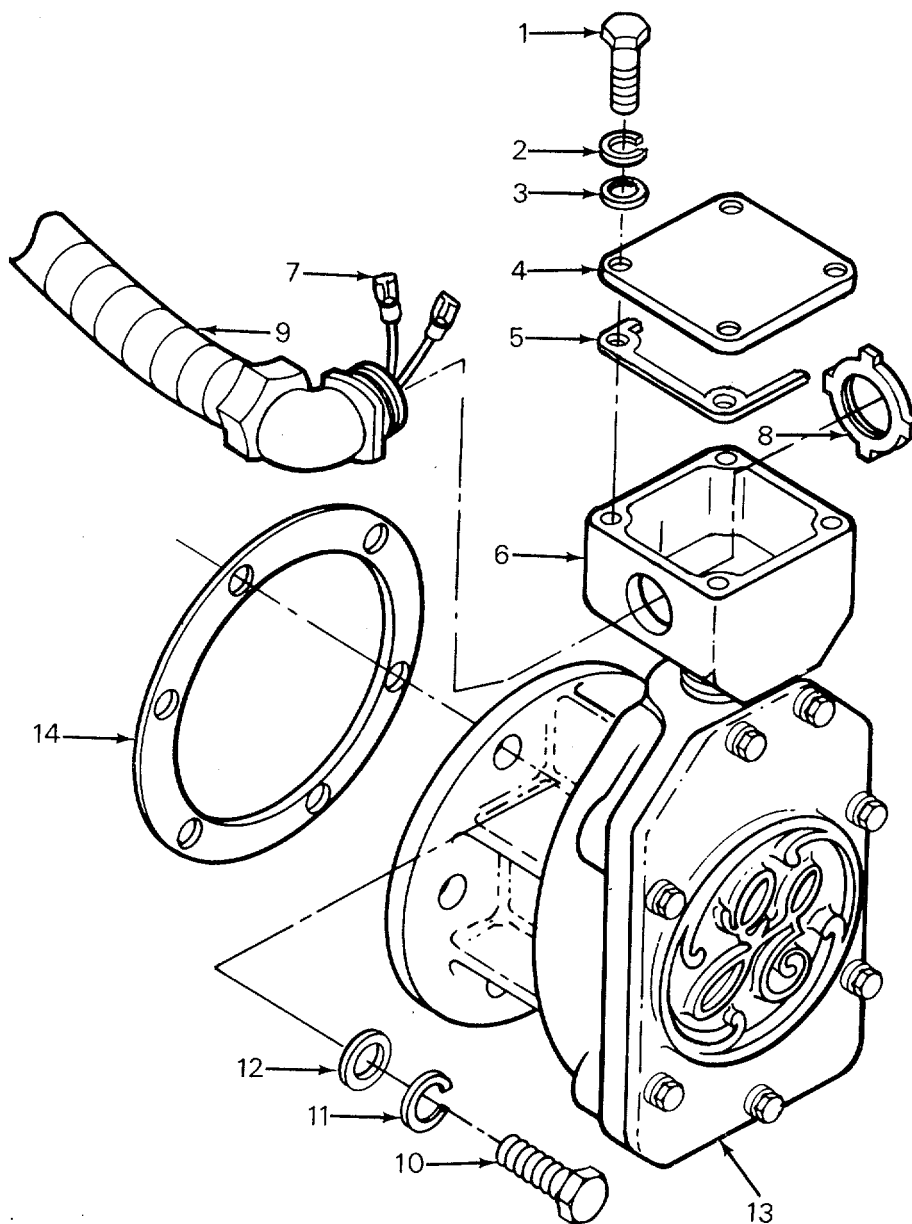
- ⚠ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⚠ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

2. Open electrical equipment cabinet door and set battery switch to OPEN.

**3-35. SPEED-SENSING ALTERNATOR (cont)**

**REMOVAL (cont)**

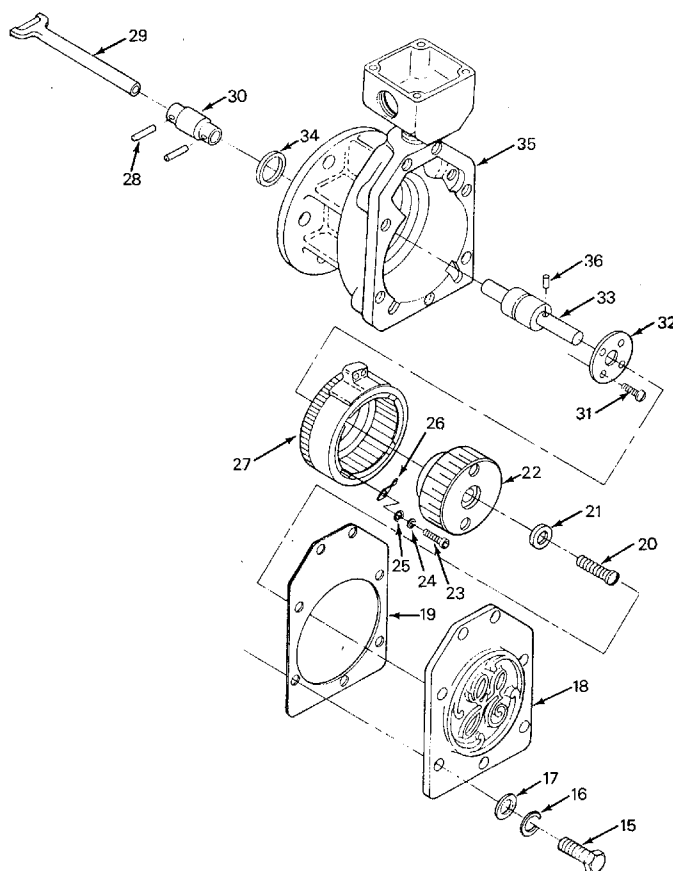
3. Remove lockwire and remove four capscrews (1), lockwashers (2), flat washers (3), cover (4), and gasket (5) from terminal box (6).
4. Tag and disconnect electrical wires (7) from terminals inside terminal box (6). Disconnect conduit nut (8) and remove conduit (9) and electrical wires.
5. Remove six capscrews (10), lockwashers (11), and flat washers (12). Remove speed-sensing alternator (13) and gasket (14) from traction motor.



**3-35. SPEED-SENSING ALTERNATOR (cont)**

**DISASSEMBLY**

6. Remove seven capscrews (15), lockwashers (16), flat washers (17), cover (18), and gasket (19).
7. Tag and disconnect wires from coil of stator (27).
8. Remove locking screw (20) and flat washer (21). Use a puller and pull rotor (22) from shaft and bearing assembly (33).
9. Remove four screws (23), lockwashers (24), flat washers (25), and spring clips (26) and remove stator (27).
10. Drive out two roll pins (28) and remove spade (29) and flexible coupling (30).
11. Remove four screws (31) and retaining ring (32) from inside housing (35).
12. Remove shaft and bearing assembly (33) and oil seal (34) from housing (35). Remove pin (36) from shaft and bearing assembly.



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**3-35. SPEED-SENSING ALTERNATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

13. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of body and other metal parts. Dry with compressed air.
14. Inspect metal parts for cracks, breaks, cuts, or other damage. Replace damaged parts.
15. Use a multimeter and measure coil resistance. Resistance should be 73.4 to 83.5 ohms.
16. Inspect stator (27) and rotor (22) for chipped or cracked epoxy.
17. Inspect flexible coupling (30) to see if it is cracked or has been stretched out of shape.
18. Check to see if oil seal (34) is worn or has been leaking.
19. Inspect spade (29) to see if it is worn or fits loosely on the axle.
20. Inspect shaft and bearing assembly (33) for excessive play. Remove any burrs on shaft, particularly around roll pin hole.

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**3-35. SPEED-SENSING ALTERNATOR (cont)**

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**ASSEMBLY**

21. Install pin (36) in shaft and bearing assembly (33). Install oil seal (34) in housing (35). Check that oil seal is flush with housing bore and with the rubber edge of seal toward outside of housing.
22. Install shaft and bearing assembly (33) in housing (35). Check that bearing part of shaft is back against its fit in housing.
23. Position retaining ring (32) and install four screws (31) in housing (35).
24. Install flexible coupling (30) and spade (29) on shaft and bearing assembly (33) and install two roll pins (28).
25. Position stator (27) in housing (35) and position four spring clips (26) and install flat washers (25), lockwashers (24), and screws (23).
26. Press rotor (22) on shaft and bearing assembly (33) and install flat washer (21) and locking screw (20). Tighten locking screw to 30 lb-in (3.39 N.m). Check to see that the notches in rotor hub engage roll pin inserted into shaft.
27. Connect wires to coil of stator (27). Remove tags.
28. Position gasket (19) and cover (18) on housing (35) and install seven flat washers (17), lockwashers (16), and capscrews (15). Lockwire the capscrews as groups.

**INSTALLATION**

29. Position gasket (14) and speed-sensing alternator (13) on traction motor. Check to see that spade (29) properly engages drive shaft of traction motor. Install six flat washers (12), lockwashers (11), and capscrews (10). Tighten capscrews to 33  $\pm$  3 lb-ft (44.7  $\pm$  4.1 N.m) torque. Lockwire capscrews in pairs.
30. Feed electrical conduit (9) and wires (7) into terminal box (6) and tighten conduit nut (8). Connect electrical wires to terminals.
31. Position gasket (5) and cover (4) on terminal box (6) and install four flat washers (3), lockwashers (2), and capscrews (1). Tighten capscrews to 6.5  $\pm$  1.5 lb-ft (8.8  $\pm$  2.03 N.m).

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**3-36. TRANSITION RELAY PANEL**

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This task covers:

a. Test

b. Removal

c. Installation

---

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

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**TEST**

1. If the locomotive does not transition before removing transition relay panel, perform the following:
  - a. Connect positive lead of multimeter to TB1-M and negative lead to TB1-K.
  - b. Operate the locomotive to the speed where transition should take place.
  - c. The indication on the multimeter should be 10 V ac or more.
  - d. If a 10 V ac signal is present on TB1-M, transition relay panel is probably defective. If no signal is present, speed-sensing alternator is probably defective.

**WARNING**

- ⌚ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**
- ⌚ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**

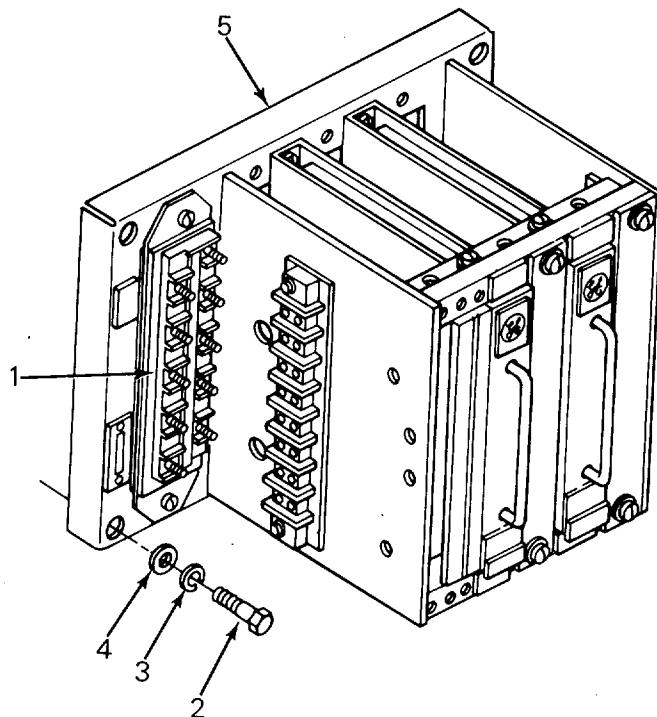
2. Open electrical equipment cabinet door and set battery switch to OPEN.

**3-36. TRANSITION RELAY PANEL (cont)****REMOVAL**

3. Tag and disconnect wires from terminal board (1).
4. Remove four screws (2), lockwashers (3), and flat washers (4).
5. Remove transition relay panel (5).

**INSTALLATION**

6. Position transition relay panel (5) on locomotive wall and install four flat washers (4), lockwashers (3), and screws (2).
7. Connect wires to terminal board (1). Remove tags.
8. Close electrical equipment cabinet door.



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### 3-37. MAIN GENERATOR

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This task covers:

- |                |               |           |                 |
|----------------|---------------|-----------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair | g. Assembly     |
| b. Disassembly | d. Inspection | f. Test   | h. Installation |
- 

#### INITIAL SETUP

##### Tools

Tool kit SC4940-97-CL-E12  
Mica undercutter 5210-00-640-0953  
Dial indicator 5210-00-640-0953  
Induction heater 2815-00-366-1432  
Puller set  
Nylon sling

##### Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
Grease (Item 14, Appendix B)  
Clear acrylic lacquer (Item 19, Appendix B)  
Insulating varnish (Item 37, Appendix B)  
Gray gloss enamel (Item 11, Appendix B)  
Electrical tape (Item 36, Appendix B)  
Insulating paper (Item 29, Appendix B)  
Wiping rags (Item 32, Appendix B)  
Pipe, 3 inch, 15 ft (Item 31, Appendix B)  
Lumber, 4 X 4 inch, 16 ft (item 23, Appendix B)

##### Personnel Required

3

##### Equipment Condition

##### Reference

TM 55-2210-224-12  
Para 3-7  
Para 3-32

##### Condition Description

Air compressor drive belts removed  
Engine hood removed  
Resistor cages removed

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#### REMOVAL

##### **WARNING**

- ⓘ **Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.**
- ⓘ **High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.**

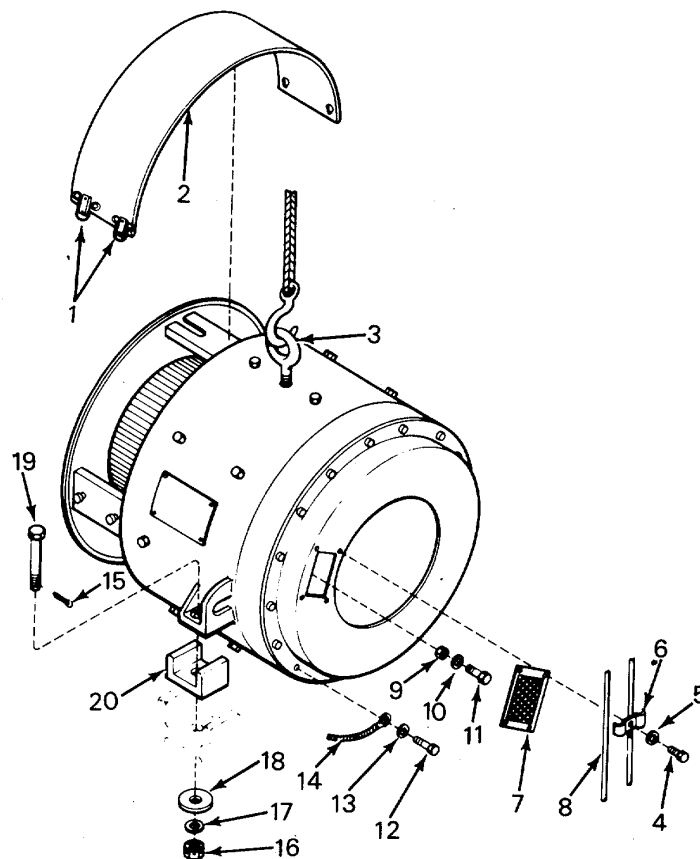
1. Open electrical equipment cabinet door and set battery switch to OPEN.



**3-37. MAIN GENERATOR (cont)****REMOVAL (cont)****NOTE**

If repair of main generator is limited to resurfacing commutator, refer to step 24f below.

2. Unlatch two latches (1) and remove covers (2). Install lifting eye (3) in hole provided in main generator frame.
3. Remove four capscrews (4), lockwashers (5), clamp (6), and two screens (7). Position lines (8) out of the way.
4. Use a punch and punch-mark main generator and engine coupling halves. Reach through large hole in engine bell housing, cut lockwire, and remove eight nuts (9), lockwashers (10), and capscrews (11).
5. Place cardboard shims between generator armature pole pieces. Remove 16 capscrews (12) and lockwashers (13). Position ground cable (14), out of the way.



6. Tag and disconnect electrical leads from main generator.
7. Remove two cotter pins (15), castle nuts (16), flat washers (17), lower pads (18), and capscrews (19).

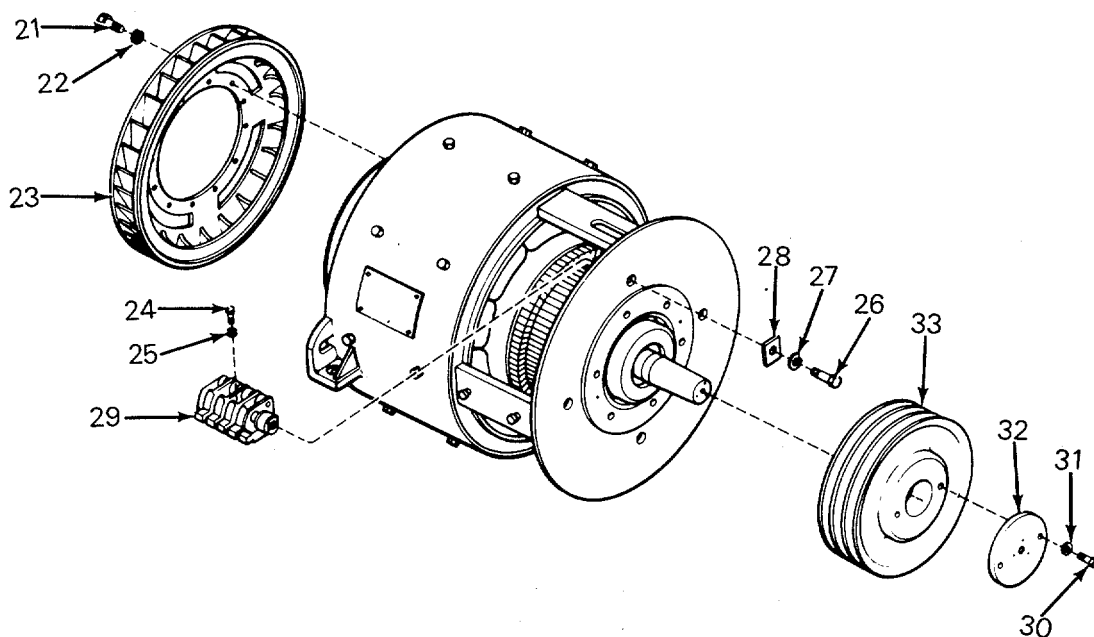
**WARNING**

**Components of the main generator are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

8. Use a suitable lifting device and move generator toward cab slowly, lift generator from base, and set on a suitable support device in horizontal position.
9. Remove two upper pads (20). Retain pads for installation.

**3-37. MAIN GENERATOR (cont)****DISASSEMBLY**

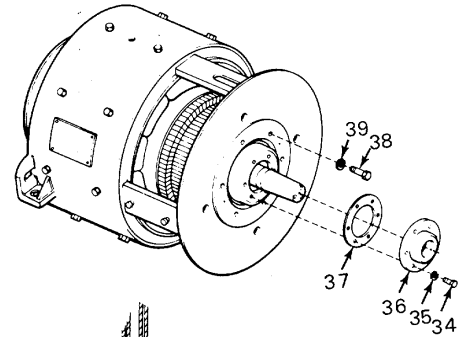
10. Use a punch and punch-mark fan (23) to armature head.
11. Cut lockwire from 16 capscrews (21) and remove capscrews and lockwashers (22). Use a puller and remove fan (23).
12. Remove four capscrews (24) and lockwashers (25). Disconnect electrical leads from brush holders (29).
13. Remove four capscrews (26), lockwashers (27), and locking plates (28). Remove four brush holders (29).
14. Wrap a piece of insulation paper around the commutator to protect it while handling.
15. Remove three capscrews (30), lockwashers (31), and locking plate (32).
16. Use a puller and remove pulley (33) from armature shaft.



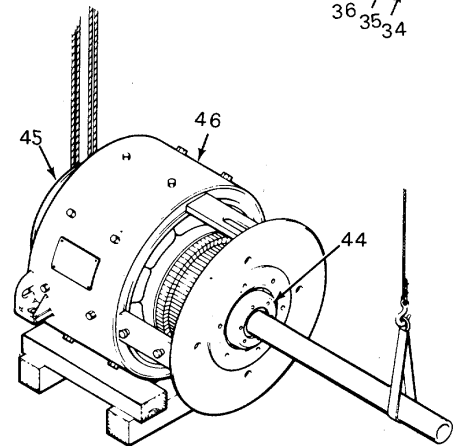
**3-37. MAIN GENERATOR (cont)**

**DISASSEMBLY (cont)**

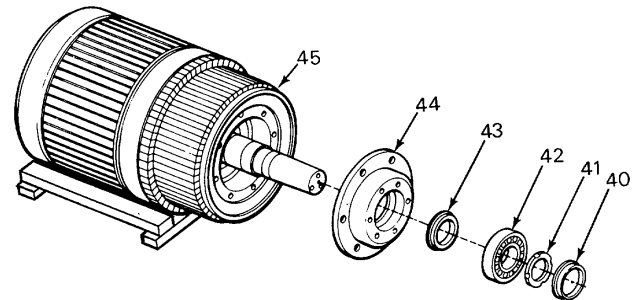
17. Remove six capscrews (34), lockwashers (35), bearing cap (36), and gasket (37).
18. Remove six capscrews (38) and lockwashers (39).



19. Use a 3-inch pipe 60 inches in length and two slings and support armature (45). Use two jack screws and remove bearing housing (44) from magnet frame (46).



20. Carefully set armature (45) on a suitable support device.



21. Use a puller and remove sleeve (40) and bearing nut (41).
22. Use a puller and remove bearing (42), oil slinger (43), and bearing housing (44) from armature (45).

---

**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR**

23. Clean, inspect, and repair bearing housing and parts by the following:

**WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and remove grease from bearing, bearing cap, sleeve, oil flinger, and bearing housing. Dry with compressed air.
- b. Inspect parts for wear, cracks, or breaks.
- c. Inspect rollers for cracks or pits.
- d. Inspect parts for overheating.
- e. Replace parts that are damaged.

**CAUTION**

**Do not paint gasket surfaces.**

- f. Paint bearing housing with electrical red insulating varnish.

---

**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

24. Clean, inspect, and repair armature assembly by the following:

**WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

**CAUTION**

**Check that drycleaning solvent does not get on commutator, copper parts, coils, and windings. Damage to equipment will result.**

- a. Blow carbon dust from armature assembly with compressed air. Direct air into the pockets and through the openings of the armature to remove internal accumulations of dirt.
- b. Use a wiping rag dampened with drycleaning solvent and wipe armature surface to remove external grease and dirt. Dry with compressed air.
- c. Inspect for journal damage. If journal shows signs of bearing slippage, replace armature.

**NOTE**

**If varnished surfaces of coil insulation are damaged, repair at depot level maintenance facility.**

- d. Inspect varnished surfaces of coil insulation. Replace insulation if blistered, flaked, or cracked.

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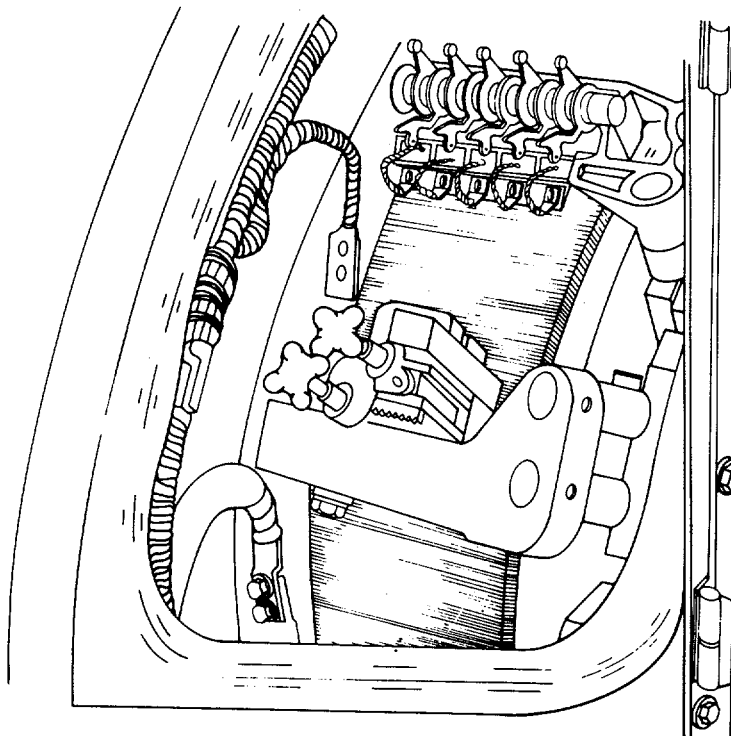
**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)****NOTE**

**If bands are loose, repair at depot level maintenance facility.**

- e. Check that bands are tight and secure and soldering is intact.
- f. Use a dial indicator and check commutator for roughness or out-of-roundness. Commutator is out of round if there is a 0.002-inch (0.05 mm) variance within a six-bar span. Inspect surface for wear, burns, or pitting. If these conditions exist, resurface commutator by the following:
  - (1) Grinder method (main generator in place):
    - (a) Remove brush holder and install grinding equipment.
    - (b) Start diesel engine and run at idle speed.
    - (c) Slowly feed grinding stones into commutator until light contact is made.
    - (d) Run stones across commutator enough to give a uniform surface.
    - (e) Stop diesel engine.



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**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- (2) Check that mica is undercut to a depth of 1/16 to 3/32 inch (1.6 to 2.4 mm). If mica depth is not within these limits, use an undercutter and regroove mica.

**CAUTION**

**Do not damage commutator bars during cleaning process.**

- (3) Clean slots between commutator bars to remove burrs.

**WARNING**

**Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- (4) Use dry compressed air and remove loose mica and copper from commutator.

**CAUTION**

**Do not paint gasket surfaces.**

- g. Paint surfaces of coil insulation with electrical insulating varnish.
25. Clean, inspect, and repair stator frame assembly by the following:

**WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use a wiping rag dampened with drycleaning solvent and remove dirt and foreign material from stator frame and field assembly. Dry with compressed air.

---

**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- b. Check that field coils, leads, and cable connections are secure.
- c. Check that shunt and interpole fields are tight.

**CAUTION**

**Do not paint gasket surfaces.**

- d. Paint insulation surfaces with electrical insulating varnish.
  - e. Paint outside surface with gray gloss enamel.
26. Clean, inspect, and repair brush holder assembly by the following:

**WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and clean brush holder assemblies. Dry with compressed air.
- b. Inspect brush holder for wear, cracks, or breaks. Replace defective brush holder.
- c. Inspect insulators for breaks, cracks, burns, or dull surface. Replace defective insulators by pressing off stud and pressing new one on.
- d. Inspect studs for cracks or breaks. Replace defective studs by pressing out of brush holder and pressing new one in.



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**3-37. MAIN GENERATOR (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- e. Inspect spring assemblies for tension and check that braiding is not frayed. Replace defective spring assemblies.

**CAUTION**

**Do not spray brush contact area.**

- f. Paint brush holders with clear acrylic lacquer.

**27. Clean, inspect, and repair ring assembly by the following:**

- a. Check that insulation is not cracked or blistered.
- b. Check that fiberglass rings are not cracked or broken.

**CAUTION**

**Do not paint gasket surfaces.**

- c. Paint assembly with electrical insulating varnish.

**28. Clean, inspect, and repair remaining parts by the following:****WARNING**

- ⚠ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⚠ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and clean parts. Dry with compressed air.
- b. Inspect parts for cracks or breaks.
- c. Replace defective parts.

3-37. MAIN GENERATOR (cont)

CLEANING, INSPECTION, AND REPAIR (cont)

d. Paint the following with electrical insulating varnish:

**CAUTION**

**Do not paint machined surfaces.**

- (1) Fan
- (2) Inside surface of stator frame cover
- (3) Inside surface of main generator covers

e. Paint the following with gray gloss enamel:

**CAUTION**

**Do not paint gasket surfaces.**

- (1) Coupler assembly
- (2) Inside surface of pulley
- (3) Outside surface of main generator covers
- (4) Outside surface of stator frame cover

29. Refer to table 3-4 for main generator data.

Table 3-4. Main Generator

Item	Specification
Classification.....	dc, 4-pole, self-excited, shunt-wound, commutating pole, self-ventilated
Nominal Rating - Input .....	210 hp at 2100 rpm
Resistance AT 77°F (25°C) (Nominal)	
Shunt Field .....	8.50 ohms
Commutating Field .....	0.0035 ohm
Starting Field .....	0.00280 ohm
Brush Data	
Size (new) .....	1-1/4 x 3/4 x 2-1/2 in. (31.75 x 19.05 x 63.5 mm)
Minimum worn length .....	1-1/2 in. (38.1 mm)
Pressure per brush .....	3 to 4 lb. (1.3 to 1.8 kg)
Brush holder to commutator clearance.....	3/32 in. (2.38 mm)

3-37. MAIN GENERATOR (cont)

CLEANING, INSPECTION, AND REPAIR (cont)

Table 3-4. Main Generator (cont)

Item	Specification
<b>Commutator Data</b>	
Type .....	Arch bound
Diameter (new) .....	12 in. (304.8 mm)
Diameter (minimum worn) .....	11-3/8 in. (288.9 mm)
Side mica thickness .....	0.030 in. (0.762 mm)
Side mica grooving depth .....	3/64 in. (1.19 mm)
Bearing Grease Capacity (70%) .....	6-1/2 oz (1894.28 g)
Type .....	RA 71005 (93508)
<b>Pole Bores (Measured between centers of opposite pole faces)</b>	
<b>Exciting Field</b>	
Maximum .....	15.204 in. (386.18 mm)
Minimum .....	15.185 in. (385.69 mm)
<b>Commutating Field</b>	
Maximum .....	15.597 in. (396.16 mm)
Minimum .....	15.581 in. (395.75 mm)
<b>Temperatures:</b>	
Temperature to heat flinger and bearing housing before seating bearing .....	212 to 230 $\pm$ F (100 to 110 $\pm$ C)
Temperature to heat bearing and flinger housing assembly before mounting on armature shaft .....	12 to 230 $\pm$ F (100 to 110 $\pm$ C)
Temperature to heat sleeve before mounting on armature shaft .....	212 to 230 $\pm$ F (100 to 110 $\pm$ C)
Torque to apply to armature fan cap-screws when installing on armature frame head .....	180 to 225 lb.-ft (244 to 305 N.m)
<b>Weights (approximate, for lifting purposes only)</b>	
Magnet frame (coiled).....	1550 lb (703.08 kg)
Armature .....	895 lb (405.97 kg)
Commutating pole piece and coil .....	3 5 lb (15.88 kg)
Exciting pole piece and coil .....	100 lb (45.36 kg)
Total generator .....	2450 lb (1 111.32 kg)

## 3-37. MAIN GENERATOR (cont)

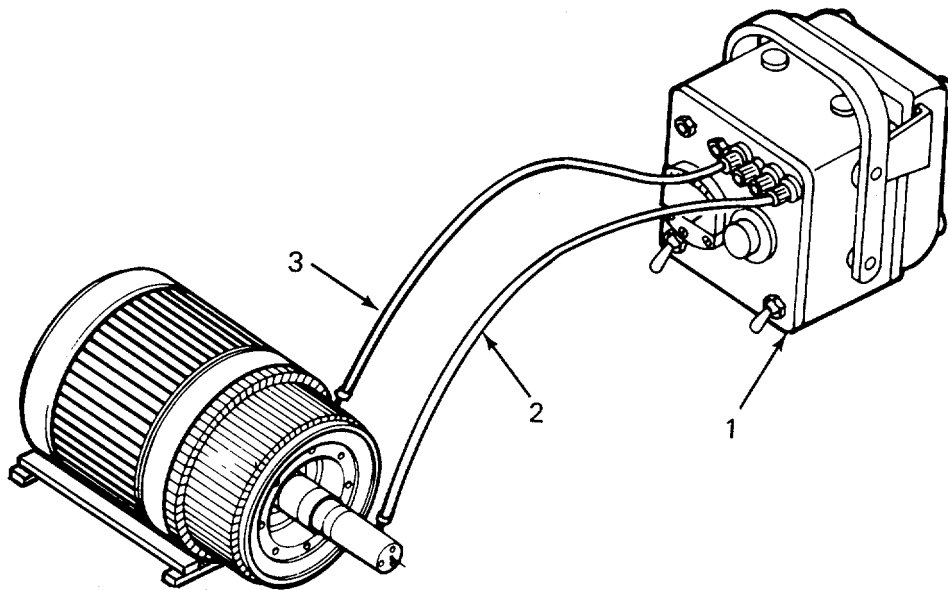
## TEST

30. Perform the armature and stator megohmmeter test by the following:

**NOTE**

**A minimum of 500 V at 1 megohm is required for this test.**

- a. Place lead (1) of megohmmeter (2) on shaft or core of armature (44).



- b. Place lead (3) of megohmmeter (2) on one of the commutator bars. Note indication on megohmmeter. Place lead (3) on each successive bar around the commutator and note indication.

**WARNING**

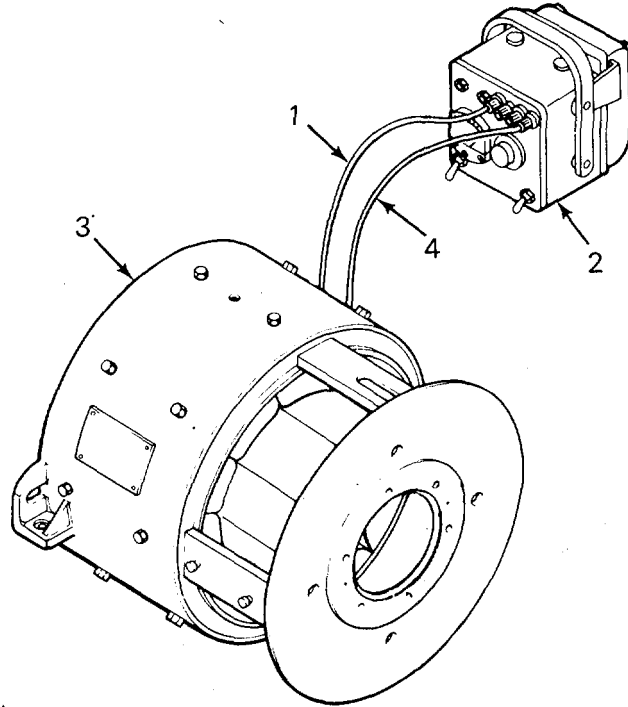
**Procedures specify the heating of parts to aid in disassembly and assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- c. If an indication of less than 3 megohms is obtained, bake armature for 4 hours at 230 $\pm$ F (110 $\pm$ C) in a convection oven. Recheck after cooling armature to room temperature. If the indication is still low, replace the armature.

## 3-37. MAIN GENERATOR (cont)

## TEST (cont)

- d. Attach lead (1) of megohmmeter (2) to lead GA on stator housing (3).



- e. Attach lead (4) of megohmmeter (2) to lead GAA on stator housing (3) and note indication on megohmmeter.
- f. Attach lead (1) of megohmmeter (2) to lead GSS on stator housing (3).
- g. Attach lead (4) of megohmmeter (2) to lead GSM on stator housing (3) and note indication on megohmmeter.

**WARNING**

**Procedures specify the heating of parts to aid in disassembly and assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

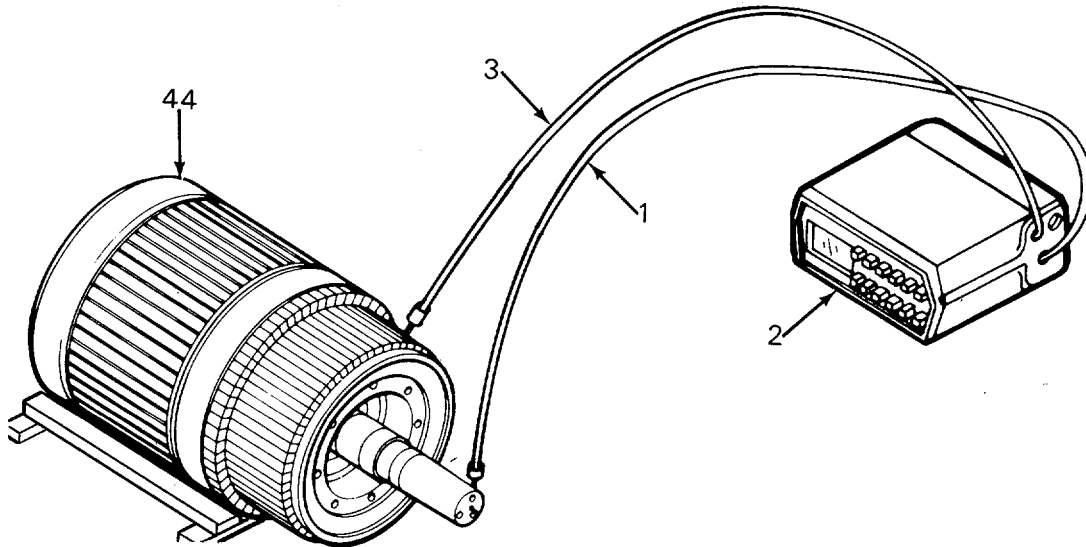
- h. If an indication of less than 3 megohms is obtained on the two sets of leads, bake stator for 4 hours at 230°F (110°C) in a convection oven. Recheck after cooling stator to room temperature. If the indications are still low, replace stator.

## 3-37. MAIN GENERATOR (cont)

## TEST (cont)

## 31. Perform bar-to-bar resistance test.

- a. Place lead (1) of multimeter (2) on the shaft or core of armature (44).



- b. Place lead (3) of multimeter (2) on one of the commutator bars. Note and record indications on multimeter. Place lead on each successive bar around the commutator and record each indication.
- c. If resistance indications are 10 percent or more above the average recorded indications on 20 or more connections, TIG weld all coil leads to commutator neck connections. Resistance indications of 1/2 percent below the average, or a full-scale meter deflection of the multimeter, indicates a shorted coil to the armature.

**WARNING**

**Procedures specify the heating of parts to aid in disassembly and assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- d. Below-average readings could indicate the presence of water in the coils. If below-average readings are obtained, bake armature in a convection oven for 4 hours at 230° (110±C).
- e. Cool at room temperature and repeat steps a and b above.
- f. If readings are still low, replace armature.

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3-37. MAIN GENERATOR (cont)

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## ASSEMBLY

**WARNING**

**Procedures specify the heating of parts to aid in assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

32. Place oil slinger (42) in bearing housing (43) and place on an induction heater. Heat parts to 212 to 230°F (100 to 110°C).
33. Remove bearing housing (43) and oil slinger (42) from heater. Install bearing (41) cold in housing.
34. Place bearing housing assembly on a induction heater. Heat parts to 212 to 230°F (100 to 110°C).
35. Remove bearing housing assembly from heater and install on shaft of armature (44), with oil slinger (42) tight against shaft shoulder and inner race of bearing (41) tight against oil slinger. Hold in place until cooled. Install bearing nut (40) tight against inner race of bearing.

**WARNING**

**Procedures specify the heating of parts to aid in disassembly and assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

36. Place sleeve (39) on an induction heater. Heat part to 212 to 230°F (100 to 110°C).
37. Remove sleeve (39) from heater. Install on shaft of armature (44) tight against bearing nut (40). Hold firmly in place until cooled. Rotate bearing assembly on shaft and check for binding.
38. Wrap a layer of insulation paper around commutator to protect it during assembly.
39. Position the two cradles with armature (44) behind cradle with magnet frame (45). Install the pipe over the armature shaft.
40. Use two slings and slowly feed armature (44) into magnet frame (45). Install six lockwashers (38) and capscrews (37). Draw armature into final position by tightening capscrews evenly and tightly.
41. Measure out 6-1/2 oz (187. 249 gm) of ball-bearing grease. Fill grease pocket in bearing cap (35) two-thirds full of grease. Smear remainder into and around bearing (41).

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3-37. MAIN GENERATOR (cont)

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## ASSEMBLY (cont)

42. Install gasket (36) on bearing cap (35), position bearing cap on bearing housing (42), and install six lockwashers (34) and capscrews (33).
43. Install pulley (32), locking plate (31), three lockwashers (30), and capscrews (29).
44. Remove insulating paper. Position four brush holders (28) in magnet frame (45). Install four locking plates (27), lockwashers (26), and capscrews (25). Connect electrical leads to brush holders and install four lockwashers (24) and capscrews (23). Position fan (22) and install 16 lockwashers (21) and capscrews (20). Lockwire capscrews.
45. Adjust brush holders to within 3/32 inch (2.38 mm) of commutator. Carbon way must be parallel to commutator segments.
46. Install brushes. Refer to TM 55-2210-224-12 for brush adjustment data.

## INSTALLATION

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

47. Install lifting eye (3). Use a suitable lifting device and lift main generator over mounting base.
48. Install two upper and lower pads (19) and slowly lower main generator, moving it toward engine. Lower into position on pads.
49. Install two capscrews (18), flat washers (17), castle nuts (16), and cotter pins (15).
50. Check that punch marks on engine flywheel and main generator line up.
51. Position ground cable (14) and install 16 lockwashers (13) and capscrews (12). Reach through large hole in bell housing and install eight capscrews (11), lockwashers (10), and nuts (9).
52. Position lines (8), two screens (7), and clamp (6) and install four lockwashers (5) and capscrews (4).
53. Connect electrical leads to main generator and remove tags.
54. Remove lifting eye (3). Install covers (2) and latch latches (1).
55. Close electrical equipment cabinet door.



3-38. EMERGENCY SHUTDOWN SWITCH

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly |                 |

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

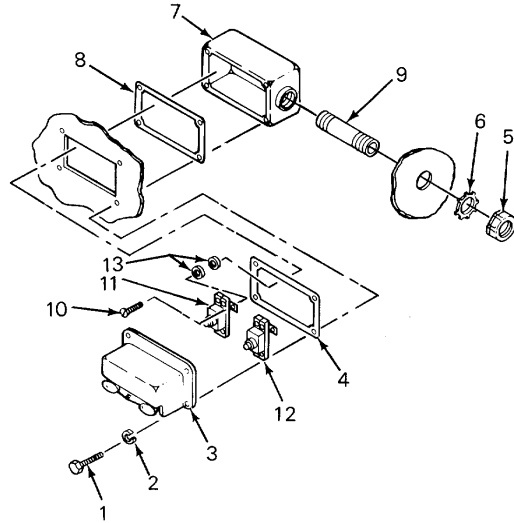
Material/Parts

Drycleaning solvent (Item 34, Appendix B)

REMOVAL

**WARNING**

- ⚠ Remove rings, bracelets, wristwatches, and neck chains before working around the locomotive. Jewelry can catch on equipment and cause injury, or may short across an electrical circuit and cause severe burns or electrical shock.
  - ⚠ High voltage is used in the operation of equipment. Do not be misled by the term LOW VOLTAGE. Potentials as low as 50 volts may cause death.
1. Open electrical equipment cabinet door and set battery switch to OPEN.



2. Remove four capscrews (1) and lockwashers (2). Remove front cover (3) and cork gasket (4).
3. Tag and disconnect wires from switches and pull wires through conduit.

DISASSEMBLY

4. Remove insulation bushing (5) and conduit nut (6).
5. Remove switch housing (7) and cork gasket (8) with conduit (9) from stair frame.
6. Remove conduit (9) from switch housing (7).
7. Remove four countersunk screws (10) and remove switches (11) and (12). Remove and retain washers (shims) (13) from between switches and switch housing. Keep washers in the order that they were removed.

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3-38. EMERGENCY SHUTDOWN SWITCH (cont)

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REMOVAL (cont)

CLEANING, INSPECTION, AND REPAIR

**WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

8. Use a cloth dampened with drycleaning solvent and remove dirt and grease from housing, shim, and insignia plate.
9. Repair consists of replacement of damaged parts. ASSEMBLY
10. Position washers (shims) (13) and switches (12) and (11) in switch housing (7) and install four countersunk screws (10).
11. Install conduit (9) into switch housing (7). INSTALLATION
12. Position cork gasket (8) and switch housing (7) in stair frame.
13. Install conduit nut (6) and insulation bushing (5).
14. Feed wires through conduit (9), connect to switches (11) and (12), and remove tags.
15. Position cork gasket (4) and front cover (3) on stair frame and install four lockwashers (2) and capscrews (1).
16. Close electrical equipment cabinet door.

---

**3-39. FUEL TANK AND FUEL LEVEL GAGE**

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This task covers:

- a. Removal   b. Cleaning   c. Inspection   d. Repair   e. Installation
- 

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

Equipment Condition

**Reference**

Para 3-59

**Condition Description**

Main air reservoirs removed

---

**REMOVAL****NOTE**

**Check that fuel tank is drained.**

1. Remove eight capscrews (1) and lockwashers (2). Remove two fuel filler pipe connections (3) and gaskets (4).
2. Disconnect two fuel supply lines (5) and fuel return lines (6).

---

**3-39. FUEL TANK AND FUEL LEVEL GAGE (cont)**

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3. Remove two capscrews (7), lockwashers (8), and clamps (9) from vent pipe (10). Disconnect pipe union (11).
4. Place a suitable support device under fuel tank (15).
5. Remove 20 nuts (12), lockwashers (13), and capscrews (14).

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

6. Use a suitable lifting device and remove fuel tank (15).
7. Remove six capscrews (16), lockwashers (17), fuel level gage (18), and gasket (19).

**CLEANING, INSPECTION, AND REPAIR**

8. Steam clean exterior of fuel tank (15) and remove dirt and grease.
9. Purge interior of fuel tank (15).
10. Check that pipes, connections, and vent valves are tight and do not leak.
11. Check that fuel level gage (18) is not cracked or broken.
12. Repair leaks by welding, sanding, and painting as required.
13. Replace damaged parts as required.

**INSTALLATION****WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

14. Position gasket (19) and fuel level gage (18) on tank (15) and install six lockwashers (17) and capscrews (16).
15. Use a suitable lifting device and position fuel tank (15). Install 20 capscrews (14), lockwashers (13), and nuts (12).
16. Connect union (11). Position vent pipe (10) and install two clamps (9), lockwashers (8), and capscrews (7).
17. Connect fuel return line (6) and fuel supply line (5).
18. Position two gaskets (4) and fuel filler pipe connections (3) on fuel tank (10) and install eight lockwashers (2) and capscrews (1).

## 3-40. COOLING FAN ASSEMBLY

This task covers:

- a. Removal
- b. Installation

INITIAL SETUPTools

Tool kit SC4940-97-CL-E12

Equipment Condition

Reference

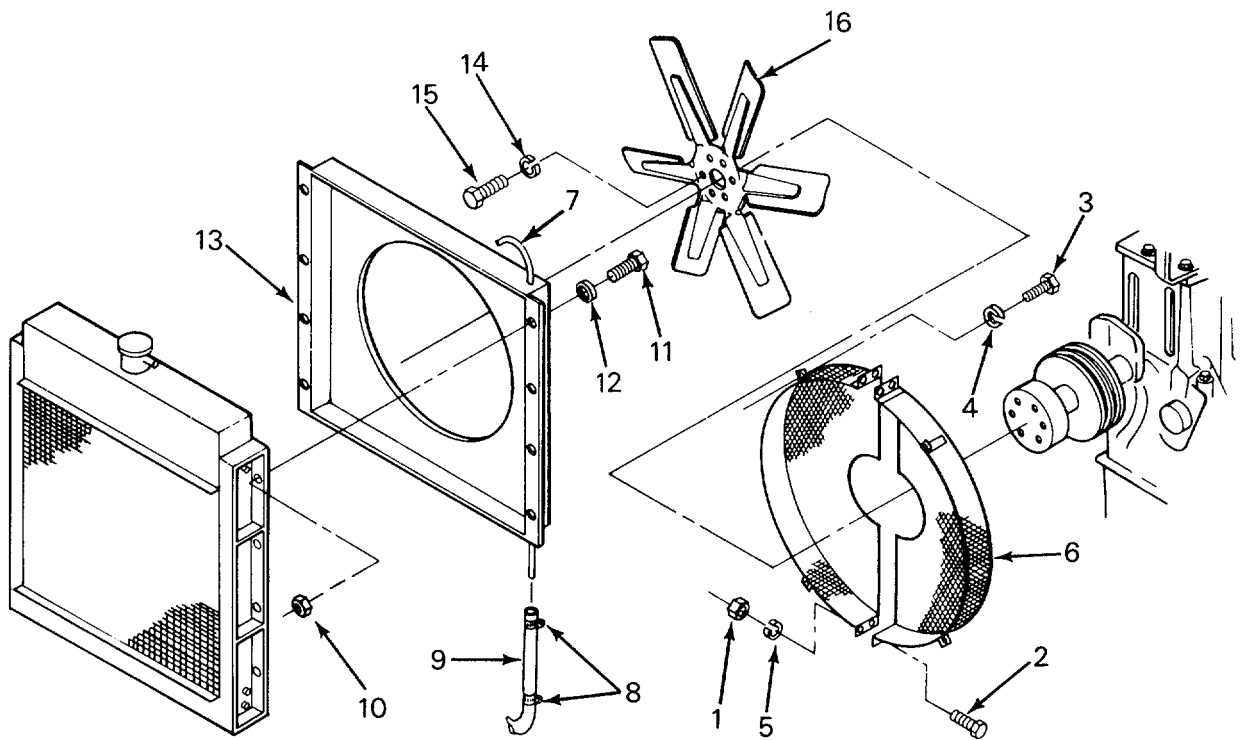
TM 5-2210-224-12

Condition Description

Cooling fan belts removed

REMOVAL

1. Remove 4 nuts (1) 11 bolts (2) and (3), lockwashers (4) and (5) and remove 2 screens (6).
2. Remove radiator overflow hose (7) from top of radiator. Loosen two hose clamps (8) and remove hose (9).
3. Remove eight locknuts (10), bolts (11), and flat washers (12) and position fan shroud (13) out of the way.
4. Remove six bolts (14) and lockwashers (15) that secure fan (16) to fan shaft.
5. Use a puller and remove fan (16) from shaft.



---

**3-40. COOLING FAN ASSEMBLY (cont)**

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**INSTALLATION**

6. Position fan (16) on fan shaft and secure with six lockwashers (15) and bolts (14).
7. Slide fan shroud (13) over fan (16) and secure with eight flat washers (12), bolts (11), and locknuts (10).
8. Install hose (9) and tighten two hose clamps (8).
9. Install radiator overflow hose (7) on top of radiator.
10. Position 2 screens (6) and install 11 lockwashers (5) and (4) and bolts (3) and (2), and 4 nuts (1).

3-41. RADIATOR

This task covers:

a. Removal

b. Test

c. Installation

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
Suitable lifting device

Personnel Required

2

Material/Parts

Ethylene glycol antifreeze (Item 2, Appendix B)

Equipment Condition

Reference

Para 3-7  
Para 3-40

Condition Description

Engine hood removed  
Fan and fan shroud removed

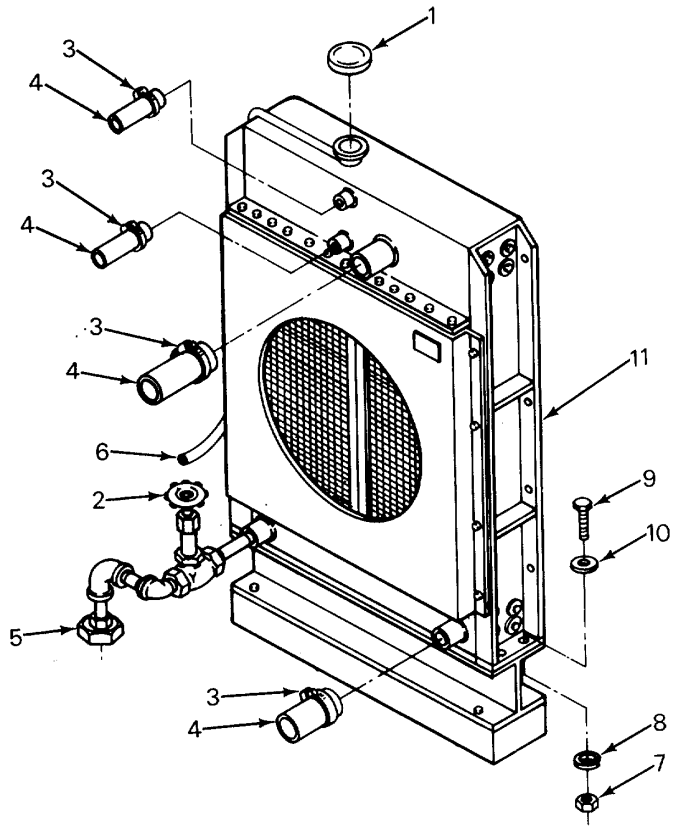
REMOVAL

1. Drain coolant from locomotive cooling system by the following:
  - a. Remove radiator filler cap (1) to prevent air lock.
  - b. Open main drain valve (2) and drain coolant.
2. Loosen hose clamps (3) on four hoses (4). Slide hoses off radiator connections.
3. Disconnect union (5) in drain line. Remove overflow hose (6) from drain line.

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

4. Use a suitable lifting device and support radiator.
5. Remove four nuts (7), lockwashers (8), capscrews (9), and flat washers (10).
6. Lift radiator (11) from locomotive and place on suitable support.



## 3-41. RADIATOR (cont)

## TEST

7. Apply 10 psi (69 kPa) air pressure to radiator and submerge radiator in a water tank. Check for air leaks. Straighten bent fins as required.

## INSTALLATION

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

8. Use a suitable lifting device and lift radiator assembly (11) into place. Install four flat washers (10), capscrews (9), lockwashers (8), and nuts (7).
9. Install radiator overflow hose (6) and connect union (5).
10. Install four hoses (4) and tighten hose clamps (3).
11. Close main drain valve (2) and fill radiator with a mixture of ethylene glycol antifreeze and water. Refer to TM 55-2210- 225-12 for cooling system filling procedures. Install radiator filler cap (1).



3-42. AIR COMPRESSOR ASSEMBLY

This task covers:

a. Removal

b. Installation

c. Test

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
 Air gage  
 Strobe light  
 Suitable lifting device

Material/Parts

Antiseize tape (Item 35, Appendix B)

Equipment Condition Reference

Para 3-7  
 TM 55-2210-224-12

Condition Description

Hood removed  
 Air compressor belts removed

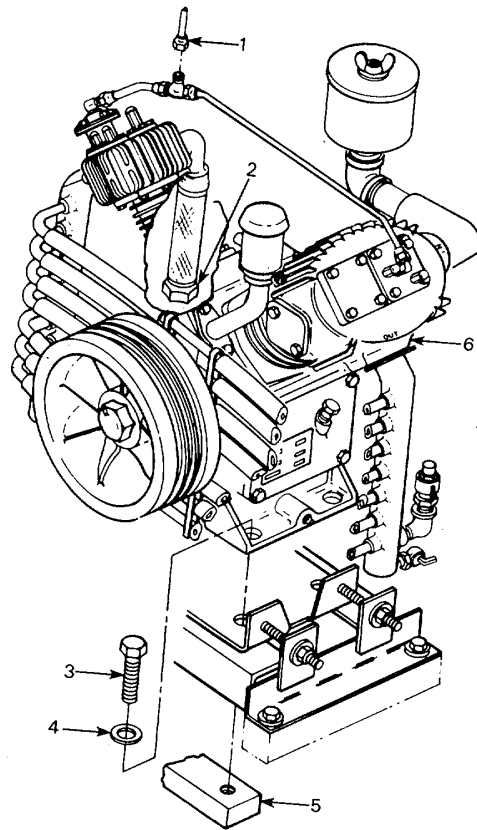
REMOVAL

1. Drain oil from crankcase.
2. Disconnect unloader air line fitting (1).
3. Disconnect flex pipe (2).
4. Remove four bolts (3), lockwashers (4), and two bars (5).

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

5. Use a suitable lifting device and slowly remove air compressor (6). Set on suitable support device.



---

3-42. AIR COMPRESSOR ASSEMBLY (cont)

---

## INSTALLATION

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

6. Use a suitable lifting device and slowly lift air compressor (6) on locomotive deck.
7. Position two bars (5) and install four lockwashers (4) and bolts (3).
8. Use antiseize tap and connect flex pipe (2). Connect unloader air line fitting (1).
9. Refer to TM 55-2210-224-12 and install and adjust belts.
10. Refer to LO 55-2210-224-12 and fill air compressor with oil.
11. Refer to paragraph 4-8 and test and inspect air compressor.

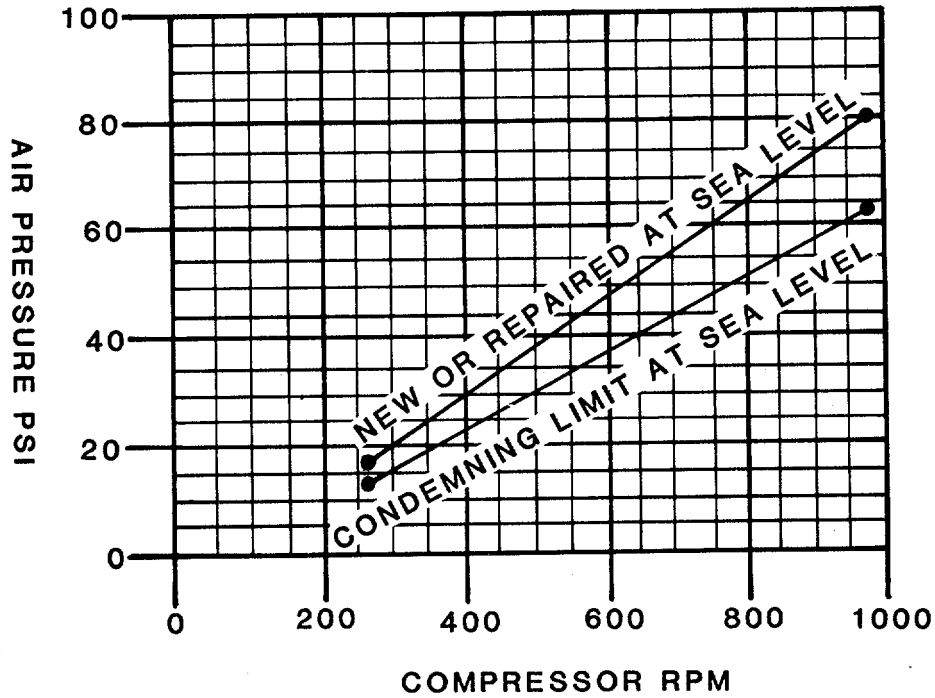
## TEST

12. Connect an orifice holder with 1/4-inch (6.4 mm) orifice in the plugged hole at the bottom of No. 1 air reservoir. Use orifice with square edges bored through plate 1/16 inch (1.6 mm) thick.
13. Connect a calibrated test gage in reservoir No. 2. Disconnect electrical leads to automatic drain valves at timer in high-voltage cabinet. Check that all air-operated devices on locomotive are shut off.
14. Start engine No. 1 and idle until engine and compressor are warm. Place throttle lever in position No. 3. Operate engine in throttle position No. 3 until air pressure in reservoir No. 2 is stabilized.
15. Record reading from test gage in reservoir No. 2.
16. Place throttle lever in idle position and let engines idle for a minimum of 2 minutes. Shut down engine. Drain air reservoir No. 2 to 50 psi (345 kPa).
17. Start No. 2 engine and idle until engine and compressor are warm. Repeat steps 14 thru 16 and test compressor No. 2.
18. Compare readings with table 3-4. Readings must be above condemning limits after compensating for altitudes. Drain air from reservoirs. Remove orifice and test gage. Install plugs.

3-42. AIR COMPRESSOR ASSEMBLY (cont)

TEST (cont)

Table 3-4. Compressor Passing and Condemning Limit



AVLAL TYPE AIR COMPRESSORS  
 LIMITING PRESSURES vs. SPEED  
 (SEA LEVEL CONDITIONS)  
 (DATA IS BASED ON THE FOLLOWING)

NOTES: High-pressure orifice test is calculated using the following conditions:

- (1) 0. 250-inch diameter orifice with square edges, bored through 0. 0625-inch thick plate.
- (2) Orifice coefficient 85%.
- (3) Atmospheric pressure 14. 7 (for higher altitudes, deduct 1% from pressures for each 260 feet above sea level)
- (3) Atmospheric pressure 14. 7 (for higher altitudes, deduct IT from pressures for each 260 feet above sea level.)
- (4) Compressor displacement 103. 5 cfm at 980 rpm.
- (5) Volumetric efficiency 70% for new unit.
- (6) Condemning limit 80% of new unit.

3-43. AIR COMPRESSOR SAFETY VALVE

This task covers:

- a. Removal
- b. Test
- c. Adjustment
- d. Installation

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Antiseize tape (Item 35, Appendix B)

REMOVAL

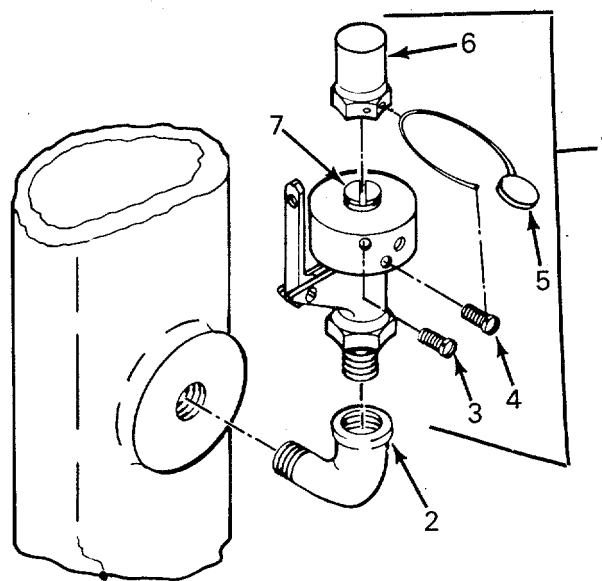
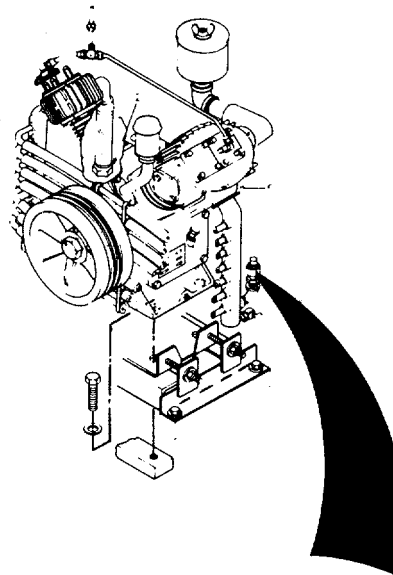
**WARNING**

- ⌚ Whenever the air compressor safety valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the air compressor safety valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the air compressor safety valve. Residual air may escape and cause injury to personnel.

**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove air compressor safety valve (1) from street elbow (2).
2. If necessary, remove street elbow (2).



---

3-43. AIR COMPRESSOR SAFETY VALVE (cont)

---

TEST AND ADJUSTMENT

3. Apply 55 psi (379 kPa) of air pressure to safety valve.
4. Remove screws (3) and (4) lockwire and seal (5).
5. Remove capnut (6) and turn adjusting nut (7) until safety valve blows at 55 psi (379 kPa).
6. Install capnut (7). Install lockwire and seal (5) and screws (4) and (3).

INSTALLATION

7. Apply antiseize tape to threads of air compressor safety valve (1).
8. Install air compressor safety valve (1) in street elbow (2).

3-44. AIR COMPRESSOR GOVERNOR ASSEMBLY

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly | h. Test         |

INITIAL SETUP

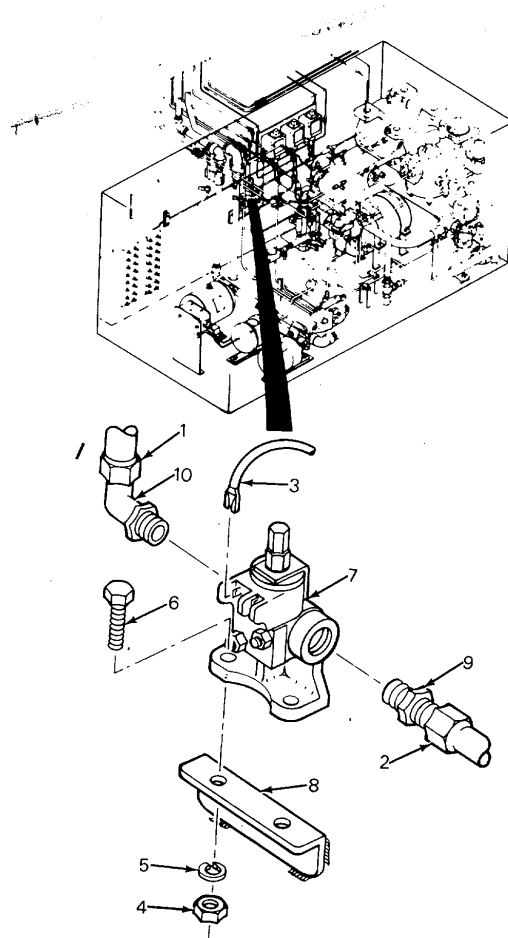
- |                           |   |
|---------------------------|---|
| <u>Tools</u>              | <u>Material/Parts</u>                     |
| Tool kit SC4940-97-CL-E12 | Drycleaning solvent (Item 34, Appendix B) |

REMOVAL

**WARNING**

- ⌚ Whenever the air compressor governor is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the air compressor governor functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the air compressor governor. Residual air may escape and cause injury to personnel.

1. Remove air line fittings (1) and (2). Tag and disconnect electrical leads (3).
2. Remove two nuts (4), lockwashers (5), and capscrews (6). Remove governor (7) from mounting bracket (8). Remove adapter (9) and elbow (10) from governor.



3-44. AIR COMPRESSOR GOVERNOR ASSEMBLY (cont)

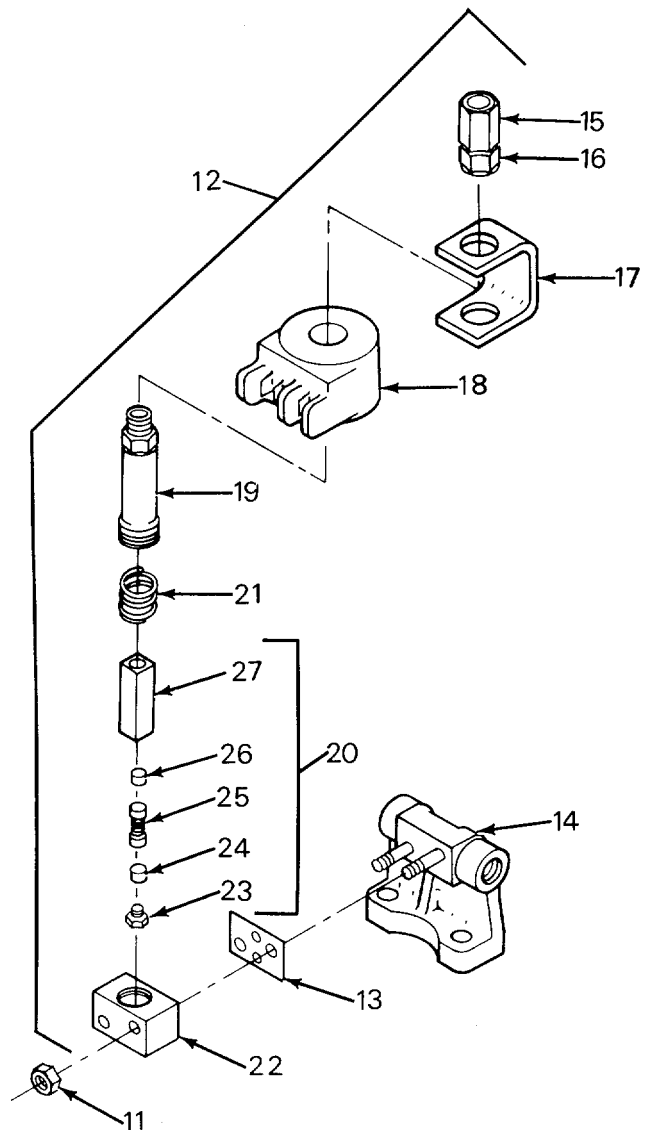
DISASSEMBLY

3. Remove two nuts (11) and remove valve assembly (12) and gasket (13) from bracket (14).
4. Remove exhaust nut (15), seal (16), field yoke (17), and coil (18).
5. Remove valve (19), plunger assembly (20), and spring (21) from valve body (22).
6. Disassemble plunger assembly (20) by removing cap (23), seat (24), spacer (25), and seat (26) from body (27).

CLEANING, INSPECTION, AND REPAIR

**WARNING**

- ⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.



7. Use a cloth dampened with drycleaning solvent and remove dirt, grease, and oil from body. Dry with compressed air.
8. Use drycleaning solvent and remove dirt, grease, and oil from parts. Dry with compressed air.

**NOTE**

If it is necessary to replace a valve or valve seat, they must be replaced as a combination valve and valve seat assembly because of required close tolerances.

9. Inspect metal parts for cracks, breaks, cuts, or other damage. Replace damaged parts.

---

**3-43. AIR COMPRESSOR GOVERNOR ASSEMBLY (cont)**

---

**DISASSEMBLY (cont)**

10. Check that the spring is not rusted or distorted or have taken a permanent set. Replace damaged spring.
11. Use a multimeter and measure resistance of coil (18). If resistance is not 80 ohms  $\pm$  5%, replace coil.

**ASSEMBLY**

12. Assemble plunger assembly (20) by installing seat (26), spacer (25), seat (24), and cap (23) in valve body (27).
13. Install spring (21) and plunger assembly (20) in valve (19) and install in valve body (22).
14. Position field yoke (18) and coil (17) on valve body (22) and install seal (16) and exhaust nut (15).
15. Position gasket (13) and valve assembly (12) on bracket (14) and install two nuts (11).

**INSTALLATION**

16. Install elbow (10) and adapter (9) in governor (7).
17. Position governor (7) on mounting bracket (8) and install two capscrews (6), lockwashers (5), and nuts (4). Connect electrical leads (3) and remove tags. Install air line fittings (2) and (1).

**TEST**

18. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.



---

3-45. AUTOMATIC BRAKE VALVE

---

This task covers:

- a. Removal    b. Installation    c. Test
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

---

**REMOVAL****WARNING**

- ⓘ **Whenever the automatic brake valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the automatic brake valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the automatic brake valve. Residual air may escape and cause injury to personnel.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P.**

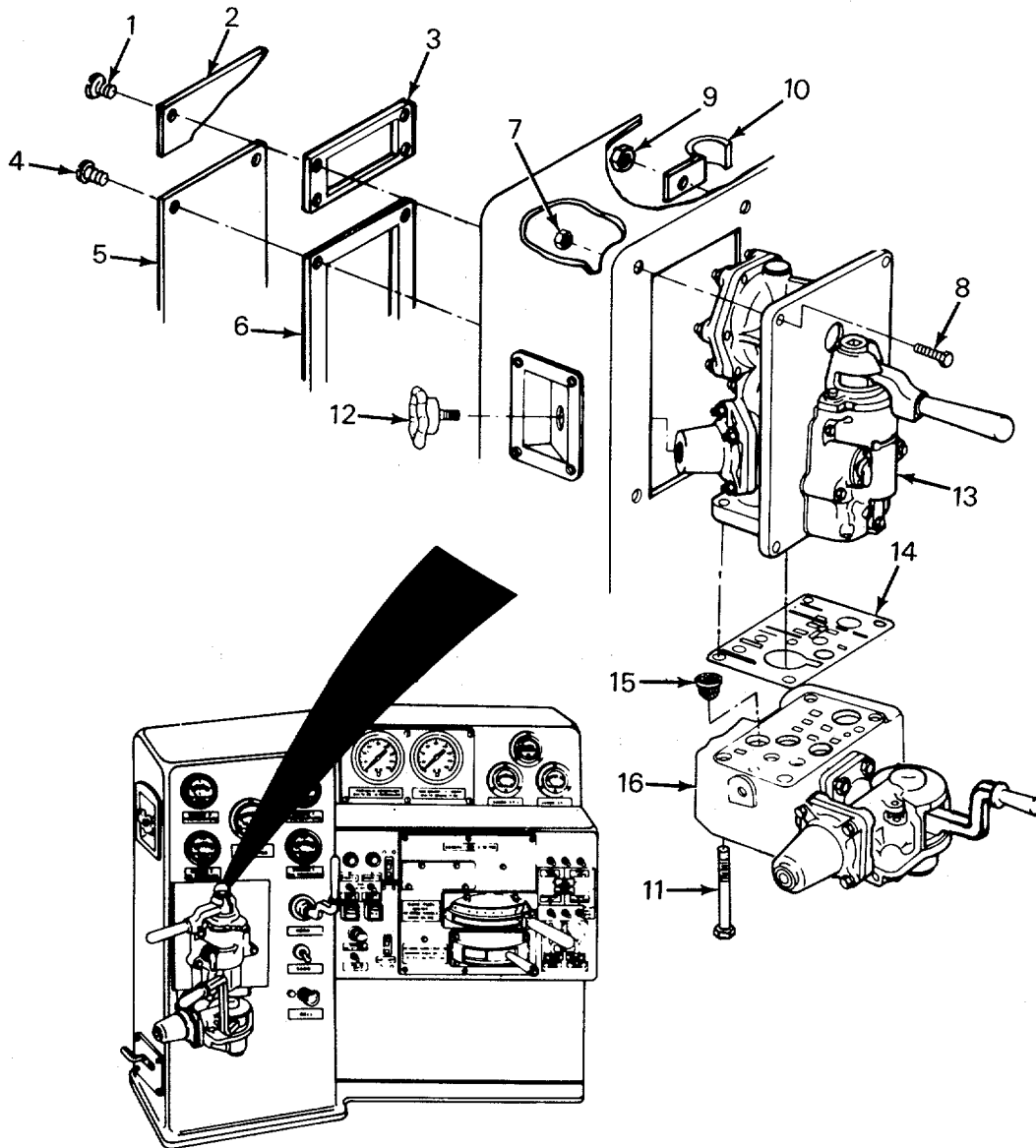
1. Remove eight screws (1), cover (2), and gasket (3).
2. Remove eight screws (4), cover (5), and gasket (6).
3. Remove four locknuts (7) and bolts (8).
4. Remove nut (9) and clamp (10). Position tube clamp out of the way. Replace nut.
5. Remove four bolts (11). Remove regulator handle (12).
6. Remove automatic brake valve (13).
7. Remove gasket (14) and strainer (15) from pipe bracket (16).

3-45. AUTOMATIC BRAKE VALVE (cont)

REMOVAL (cont)

NOTE

Automatic brake valve must be repaired at intermediate general support level facility.



---

3-45. AUTOMATIC BRAKE VALVE (cont)

---

## INSTALLATION

8. Position strainer (15) and gasket (14) on pipe bracket (16).
9. Position automatic brake valve (13) and install four bolts (11). Install regulator handle (12).
10. Remove nut (9), position clamp (10), and replace nut.
11. Install four bolts (8) and locknuts (7).
12. Position gasket (6) and panel (5) and install eight screws (4).
13. Position gasket (3) and panel (2) and install eight screws (1).

## TEST

14. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

3-46. INDEPENDENT BRAKE VALVE

This task covers:

- a. Removal
- b. Installation
- c. Test

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

REMOVAL

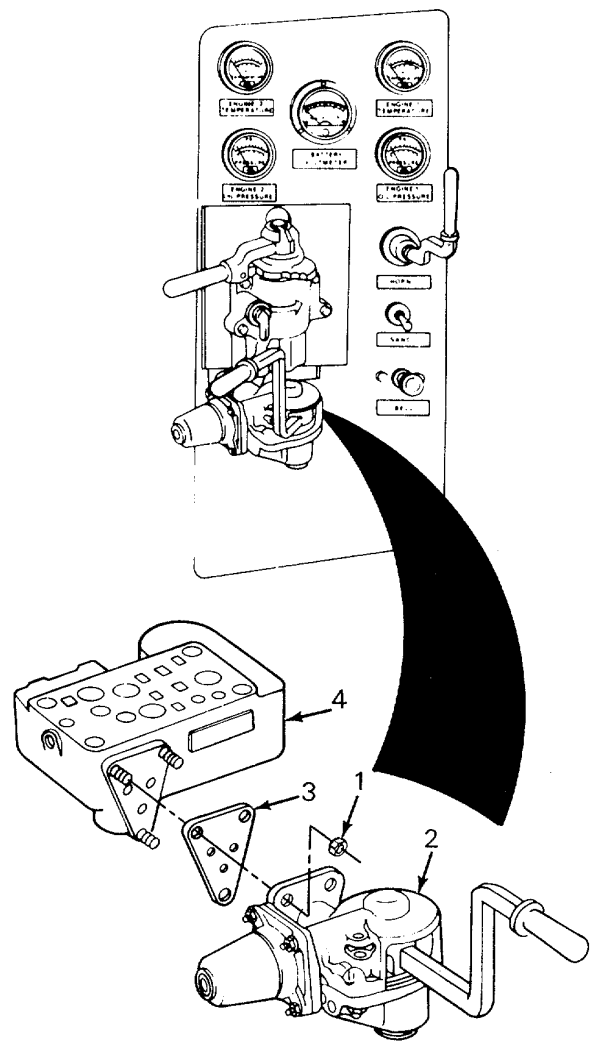
**WARNING**

- ⌚ Whenever the independent brake valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the independent brake valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the independent brake valve. Residual air may escape and cause injury to personnel.

**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210224-24P for identification of piping.

1. Remove three nuts (1).
2. Remove independent brake valve (2) and gasket (3) from pipe bracket (4).



---

3-46. INDEPENDENT BRAKE VALVE (cont)

---

REMOVAL (cont)

**NOTE**

**Independent brake valve must be repaired at intermediate general support level maintenance facility.**

INSTALLATION

3. Position gasket (3) and independent brake valve (2) on pipe bracket (4) and install three nuts (1).

TEST

4. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

---

### 3-47. 6-NFR DISTRIBUTING VALVE

---

This task covers:

a. Removal

b. Installation

c. Test

---

### INITIAL SETUP

#### Tools

Tool kit SC4940-97-CL-E12

---

### REMOVAL

#### **WARNING**

- ⓘ Whenever the 6-NFR distributing valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the 6-NFR distributing valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⓘ Make sure air is drained before removal of the 9 6-NFR distributing valve. Residual air may escape and cause injury to personnel.

#### **NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

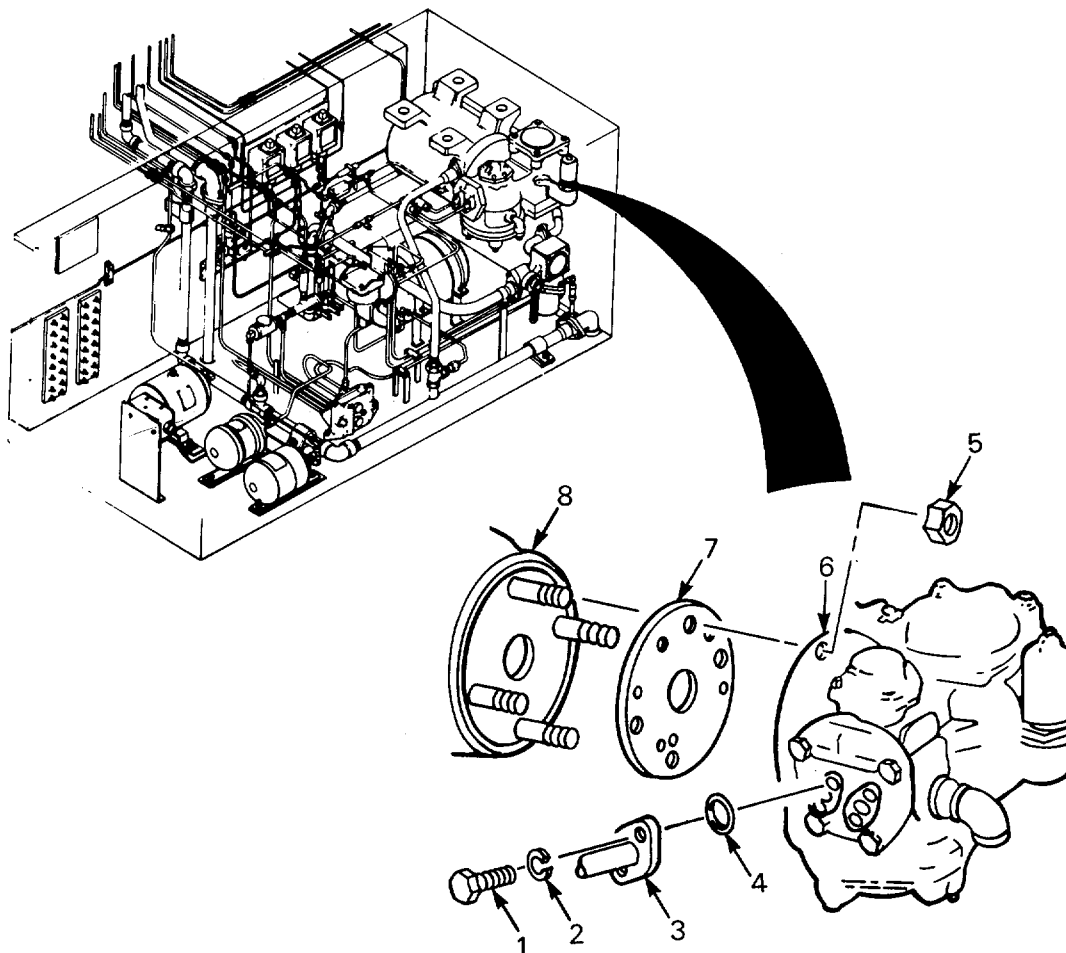
1. Remove four bolts (1) and lockwashers (2). Disconnect two air line fittings (3) and remove O-rings (4).
2. Remove four nuts (5).
3. Remove 6-NFR distributing valve (6).
4. Remove rubber gasket (7) from reservoir tank (8).

## 3-47. 6-NFR DISTRIBUTING VALVE (cont)

## REMOVAL (cont)

## NOTE

The 6-NFR distributing valve must be repaired at intermediate general support level maintenance facility.



## INSTALLATION

5. Position rubber gasket (7) and 6-NFR distributing valve (6) on reservoir tank (8).
6. Install four nuts (5).
7. Connect two O-rings (4) and air line fittings (3) and install four lockwashers (2) and bolts (1).

## TEST

8. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

---

**3-48. 6-NFR DISTRIBUTING VALVE SAFETY VALVE**

---

This task covers:

- a. Test                      b. Removal                      c. Installation                      d. Adjustment
- 

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

**Material/Parts**

Antiseize tape (Item 35, Appendix B)

---

**TEST****WARNING**

- ⓘ **Whenever the 6-NFR distributing valve safety valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the 6-NFR distributing safety valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the 6-NFR distributing valve safety valve. Residual air may escape and cause injury to personnel.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Start locomotive and let air pressure build up.
2. Move automatic brake valve handle to FULL APPLICATION.
3. Monitor brake cylinder air pressure gage and move automatic brake valve handle into the service zone until brake cylinder pressure rises to 67 psi (462 kPa). Between 67 and 68 psi (462 and 469 kPa), the 6-NFR distributing valve safety valve should blow. If the safety valve is adjusted incorrectly, refer to steps 7 thru 9.



**3-48. 6-NFR DISTRIBUTING VALVE SAFETY VALVE (cont)**

**REMOVAL**

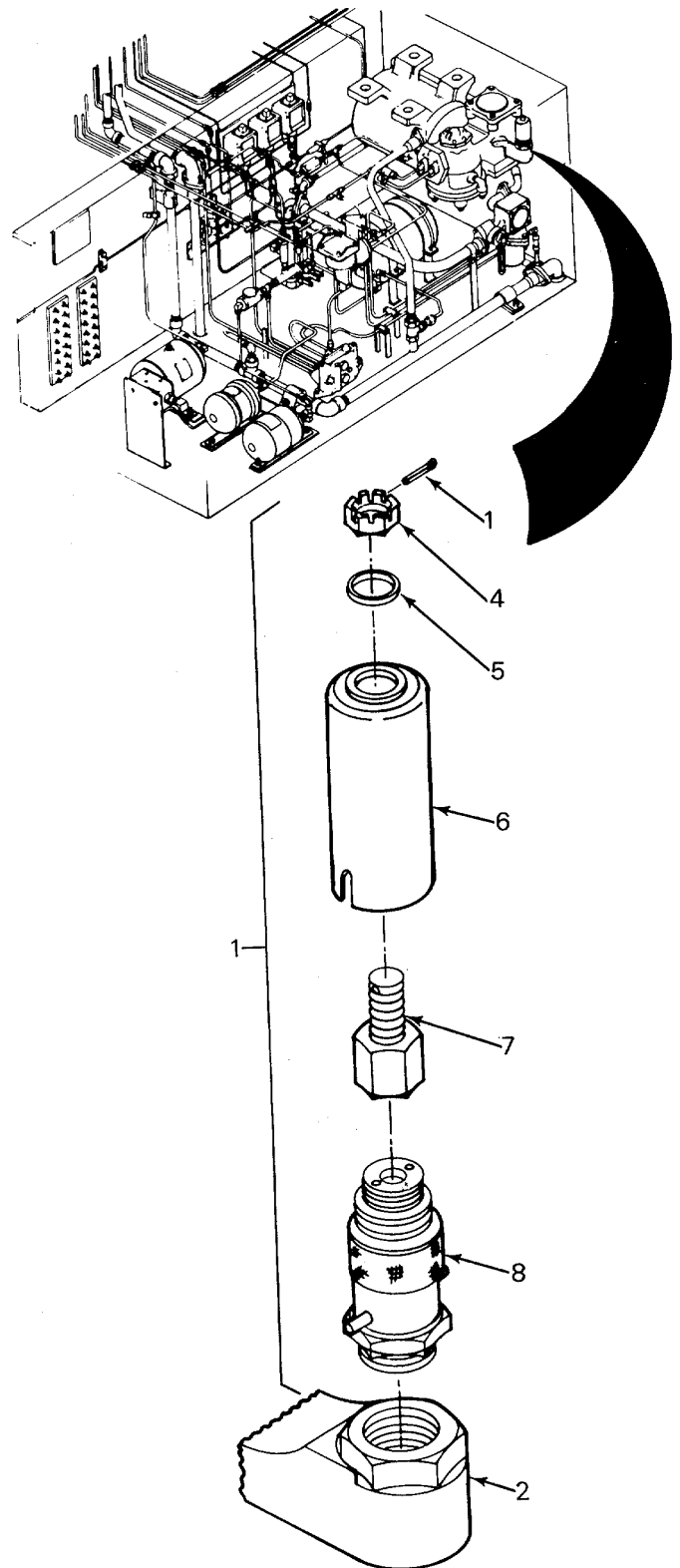
4. Remove 6-NFR distributing valve safety valve (1) from elbow (2).

**INSTALLATION**

5. Apply antiseize tape to threads of 6-NFR distributing valve safety valve (1).
6. Install 6-NFR distributing valve safety valve (1) in elbow (2).

**ADJUSTMENT**

7. Remove lockwire, cotter pin (3), nut (4), flat washer (5), and cover (6). Apply 67 psi (462 kPa) of air pressure to safety valve.
8. Remove locknut (7) and turn adjustment screw (8) until safety valve blows at 67 psi (462 kPa).
9. Install locknut (7). Position cover (6) and install flat washer (5), nut (4), cotter pin (3), and lockwire.



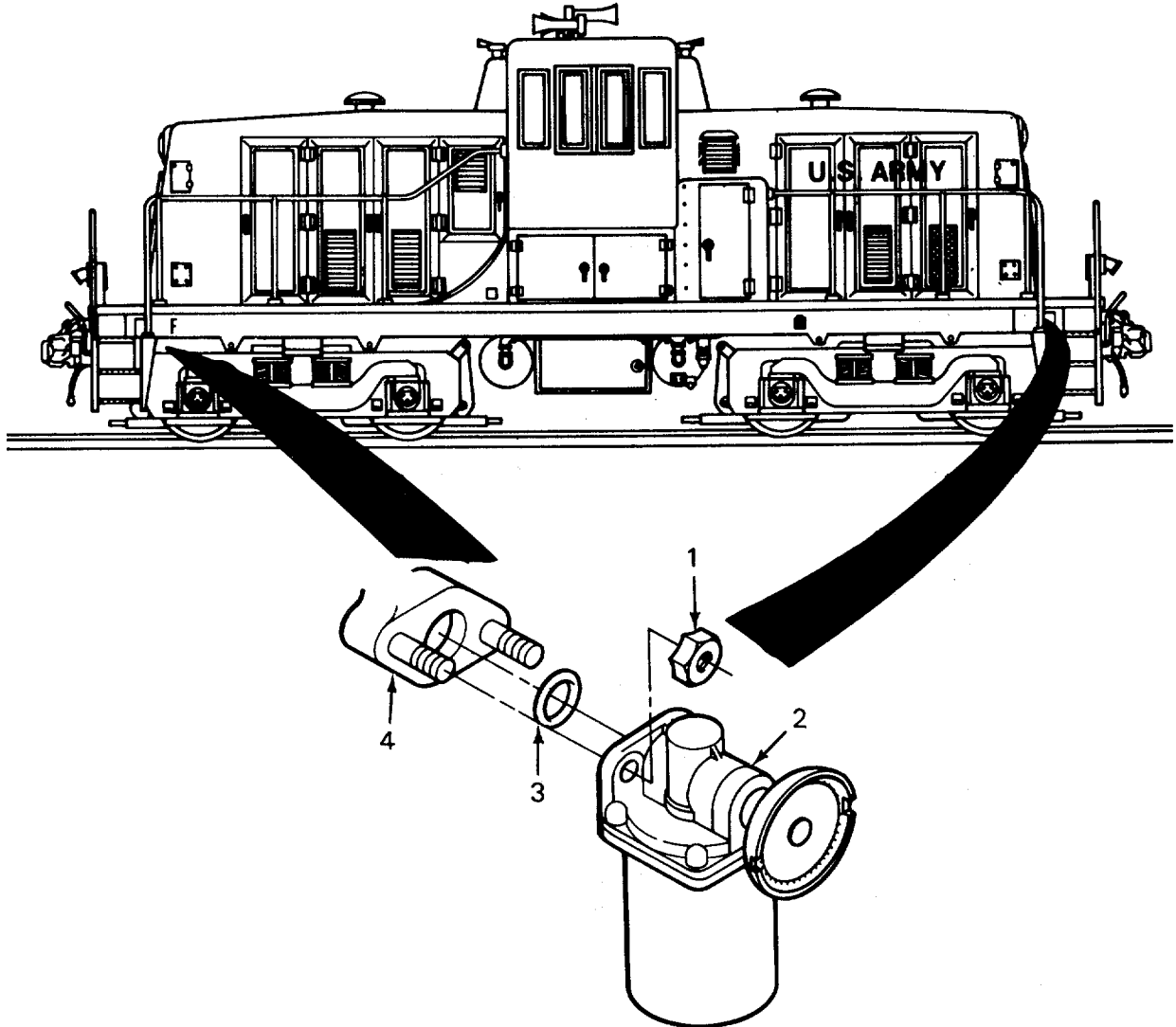


## 3-49. NO. 8 VENT VALVE (cont)

## REMOVAL (cont)

## NOTE

The No. 8 vent valve must be repaired at intermediate general support level maintenance facility.



## INSTALLATION

4. Position O-ring (3) and No. 8 vent valve (2) on pipe bracket (4) and install two nuts (1).
5. Repeat step 4 and install remaining No. 8 vent valve.

## TEST

6. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

---

**3-50. A-1 CHARGING CUTOFF PILOT VALVE**

---

This task covers:

- a. Removal
  - b. Installation
  - c. Test
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

**REMOVAL****WARNING**

- ⓘ Whenever the A-1 charging cutoff pilot valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the A-1 charging cutoff pilot valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⓘ Make sure air is drained before removal of the A-1 charging cutoff pilot valve. Residual air may escape and cause injury to personnel.

**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove two bolts (1).
2. Remove A-1 charging cutoff pilot valve (2) and gasket (3) from pipe bracket (4).

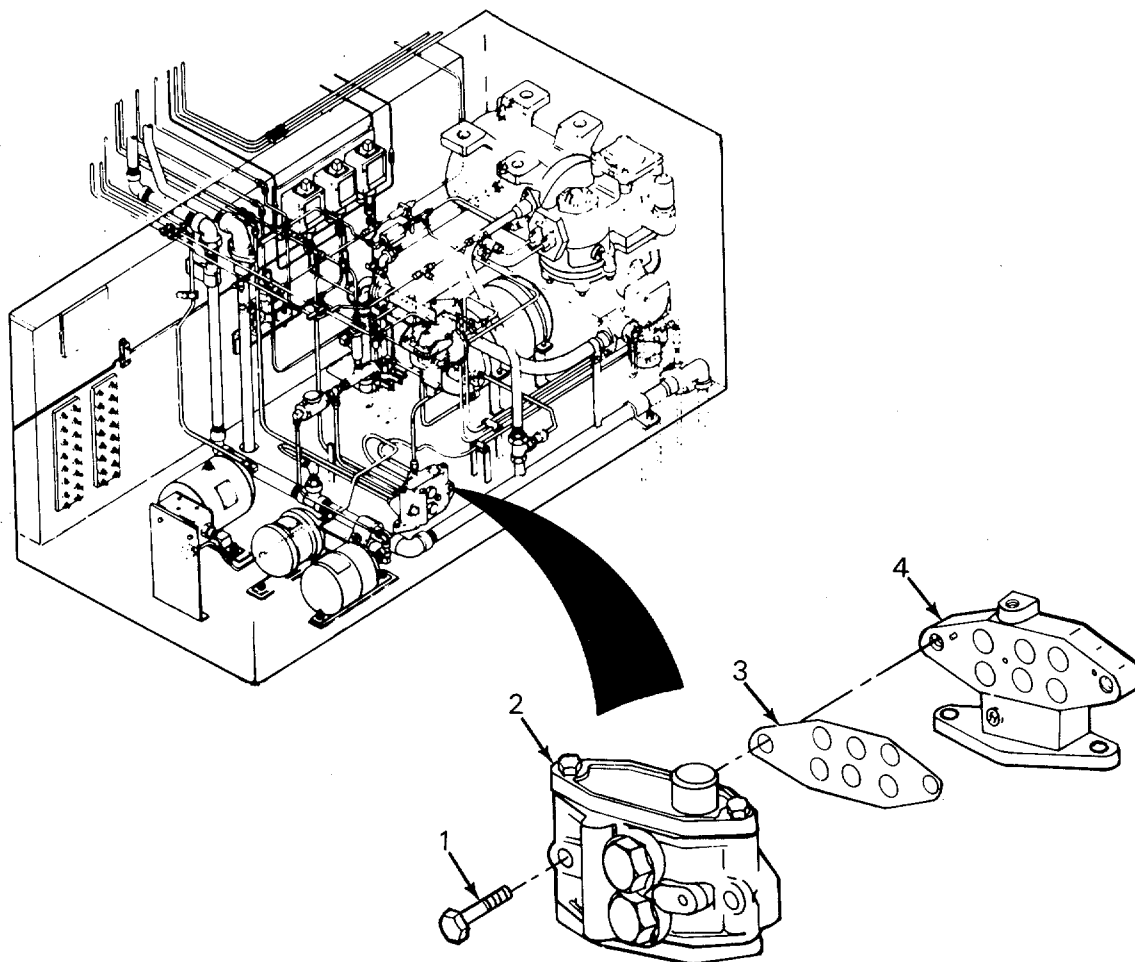
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**3-50. A-1 CHARGING CUTOFF PILOT VALVE (cont)**

---

**REMOVAL (cont)****NOTE**

A-1 charging cutoff pilot valve must be repaired at intermediate general support maintenance facility.

**INSTALLATION**

3. Position gasket (3) and A-1 charging cutoff pilot valve (2) on pipe bracket (4) and install two bolts (1).

**TEST**

4. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.



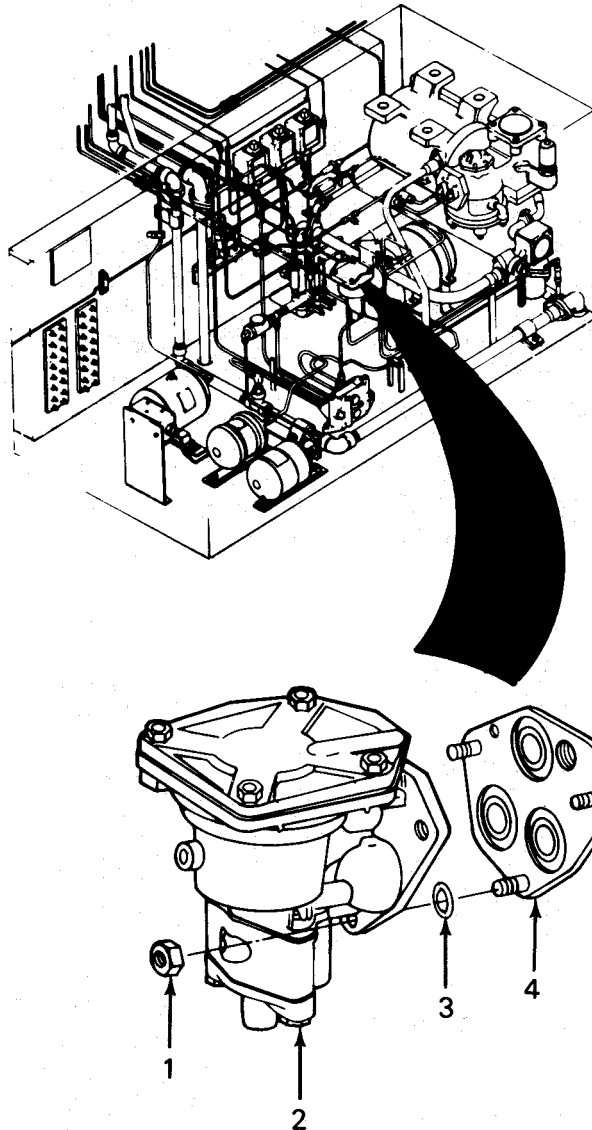
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**3-51. H-5 RELAY AIR VALVE (cont)**


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**REMOVAL (cont)****NOTE**

The H-5 relay air valve must be repaired at intermediate general support level maintenance facility

**INSTALLATION**

3. Install three O-rings (3) and H-5 relay air valve (2) on pipe bracket (4) and secure with three nuts (1)

**TEST**

4. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

---

## 3-52. EMERGENCY BRAKE VALVE

---

This task covers:

- a. Removal
  - b. Installation
  - c. Test
- 

### **INITIAL SETUP**

#### Tools

Tool kit SC4940-97-CL-E12

### **REMOVAL**

#### **WARNING**

- ⓘ **Whenever the emergency brake valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the emergency brake valve functions properly in the brake equipment arrangement. Failure to perform-test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the emergency brake valve. Residual air may escape and cause injury to personnel.**

#### **NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210- 224-24P for identification of piping.**

1. Remove two locknuts (1) and bolts (2).
2. Remove emergency brake valve (3) with exhaust pipe assembly (4) from cab floor.
3. Remove gasket (5) from pipe flange (6).
4. Remove pipe (7), elbow (8), nipple (9), elbow (10), and nipple (11).



---

**3-52. EMERGENCY BRAKE VALVE (cont)**

---

**REMOVAL (cont)****NOTE**

**Emergency brake valve must be repaired at intermediate general support level maintenance facility.**

**INSTALLATION**

5. Install nipple (11) in emergency brake valve (3) and install elbow (10), nipple (9), elbow (8), and pipe (7) so they are opposite handle.
6. Install gasket (5) on pipe flange (6).
7. Install emergency brake valve (3) and exhaust pipe assembly (4).
8. Install two bolts (2) and locknuts (1).

**TEST**

9. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.



---

**3-53. STRAINER AND CHECK VALVE (cont)**

---

**INSTALLATION**

4. Position strainer and check valve (6) in control panel (7) and connect-air line fittings (5) and (4).
5. Position gasket (3) and cover (2) and install eight screws (1).

**TEST**

6. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

**3-54. NO. 24 DOUBLE CHECK VALVE**

This task covers:

- a. Removal
- b. Installation
- c. Test

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

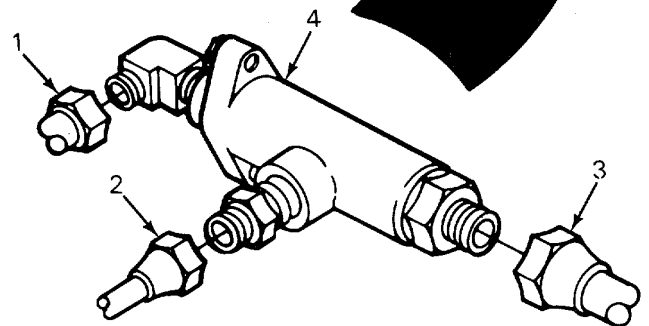
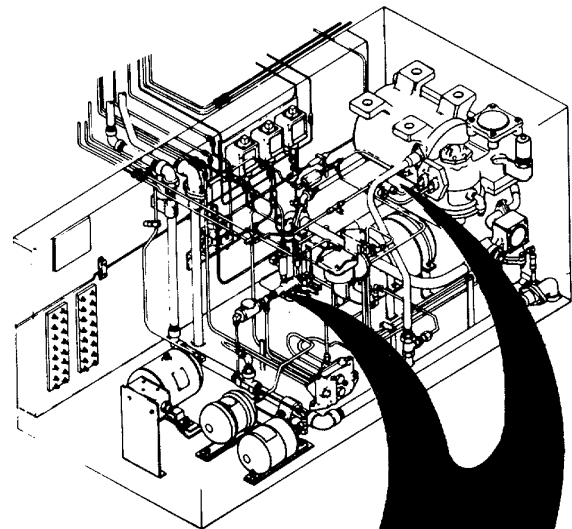
**REMOVAL**

**WARNING**

- ⌚ Whenever the No. 24 double check valve is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the No. 24 double check valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the No. 24 double check valve. Residual air may escape and cause injury to personnel.

**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.



1. Disconnect aft line fittings (1), (2), and (3). Remove No. 24 double check valve (4) from brake component.
2. Remove two remaining No. 24 double check valves in a similar manner.

---

**3-54. NO. 24 DOUBLE CHECK VALVE (cont)**

---

**INSTALLATION**

3. Position No. 24 double check valve (4) in brake compartment. Connect airline fittings (3), (2), and (1).
4. Install two remaining No. 24 double check valve in a similar manner.

**TEST**

5. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

**3-55. CUTOUT COCK AND STRAINER**

This task covers:

- a. Removal
- b. Installation
- c. Test

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

**REMOVAL**

**WARNING**

- ⚠ Whenever the cutout cock and strainer is removed and installed for any reason, a stationary locomotive airbrake test (para 2-9) must be performed to check that the cutout cock and strainer functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⚠ Make sure air is drained before removal of the cutout cock and strainer. Residual air may escape and cause injury to personnel.

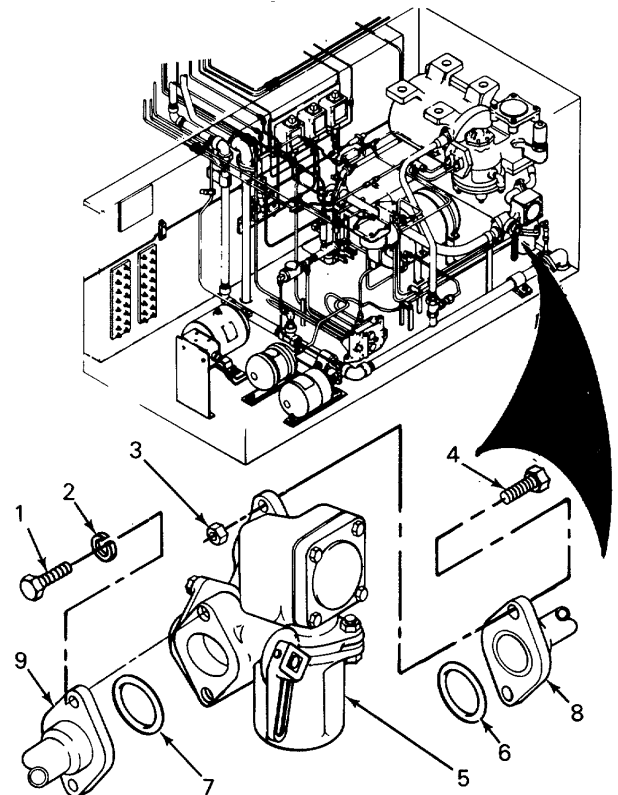
**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove two bolts (1), lockwashers (2), locknuts (3), and bolts (4).
2. Remove cutout cock and strainer (5).
3. Remove gaskets (6) and (7) from pipe flanges (8) and (9).

**NOTE**

Cutout cock and strainer must be repaired at intermediate general support level maintenance facility.



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**3-55. CUTOUT COCK AND STRAINER (cont)**

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**INSTALLATION**

4. Install gaskets (7) and (6) on pipe flanges (9) and (8).
5. Position cutout cock and strainer (5) between pipe flanges (9) and (8) and install two bolts (4) and locknuts (3). Install two lockwashers (2) and bolts (1).

**TEST**

6. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

**3-56. RUBBER SEATED CHECK VALVE**

This task covers:

- a. Removal
- b. Installation
- c. Test

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

**REMOVAL**

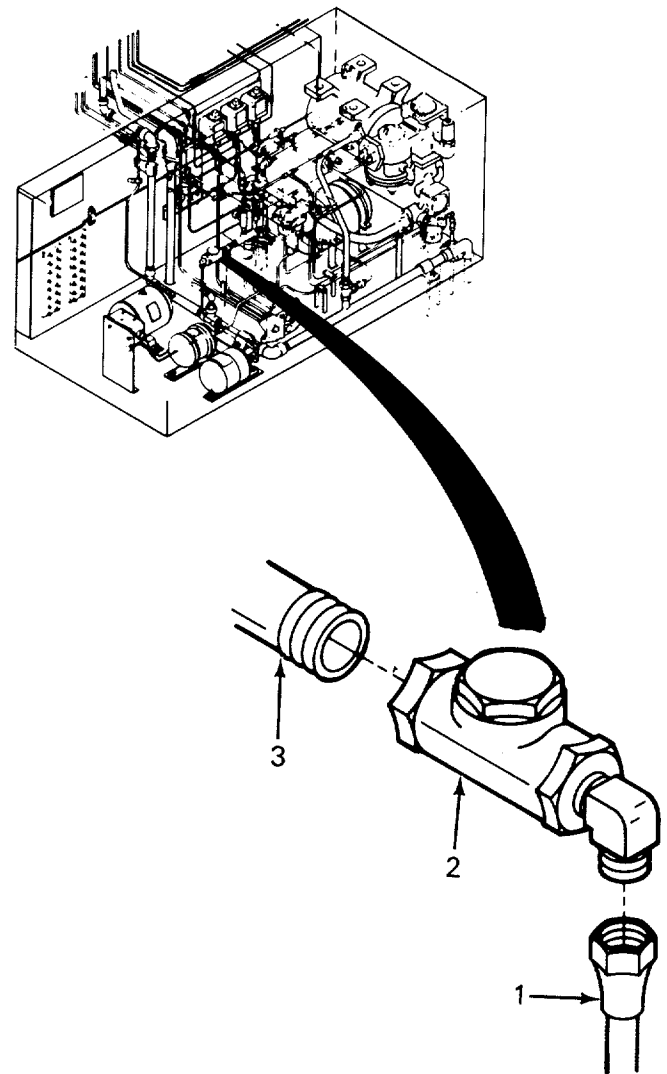
**WARNING**

- ⌚ Whenever the rubber seated check valve is removed and installed for any reason, a stationary locomotive airbrake test must be performed to check that the rubber seated check valve functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the rubber seated check valve. Residual air may escape and cause injury to personnel.

**NOTE**

- ⌚ This is a one-way valve. Note direction of air flow.
- ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210- 224-24P for identification of piping.

1. Disconnect air line fitting (1).
2. Remove rubber seated check valve (2) from pipe nipple (3).





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**3-56. RUBBER SEATED CHECK VALVE (cont)**

---

**REMOVAL (cont)**

3. Remove remaining rubber seated check valves in a similar manner.

**INSTALLATION**

**NOTE**  
**Note direction of air flow.**

4. Install rubber seated check valve (2) on pipe nipple (3). Connect line fitting (1).
5. Install remaining rubber seated check valves in a similar manner.

**TEST**

6. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

---

**3-57. BALL CUTOUT COCK**

---

This task covers:

- a. Removal
  - b. Installation
  - c. Test
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

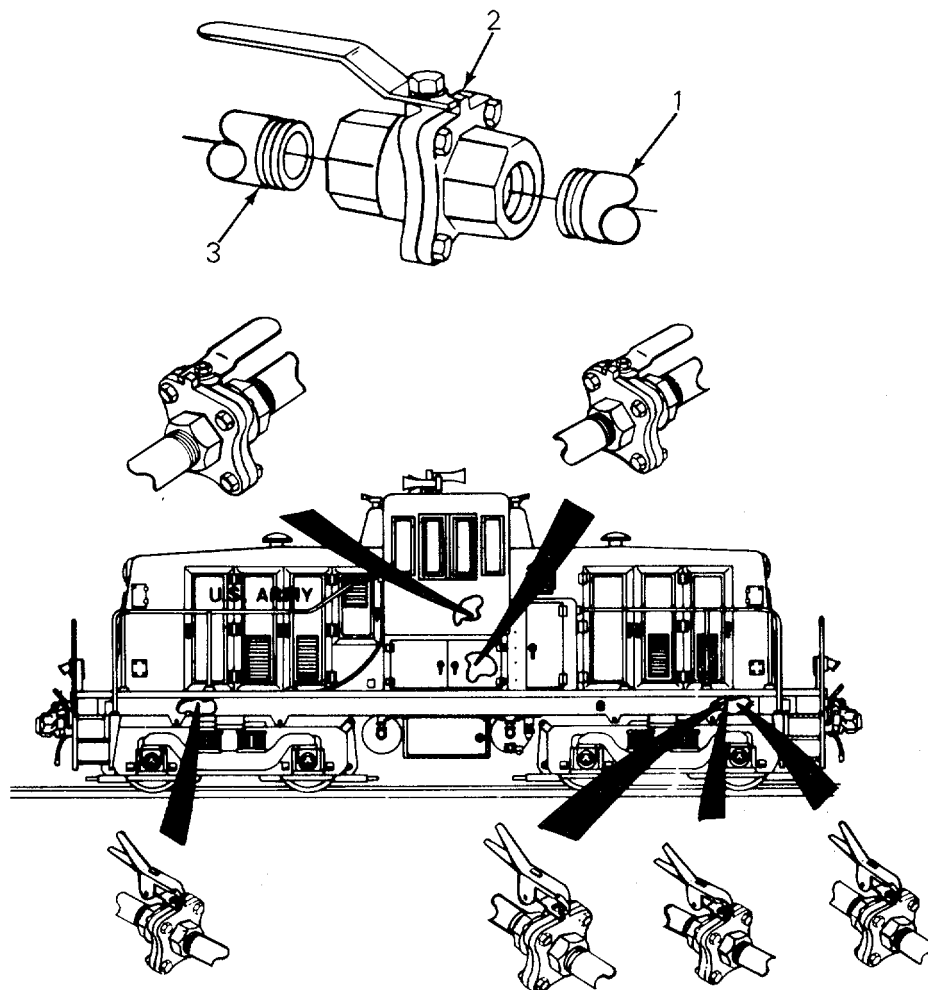
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**REMOVAL****WARNING**

- ⌚ Whenever a ball cutout cock is removed and installed for any reason, a stationary locomotive airbrake test must be performed to check that the ball cutout cock functions properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.
- ⌚ Make sure air is drained before removal of the ball cutout cock. Residual air may escape and cause injury to personnel.

**NOTE**

- ⌚ Note direction of air flow and direction of valve before removal.
  - ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.
  - ⌚ To replace any ball cutout cock, locate nearest union, disconnect union, and remove piping up to the valve.
1. Remove pipe (1).
  2. Remove ball cutout cock (2) from pipe (3).

**3-57. BALL CUTOUT COCK (cont)****REMOVAL (cont)****INSTALLATION****NOTE**

Note direction of air flow and direction of valve before installing.

3. Install ball cutout cock (2) on pipe (3).
4. Install pipe (1) on ball cutout cock (2). Connect pipe to union.

**TEST**

5. Refer to paragraph 2-9 and perform a stationary locomotive airbrake test.

**3-58. BRAKE CYLINDER**

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Test         |
| b. Disassembly | d. Inspection | f. Assembly | h. Installation |

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E31  
 Micrometer 5210-00-267-3093  
 Inside micrometer  
 5210-00-221-1921

**Material/Parts**

Drycleaning solvent (Item 34, Appendix B)  
 Brake cylinder lubricant (Item 15, Appendix B)

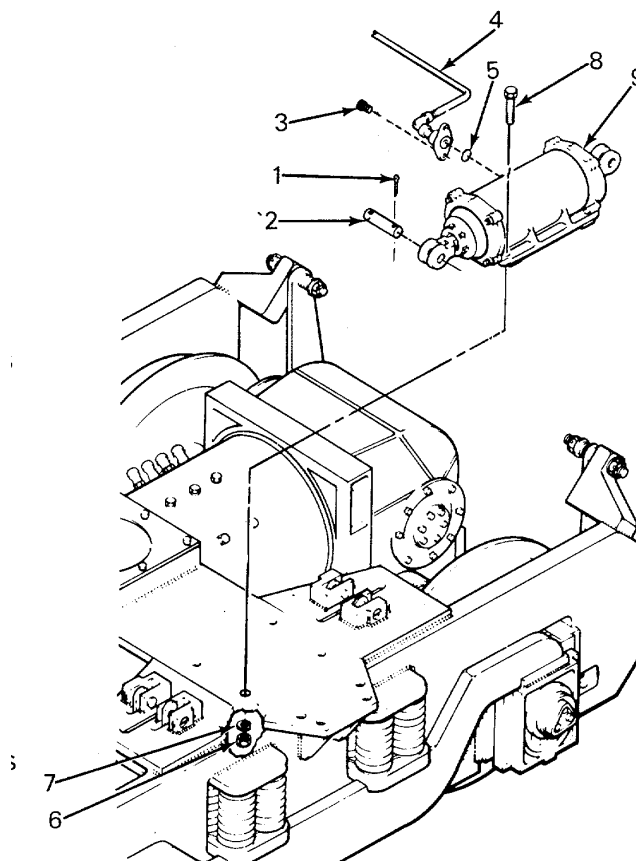
**Personnel required**

2

**REMOVAL****NOTE**

- ⌚ Stationary airbrake test (para 2-9) should be performed before brake cylinder is removed.
- ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove two cotter pins (1) and pins (2).
2. Remove two capscrews (3). Disconnect air line (4) and gasket (5).
3. Remove four nuts (6), lockwashers (7), and capscrews (8). Remove brake cylinder (9).



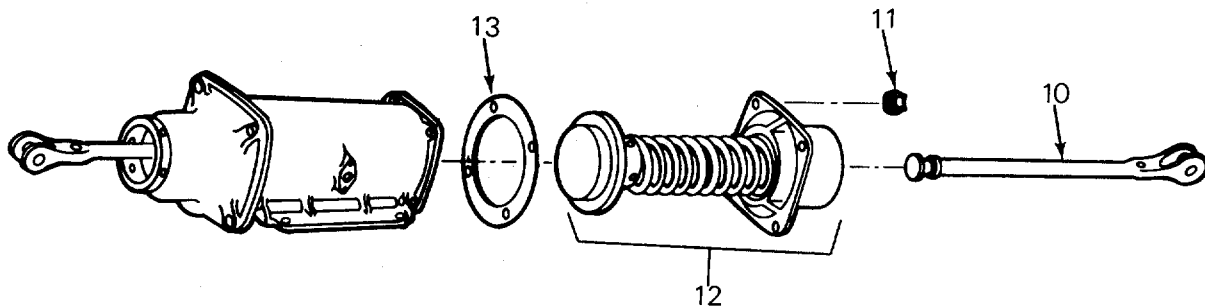
3-58. BRAKE CYLINDER (cont)

DISASSEMBLY

**NOTE**

Both ends of brake cylinder are disassembled and assembled the same way. Only one end is shown.

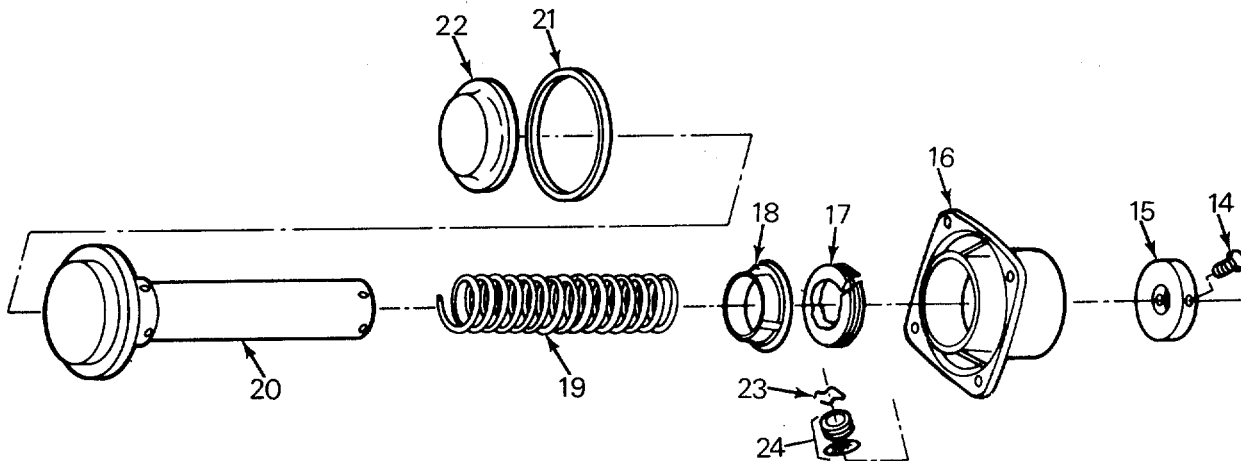
4. Remove two push rods (10). Remove four nuts (11), piston assembly (12), and gasket (13).



**WARNING**

The spring is under tension. Use caution during disassembly so the spring does not fly out, causing injury to personnel.

5. Place piston assembly (12) in compressor vise and compress spring (19).
6. Remove four capscrews (14) and push rod holder (15).
7. Slowly decompress spring (19) and remove piston assembly (12) from compressor vise. Remove nonpressure head (16) and felt gasket (17).
8. Remove spring seat (18) and spring (19) from piston (20).
9. Remove packing cup (21) and lubricator swab (22) from piston (20).
10. Remove retainer ring (23) and strainer (24) from nonpressure head (16).



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**3-58. BRAKE CYLINDER (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and get medical aid, immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

11. Use drycleaning solvent and clean parts. Dry with compressed air.
12. Inspect metal parts for cracks and breaks. Replace damaged parts.
13. Inspect rubber parts for cracks, breaks, or flattened beads. Replace damaged rubber parts.
14. Use brake cylinder lubricant and coat push rod, packing cup, and walls of cylinder.

**ASSEMBLY**

15. Install strainer (24) in nonpressure head (16) and secure with retainer ring (23).
16. Install lubricator swab (22) and packing cup (21) on piston (20).
17. Install spring (19) over piston (20) and install spring seat (18) over spring.
18. Install felt gasket (17) in nonpressure head (16).

---

**3-58. BRAKE CYLINDER (cont)**

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**ASSEMBLY (cont)****WARNING**

**The spring is under tension. Use caution during assembly so the spring does not fly out, causing injury to personnel.**

19. Place piston assembly (12) into compression vise and compress spring (19). Position push rod holder (15) on piston (20) and install four capscrews (14).
20. Remove piston assembly (12) from compression vise.
21. Install gasket (13) and piston assembly (12) and secure with four nuts (11).

**TEST**

22. Test brake cylinder by the following:
  - a. Use an air supply source with a cutout cock and a gage located between cutout cock and connector for brake cylinder. Connect brake cylinder.
  - b. Charge brake cylinder to 15 psi (103 kPa) and hold for 15 seconds.
  - c. Use cutout cock and turn off air supply.
  - d. Check that there is no pressure drop in 5 seconds.

**INSTALLATION**

23. Install push rod (10) in brake cylinder (9).
24. Position brake cylinder (9) and secure with four capscrews (8), lockwashers (7), and nuts (6).
25. Position gasket (5) and air line (4) and install two capscrews (3).
26. Install two pins (2) and secure with two cotter pins (1).

---

**3-59. MAIN AIR RESERVOIR**

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This task covers:

- |             |               |                 |
|-------------|---------------|-----------------|
| a. Removal  | c. Inspection | e. Installation |
| b. Cleaning | d. Test       |                 |
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

White enamel (Item 27, Appendix B)

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

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**REMOVAL****WARNING**

Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting device, and/or assistance from other personnel to avoid injury.

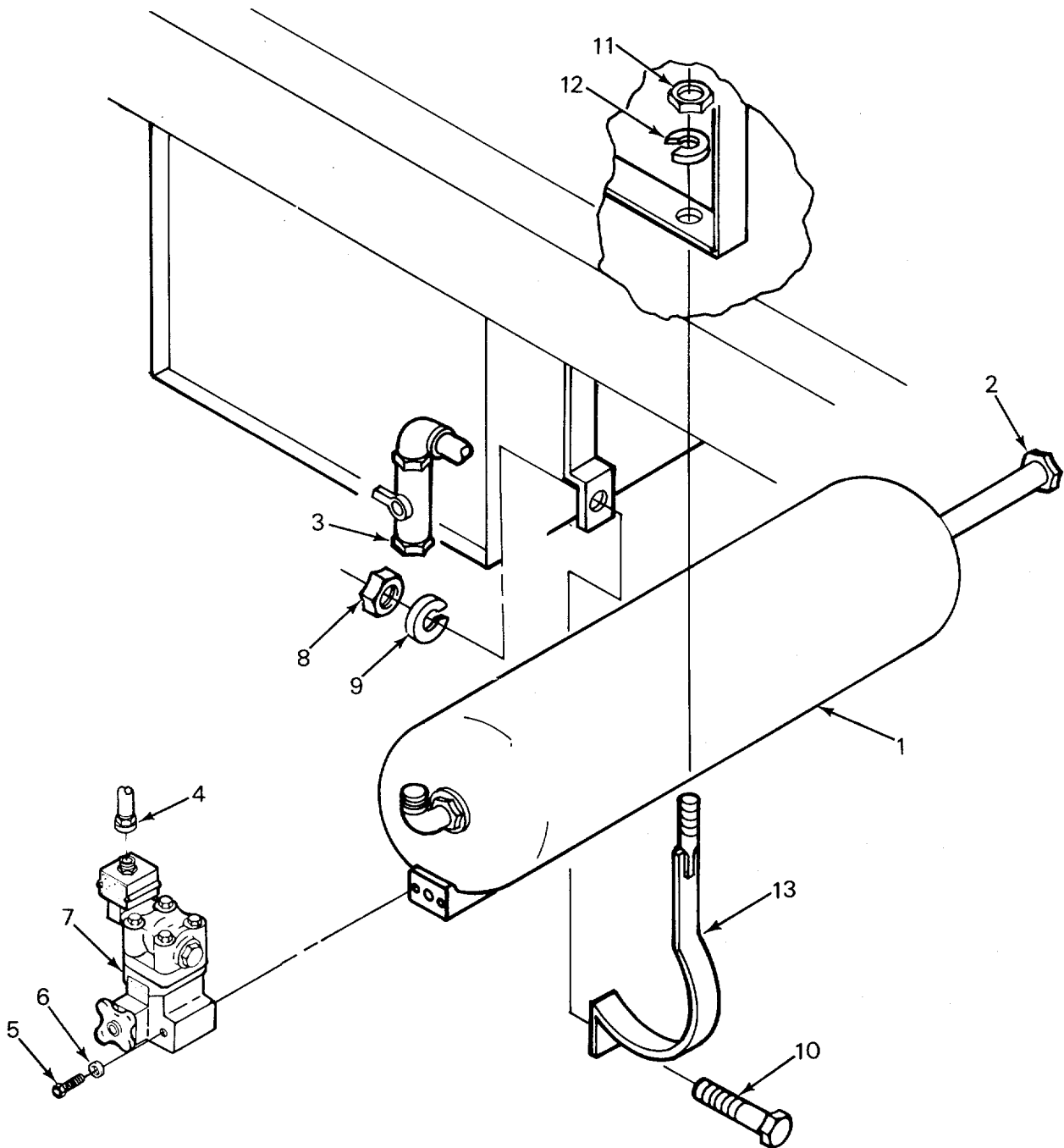
**NOTE**

- ⌚ Before removing air reservoirs, check that air system is drained.
  - ⌚ Smaller air reservoirs within the air system are removed following the same procedures as those used for main air reservoir.
  - ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.
  - ⌚ There are two main air reservoirs. Both are removed in a similar manner.
1. Place a suitable lifting device at each end of main air reservoir (1).
  2. Disconnect unions (2) and (3).
  3. Tag and disconnect electrical leads and remove electrical conduit (4).
  4. Remove two capscrews (5) and lockwashers (6). Remove automatic drain valve (7).



**3-59. MAIN AIR RESERVOIR (cont)****REMOVAL (cont)**

5. Remove two nuts (8), lockwashers (9), and capscrews (10). Remove two nuts (11) and lockwashers (12).
6. Slowly lower main air reservoir (1) and set on wooden blocks.
7. Remove two support straps (13).



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**3-59. MAIN AIR RESERVOIR (cont)**

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**CLEANING****WARNING**

- ⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

8. Use drycleaning solvent and remove dirt and grease from exterior of air reservoirs. Dry with compressed air.

**INSPECTION**

9. Inspect reservoir for cracks, breaks, and other damage. Replace if damage or cracks are apparent.

**TEST**

10. Test main air reservoir by the following:
- a. Seal one end of reservoir and apply a source of air to other end of air reservoir.
  - b. Inspect exterior of air reservoir for leaks. If there are air leaks, replace main air reservoir.
  - c. Test in accordance with FRA 229.31.
  - d. Stencil date of test on main air reservoir surface with white enamel.

**INSTALLATION**

11. Use a suitable lifting device on each end of reservoir and raise main air reservoir (1) to locomotive.
12. Install two support straps (13) and secure with two lockwashers (12), nuts (11), capscrews (10), lockwashers (9), and nuts (8). Do not tighten.
13. Position automatic drain valve (7) on air reservoir (1) and install two lockwashers (6) and capscrews (5). Connect electrical conduit (4). Connect electrical leads and remove tap.
14. Connect unions (3) and (2). Tighten nuts (11) and (8).

---

**3-60. MAIN AIR RESERVOIR SAFETY VALVE**

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This task covers:

- a. Test                      b. Removal                      c. Adjustment                      d. Installation
- 

**INITIAL SETUP**Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Antiseize tape (Item 35, Appendix B)

**TEST****WARNING**

- ⓘ **Whenever the cutout cock and strainer is removed and installed for any reason, a stationary vehicle airbrake test (para 2-9) must be performed to check that the cutout cock and strainer function properly in the brake equipment arrangement. Failure to perform test may result in injury to personnel.**
- ⓘ **Make sure air is drained before removal of the cutout cock and strainer. Residual air may escape and cause injury to personnel.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Start locomotive and let air pressure build up. Monitor main air pressure gage.
2. Close shutoff valve to governor. Main air should start to rise from 130 psi (896 kPa). When it reaches 150 psi (1034) safety valve should blow. If the safety valve is adjusted incorrectly, refer to steps 5 thru 7 below.
3. Shut down locomotive.

**3-60. MAIN AIR RESERVOIR SAFETY VALVE (cont)****REMOVAL**

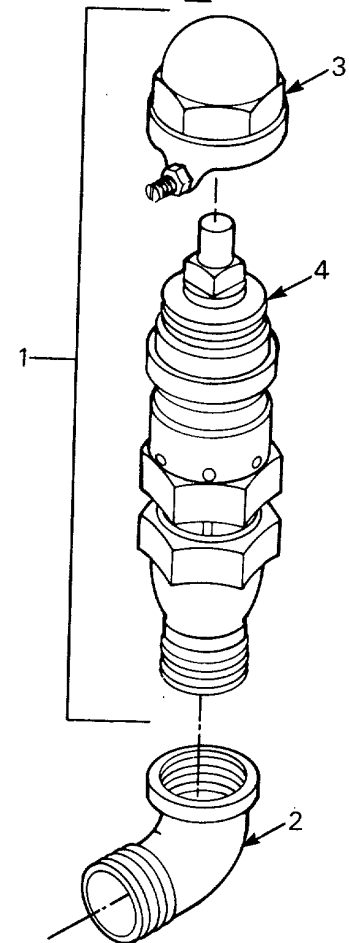
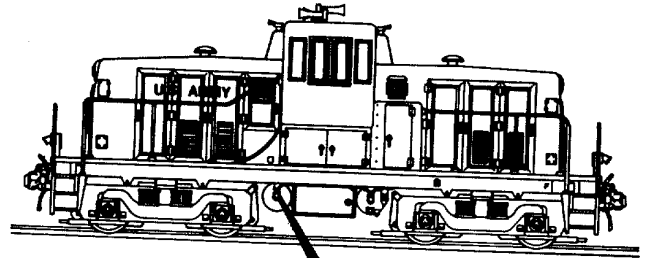
4. Remove main air safety valve (1) from elbow (2).

**ADJUSTMENT**

5. Remove lockwire and cover (3). Apply 150 psi (1035 kPa) of air pressure to main air safety valve (1).
6. Turn adjusting nut (4) until main air safety valve (1) blows at 150 psi (1034 kPa).
7. Install cover (3) and lockwire.

**INSTALLATION**

8. Apply antiseize tape to threads of main air safety valve (1).
9. Install main air safety valve (1) in elbow (2).



**3-61. CENTRIFUGAL AIR FILTER**

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly |                 |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

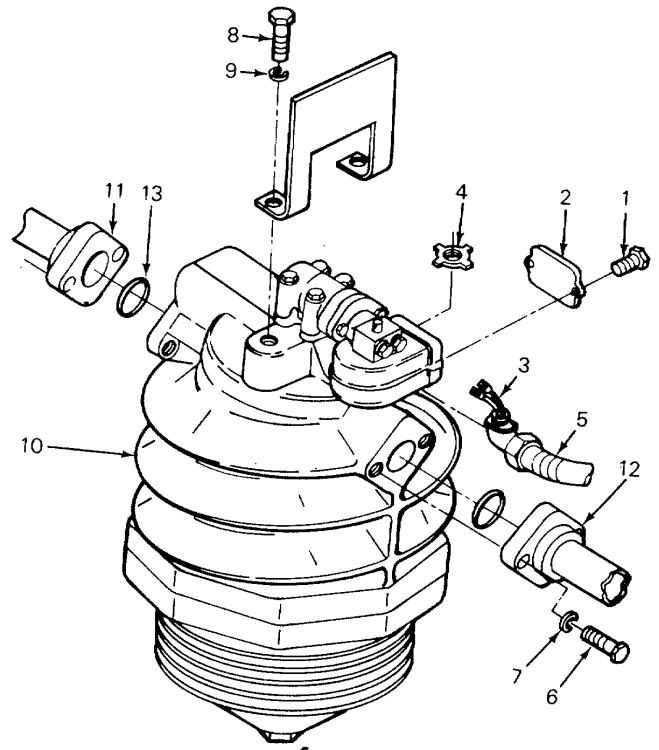
Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Filter element  
 Pneumatic grease (Item 18, Appendix B)  
 Wiping rags (Item 32, Appendix B)

**REMOVAL**

**NOTE**

- ⌚ Before removing centrifugal air filter, check that air system is drained.
- ⌚ Repair procedures are similar for the main reservoir centrifugal air filter and the secondary centrifugal air filter.
- ⌚ If repair of centrifugal air filter is limited to the replacement of the filter element, perform steps 3, 4, 20, and 21 below.
- ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

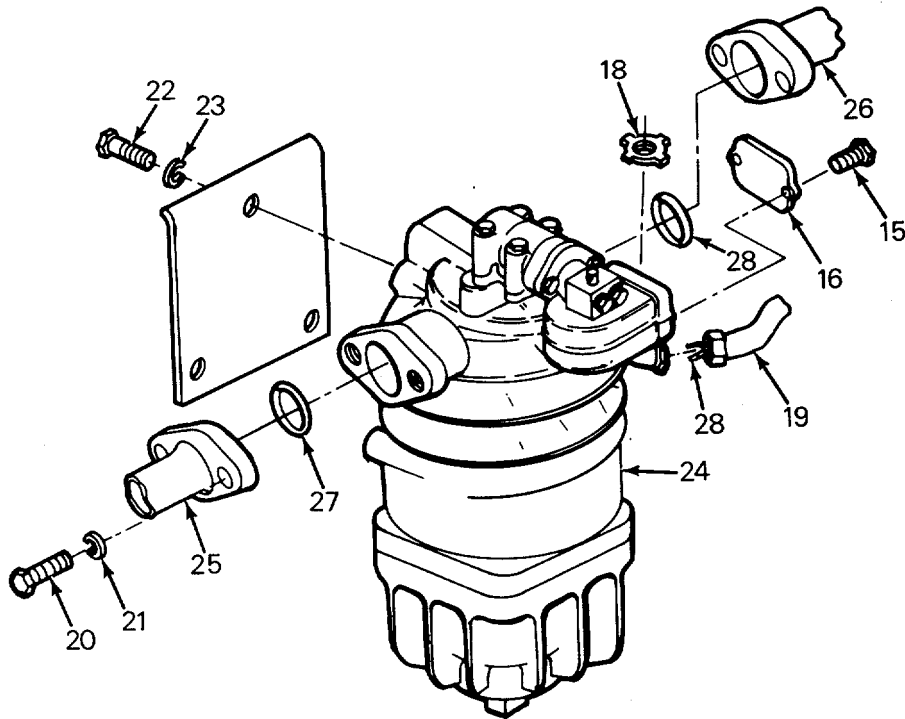


1. Remove the main centrifugal air filter by the following:
  - a. Remove two screws (1) and cover (2).
  - b. Tag and disconnect electrical leads (3). Remove conduit nut (4) and push flex conduit (5) and electrical leads from box.
  - c. Remove four capscrews (6) and lockwashers (7). Remove two capscrews (8) and lockwashers (9). Remove centrifugal air filter (10) from flange fittings (11) and (12). Remove O-rings (13) and (14).

**3-61. CENTRIFUGAL AIR FILTER (cont)**

**REMOVAL (cont)**

2. Remove secondary centrifugal air filter by the following:
  - a. Remove two screws (15) and cover (16).
  - b. Tag and disconnect electrical leads (17). Remove conduit nut (18) and push flex conduit (19) and electrical leads from box.
  - c. Remove four bolts (20) and lockwashers (21).



- d. Remove three bolts (22) and lockwashers (23).
- e. Remove secondary air filter (24) from flange fittings (25) and (26). Remove O-rings (27) and (28).

**3-61. CENTRIFUGAL AIR FILTER (cont)**

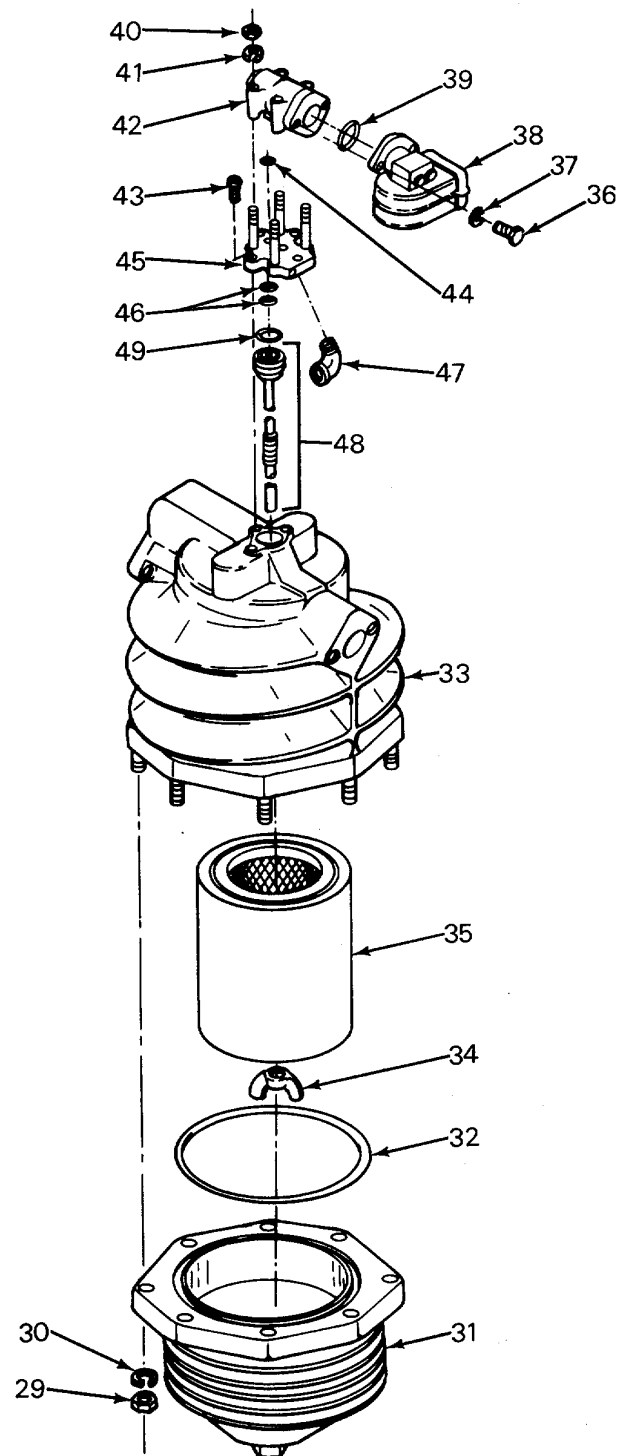
**DISASSEMBLY**

3. Remove eight nuts (29), lockwashers (30), sump bowl (31), and gasket (32) from filter body (33).
4. Remove wing nut (34) and filter element (35).

**NOTE**

**If drain and solenoid valve show obvious defects, replace entire component.**

5. Remove two capscrews (36), lockwasher (37), solenoid body (38), and O-ring (39).
6. Remove four nuts (40), flat washers (41), and valve body (42).
7. Remove three screws (43) and seal (44).
8. Remove drain valve adapter (45) and two seals (46). Remove elbow (47).
9. Remove exhaust tube assembly (48) from filter body (33), and remove O-ring (49) from exhaust tube assembly.



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**3-61. CENTRIFUGAL AIR FILTER (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

10. Use drycleaning solvent and clean metal parts. Dry with compressed air.
11. Inspect parts for cracks, breaks, and wear. Replace damaged parts.
12. Use a multimeter and measure resistance of the coil of solenoid body (37). Resistance of coil should be between 313.5 and 346.5 ohms at 680F (20°C). Replace defective coil if readings are not obtained.
13. Use pneumatic grease and apply a small amount to O-rings, seals, seats, and O-ring grooves. Use a clean wiping rag and remove excess grease.

**ASSEMBLY**

14. Install O-ring (49) on exhaust tube assembly (48). Install exhaust tube assembly in filter body.
15. Install elbow (47), two seals (46), and seal (44) on drain valve adapter (45) of filter body (33). Secure with three screws (43).
16. Install valve body (42) on drain valve adapter (45) and secure with four flat washers (41) and nuts (40).



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**3-61. CENTRIFUGAL AIR FILTER (cont)**

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**ASSEMBLY (cont)**

17. Install O-ring (39) and solenoid body (38) and secure with two lockwashers (37) and capscrews (36).
18. Install new filter element (35), wing nut (34), and filter body (33).
19. Install new gasket (32) and sump bowl (31). Secure with eight lockwashers (30) and nuts (29).

**INSTALLATION**

20. Install secondary centrifugal air filter by the following:
  - a. Install secondary air filter (24) on bracket and secure with three lockwashers (23) and bolts (22).
  - b. Install O-rings (28) and (27), connect flange fittings (26) and (25), and install four lockwashers (21) and bolts (20).
  - c. Feed flex conduit (19) and electrical leads (17) in electrical box and tighten conduit nut (18).
  - d. Connect electrical leads (17) and remove tags. Position cover (16) and install two screws (15).
21. Install main centrifugal air filter by the following:
  - a. Install centrifugal air filter (10) on bracket and secure with two lockwashers (9) and capscrews (8).
  - b. Install O-rings (14) and (13), connect flange fittings (12) and (11), and install four lockwashers (7) and capscrews (6).
  - c. Feed flex conduit (5) and electrical leads (3) in electrical box and tighten conduit nut (4).
  - d. Connect electrical leads (3) and remove tags. Position cover (2) and install two screws (1).

### 3-62. AIR PRESSURE CONTROL SWITCHES

This task covers:

- a. Removal                      b. Test                      c. Installation                      d. Adjustment

#### INITIAL SETUP

#### Tools

Tool kit SC4940-97-CL-E12

#### REMOVAL

#### NOTE

All three control switches are removed in the same manner.

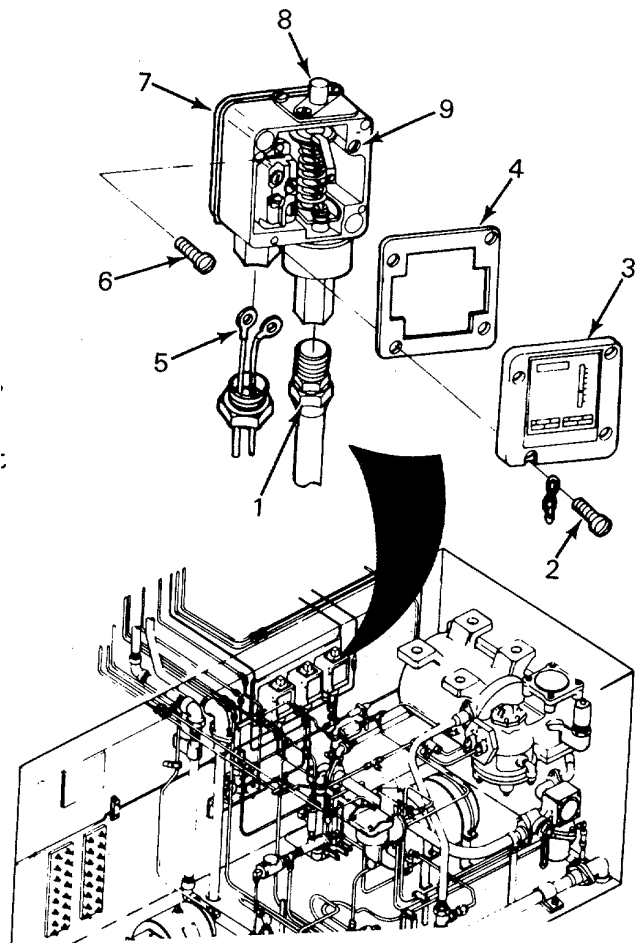
1. Disconnect air line fitting (1) from control switch (7).
2. Remove four screws (2), cover (3), and gasket (4). Tag and disconnect wires (5).
3. Remove two screws (6) and control switch (7).

#### TEST

4. Connect a multimeter to switch leads.
5. Apply a regulated air source to switch and check that switch trips at a varied range of pressure from 5 to 75 psi (34.5 to 517 kPa).

#### INSTALLATION

6. Position control switch (7) on mounting bracket.
7. Install two screws (6).
8. Connect wires (5) and remove tags. Install gasket (4) and cover (3) and secure with four screws (2).
9. Connect air line fitting (1) to control switch (7).



#### ADJUSTMENT

10. Decrease pressure setting by removing cover (8) and turning adjusting screw counterclockwise.
11. Increase pressure setting by inserting a small screwdriver in hole (9) and turn clockwise.

**3-63. TRUCK ASSEMBLY**

This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly |                 |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12  
 35-Ton jack set 4940-00-727-0490

Materials/Parts

Drycleaning solvent (Item 3, Appendix B)  
 Grease (Item 13, Appendix B)  
 Electrical tape (Item 36, Appendix B)  
 Graphite lubricant (Item 20, Appendix B)

Personnel Required

Equipment Condition

Reference

Para 3-35

Condition Description

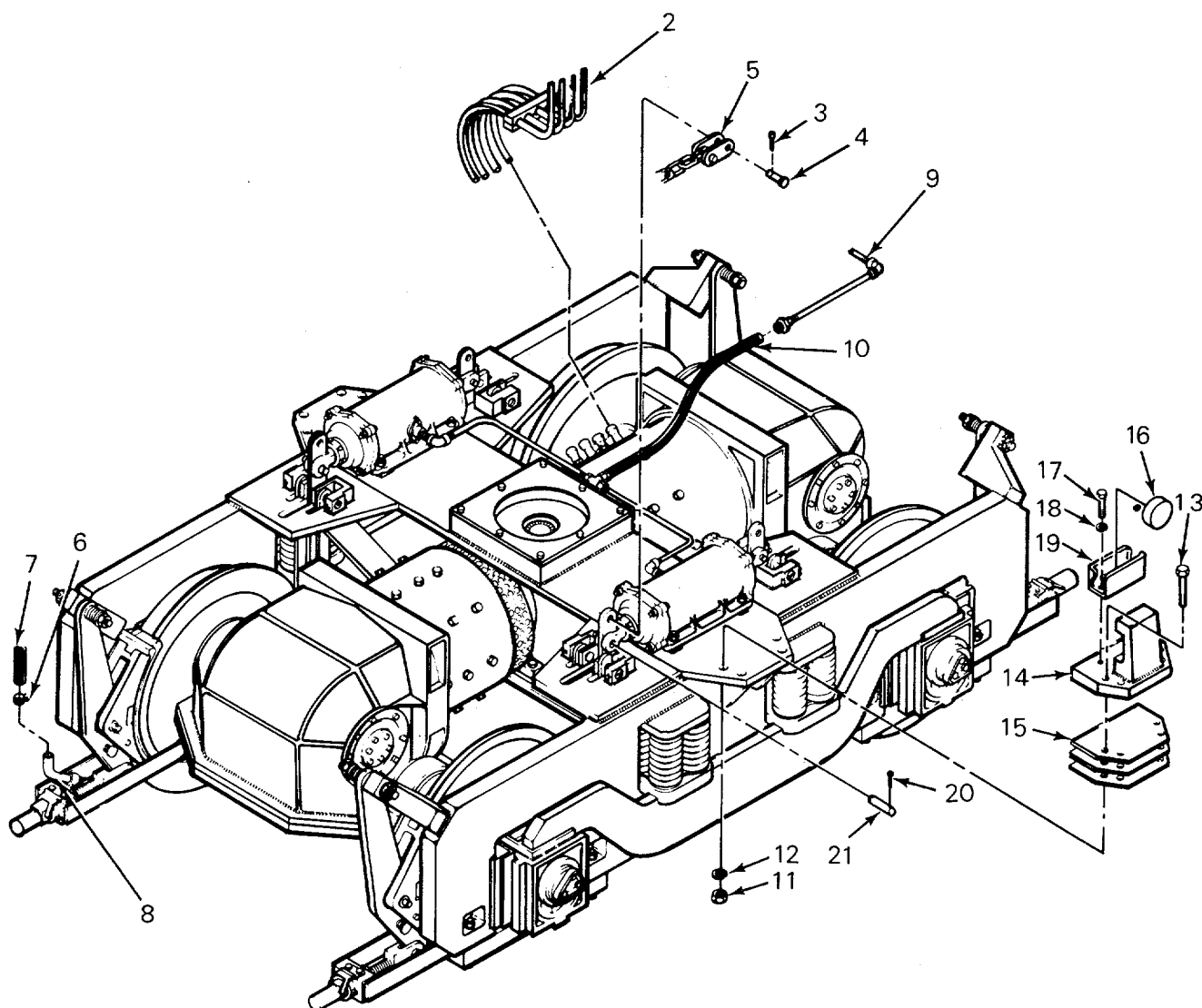
Speed sensing alternator removed

**REMOVAL**

**NOTE**

**These procedures refer to the removal and/or disassembly of one item from the truck assembly. Where there are duplicate items on the truck assembly the procedures will be repeated.**

1. Slide insulating tubes (1) along traction motor electrical leads (2). Tag and disconnect traction motor electrical leads.
2. Remove two cotter pins (3) and pins (4) and disconnect two handbrake connecting chains (5). Position chains out of the way.
3. Loosen four clamps (6) and remove sander hoses (7) from sander pipe (8). Position hoses out of the way.
4. Disconnect brake hose union (9) from brake hose (10).
5. Remove four nuts (11), lockwashers (12), capscrews (13), and side bearing safety hook (14). Remove shim pack (15).
6. Remove roller (16), two capscrews (17), lockwashers (18), and base (19) from side bearing safety hook (14).
7. Remove four cotter pins (20) and two pins (21).

**3-63. TRUCK ASSEMBLY (cont)****REMOVAL (cont)**

8. Check that all connections have been removed to enable truck removal.

**WARNING**

Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.

9. Install suitable lifting devices under pads at each corner of locomotive. Check that their location will not interfere with the removal of trucks.

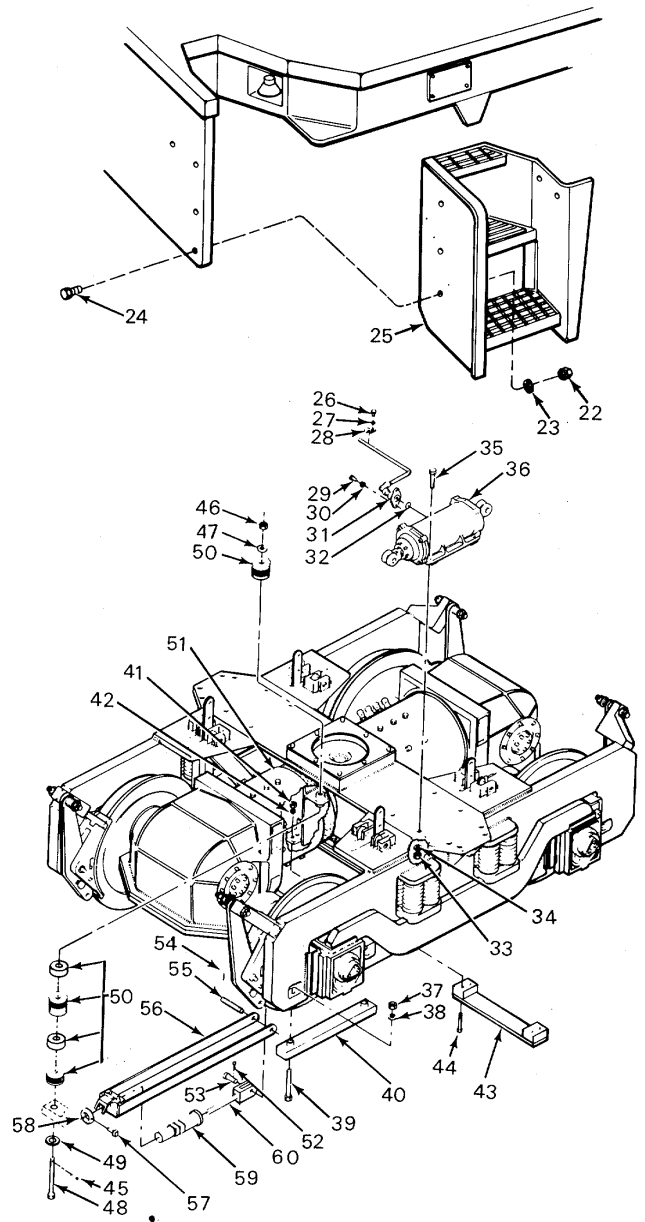
**3-63. TRUCK ASSEMBLY (cont)**

**REMOVAL (cont)**

10. Raise lifting devices simultaneously until locomotive is high enough (approximately 4 feet [1.2 m]) to clear truck assembly. If unable to raise high enough, remove 16 nuts (22), lockwashers (23), and capscrews (24). Remove two step assemblies (25).
11. Roll truck assembly out from under locomotive. Install safety stands under locomotive.

**DISASSEMBLY**

12. Remove two capscrews (26), lockwashers (27), and clamps (28).
13. Remove four capscrews (29) and lockwashers (30). Remove air line assembly (31) and two gaskets (32).
14. Remove eight nuts (33), lockwashers (34), and capscrews (35). Remove two brake cylinders (36). Refer to paragraph 3-57 for repair of brake cylinder.
15. Remove eight nuts (37), lockwashers (38), and capscrews (39). Use a pry bar and remove four stay plates (40).



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**3-63. TRUCK ASSEMBLY (cont)****DISASSEMBLY (cont)**

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16. Remove four nuts (41), lockwashers (42), and capscrews (43). Remove safety plate (44).
17. Chain or block traction motor-gear unit to keep motor from falling.

**NOTE**

**Suspension bolt must be removed in an open pit.**

18. Remove cotter pins (45), nuts (46), flat washers (47), suspension bolt (48), and flat washer (49). Remove pad assembly (50).
19. Place wooden blocking under traction motor (51) for support, remove chain or blocking, and lower traction motor-gear unit on supports.
20. Remove cotter pin (52), pin (53), two cotter pins (54), and pin (55). Remove lower brake rigging (56). Remove setscrew (57), collar (58), and collar nut (59), and adjusting screw (60). Remove adjusting screw from collar nut.
21. Chain outer equalizer (81) and inner equalizer (82) to frame assembly (61).

**WARNING**

**Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

22. Use a suitable lifting device, connect to four corners of frame assembly (61), and lift frame assembly from traction motor-gear-unit wheel-axle-assembly (62).
23. Lower frame assembly (61) to the floor.

**NOTE**

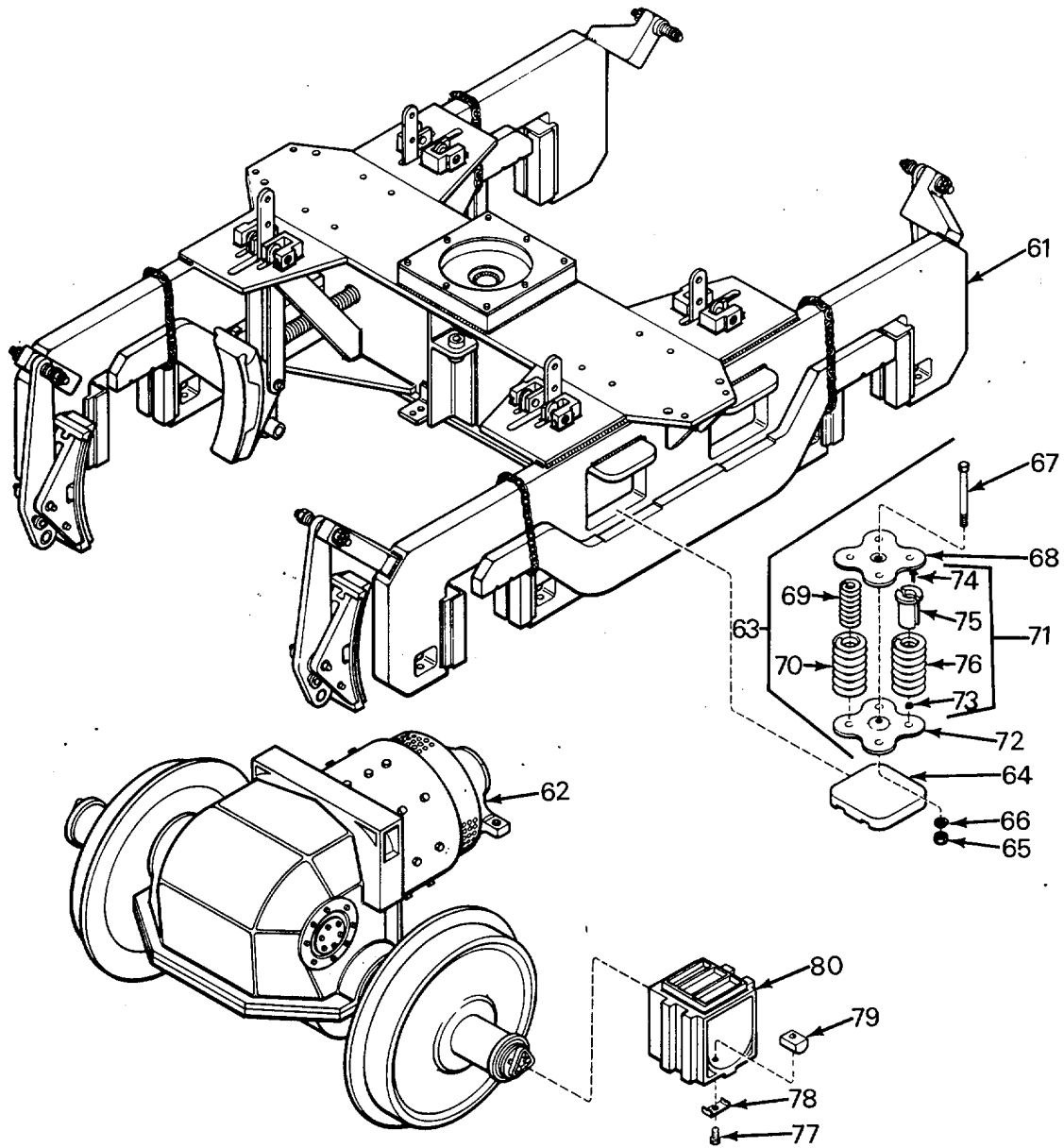
**There are four bolster spring assemblies on each truck. When removing spring cluster, note position of bolster spring assembly for aid in installation.**

24. Remove four spring clusters (63) and spring pads (64). Disassemble spring clusters as follows:
  - a. Remove nut (65), lockwasher (66), and capscrew (67).
  - b. Separate upper spring seat (68), three springs (69) and (70), bolster spring (71), and lower spring seat (72).
  - c. Disassemble bolster spring (71) by the following:
    - (1) Remove nut (73) and bolt (74).
    - (2) Remove two bolsters (75) from spring (76).

3-63. TRUCK ASSEMBLY (cont)

DISASSEMBLY (cont)

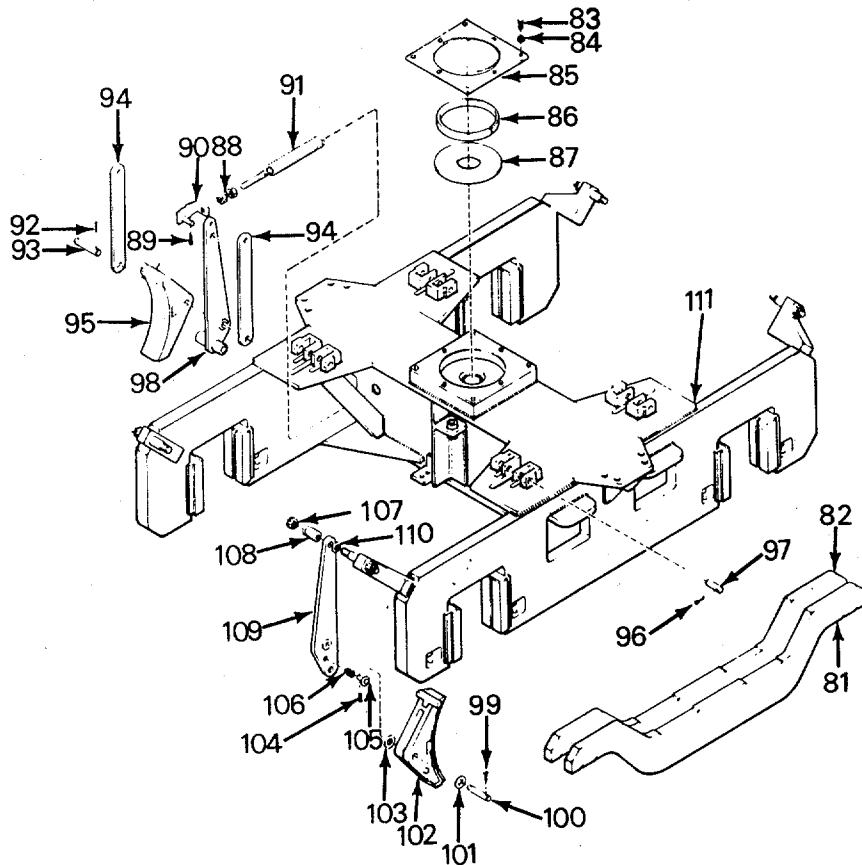
25. Remove capscrew (77), spacer (78), block (79), and journal box (80) from traction motor-gear-unit wheel-axle-assembly (62).



**3-63. TRUCK ASSEMBLY (cont)**

**DISASSEMBLY (cont)**

26. Disassemble frame assembly (61) by the following:
  - a. Use a suitable lifting device and remove chains, outer equalizer (81) and inner equalizer (82).
  - b. Remove eight capscrews (83), lockwashers (84), center plate dust guard (85), center plate wear ring (86), and center plate (87).
  - c. Remove two nuts (88), cotter pin (89), bracket (90), and spring (91).
  - d. Remove cotter pin (92), pin (93), two levers (94), brakehead (95), cotter pin (96), pin (97), and lever (98).
  - e. Remove cotter pin (99), pin (100), spacer (101), brakehead (102), spacer (103), cotter pin (104), spring seat (104), and spring (106).
  - f. Remove nut (107), spring (108), lever (109) and spacer (110) from frame (111).



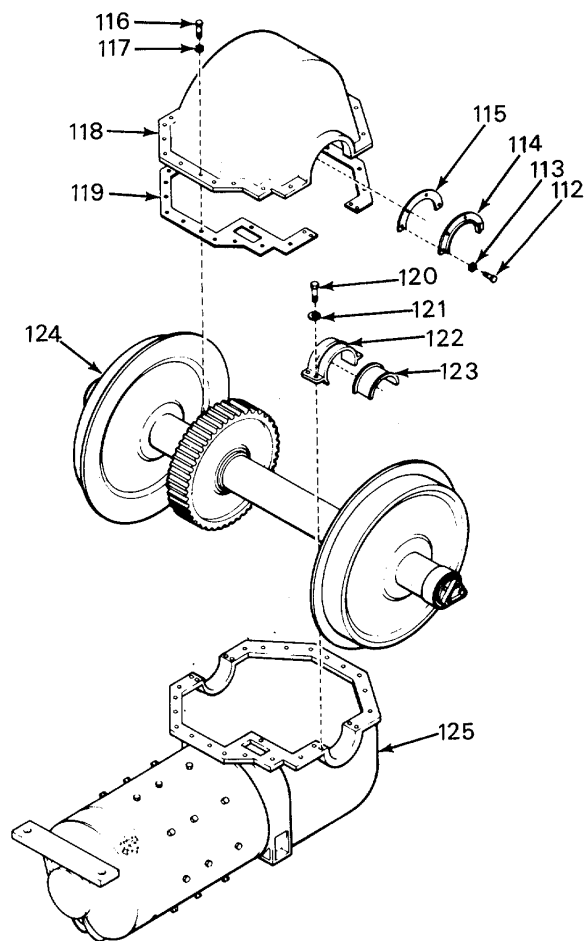


**3-63. TRUCK ASSEMBLY (cont)****DISASSEMBLY (cont)****WARNING**

Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.

7. Disassemble traction motor-gear-unit wheel-axle-assembly (62) by the following:

- a. Use a suitable lifting device and raise motor-gear-unit wheel-axle-assembly (62). Remove oil drain plug and drain oil from gear unit.
- b. Lower motor-gear-unit wheel-axle-assembly (62) to the floor and position so that traction motorear-unit assembly (126) is upside down and wheel-axle assembly (125) is in the air.



- c. Remove 10 capscrews (112), lockwashers (113), seal rings (114), and gasket (115).
- d. Remove 17 capscrews (116) and lockwashers (117). Remove gear unit cover (118) and gasket (119).
- e. Remove four capscrews (120) and lockwashers (121). Remove two axle caps (122) and axle linings (123).
- f. Use a hoist and remove wheel-axle assembly (124) from traction motor-gear-unit assembly (125).

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**3-63. TRUCK ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⓘ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⓘ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**CAUTION**

**General cleanness of trucks should be maintained to eliminate fire hazard and reduce wear. Trucks can be cleaned while under locomotive. If forced spray is used, do not direct spray toward traction motors.**

- 28. Use drycleaning solvent and clean parts. Dry with compressed air.
- 29. Inspect pedestal liners for cracks and excessive wear. Total nominal pedestal liner clearance is 1/8 inch (3.175 mm). Maximum clearance is 3/8 inch (9.525 mm). Total nominal lateral clearance is 1/8 inch (3.175 mm). Maximum clearance is 3/8 inch (9.525 mm).
- 30. Inspect side bearing clearance. Normal side bearing clearance is 1/4 inch (6.35 mm). Nominal side bearing wear plate thickness is 1/4 inch (6.35 mm) and minimum is 1/8 inch (3.175 mm).
- 31. Inspect center casting and wear plate for excessive wear. Nominal wear plate thickness is 3/8 inch (9.525 mm) and minimum is 1/4 inch (6.35 mm).
- 32. Inspect brake rods, levers, pins, and other rigging for wear, cracks, and breaks. Replace defective parts.
- 33. Inspect springs and suspension bars for cracks, breaks, and ~~otr~~ damage. Replace defective parts.

**3-63. TRUCK ASSEMBLY (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

- 34. Inspect helical springs for cracks, breaks, and tension. Check that springs are same length. Replace defective springs.
- 35. Inspect frame, bolster, and equalizers for cracks. Repair cracks by grooving, welding, and grinding smooth.
- 36. Inspect dust cover for cracks and damage. Replace if damaged.
- 37. Inspect remaining parts for damage and replace as necessary.
- 38. Refer to table 3-5 for truck assembly data.

**Table 3-5. Truck Assembly**

ITEM	SPECIFICATION
Pedestal Liner:	
Total nominal pedestal liner clearance	1/8 inch (3.175 mm)
Total maximum pedestal liner clearance	3/8 inch (9.525 mm)
Total nominal lateral clearance	1/8 inch (3.175 mm)
Total maximum lateral clearance	3/8 inch (9.525 mm)
Side Bearing:	
Normal side bearing clearance	1/4 inch (6.35 mm)
Side bearing wear plate thickness	1/4 inch (6.35 mm)
Side bearing wear plate thickness	1/8 inch minimum (3.175 mm)
Axle Lateral:	
Normal axle lateral	3/8 inch (9.525 mm)
Maximum axle lateral	5/8 inch (15.875 mm)

**3-63. TRUCK ASSEMBLY (cont)****ASSEMBLY**

39. Assemble traction motor-gear-unit to wheel-axle-assembly (62) by the following:

**WARNING**

**Components of the main generator are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

- a. Use a suitable lifting device and place traction motor-gear-unit assembly (125) upside down on the floor.
  - b. Use a suitable lifting device and raise wheel-axle assembly (124) and position over traction motor-gear-unit assembly (125). Lower wheel-axle assembly into gear unit.
  - c. Install two axle linings (123) and axle caps (122). Install four lockwashers (121) and capscrews (120).
  - d. Install gasket (119) and gear unit cover (118). Install 17 lockwashers (117) and capscrews (116).
  - e. Position gasket (115) and 2 seal rings (114), and install 10 lockwashers (114) and capscrews (112).
40. Use a suitable lifting device and turn traction motor-gear-unit wheel-axle-assembly (62) over onto the wheels.
41. Assemble frame assembly (61) by the following:
- a. Install spacer (110) and lever (109) on frame (111) and install spring (108) and nut (107).
  - b. Install spring (108), spring seat (105), cotter pin (104), spacer (103), brakehead (102), spacer (101), pin (100), and cotter pin (97).
  - c. Position lever (98) and install pin (97), cotter pin (96), brakehead (95), ~~rollers~~ (94), pin (93), and cotter pin (92).
  - d. Install spring (91), bracket (90), cotter pin (89), and two nuts (88).
  - e. Install center plate (87), center plate wear ring (86), and center plate dust guard (85) on frame (111) and install eight lockwashers (84) and capscrews (83).
  - f. Use a suitable lifting device and position inner equalizer (82) inside frame assembly (61). Position outer equalizer (81) on outside of frame and chain inner and outer equalizers to frame.

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**3-63. TRUCK ASSEMBLY (cont)****ASSEMBLY (cont)**

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42. Position journal box (80) on axle and install block (79), spacer (78), and capscrew (77).
43. Assemble four spring clusters (63) by the following:
  - a. Assemble bolster spring (71) by the following:
    - (1) Position two bolsters (75) in spring (76).
    - (2) Install bolt (74) and nut (73).
  - b. Position bolster spring (71) and three springs (70) and (69) on lower spring seat (72).
  - c. Position upper spring seat (68) and install capscrew (67), lockwasher (66), and nut (65).
44. Place four spring pads (64) in frame (61). Check that spring pads engage inner equalizer (82) and outer equalizer (81). Place four spring clusters (61) on pads. Note the position of the bolster spring assembly.
45. Use a suitable lifting device and raise frame assembly (61) and position over traction motor-gear-unit wheel-axle-assembly (62). Lower frame assembly into position and guide inner equalizer (82) and outer equalizer (81) into slots in axle journals. Remove chains from equalizers.
46. Install adjusting screw (60) in collar nut (59). Install collar nut in lower brake rigging (56) and install collar (58) and setscrew (57). Position lower brake rigging and install pin (55), two cotter pins (54), pin (53), and cotter pin (52).
47. Raise traction motor (51) into position and install pad assembly (50), flat washers (49), suspension bolt (48), flat washers (47), nuts (46), and cotter pins (45).
48. Position safety plates (44) and install four capscrews (43), lockwashers (42), and nuts (41).
49. Position four stay plates (40) on frame and install eight capscrews (39), lockwashers (38), and nuts (37).
50. Position brake cylinder (36) on frame and install eight capscrews (35), lockwashers (34), and nuts (33).
51. Position two gaskets (32) and air line assembly (31) on brake cylinders (36) and install eight lockwashers (30) and capscrews (29).
52. Position two clamps (28) over air line assembly (31) and install two lockwashers (27) and capscrews (26).

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**3-63. TRUCK ASSEMBLY (cont)**

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**INSTALLATION****WARNING**

**Components of the main generator are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

53. Roll truck assembly into position under locomotive. Use a suitable lifting device and lower locomotive into proper position on truck.
54. Position two step assemblies (25) and install 16 capscrews (24), lockwashers (23), and nuts (22).
55. Install two pins (21) and four cotter pins (20).
56. Position base (19) on side bearing safety hood (14) and install two lockwashers (18), capscrews (17), and roller (16).
57. Position shim pack (15) and side bearing safety hook (14) and install four capscrews (13), lockwashers (12), and nuts (11).
58. Position brake hose (10) and connect brake hose union (9).
59. Position sander hose (7) on sander pipe (8) and tighten four clamps (6).
60. Position two handbrake connecting chains (5) and install two pins (4) and cotter pins (3).
61. Connect traction motor electrical leads (2) and remove tags. Slide insulating tubes (1) over connections.

**3-64. TRACTION MOTOR ASSEMBLY**

This task covers:

- |                |               |           |                 |
|----------------|---------------|-----------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair | g. Assembly     |
| b. Disassembly | d. Inspection | f. Test   | h. Installation |

**INITIAL SETUP**

Tools

- Tool kit SC4940-97-CL-E12
- Pinion depth gage
- Feeler gage
- Magnaflux 6635-01-131-0730
- Dial indicator 5210-00-640-0953
- Portable propane torch 3439-00-542-0531
- Disassembly tool kit
- Induction heater 2815-00-366-1432
- Large hydraulic press
- Suitable lifting device
- Convection oven
- Lifting sling

Materials/Parts

- Abrasive cloth (Item 5, Appendix B)
- Drycleaning solvent (Item 34, Appendix B)
- Grease (Item 14, Appendix B)
- Clear acrylic lacquer (Item 19, Appendix B)
- Electrical insulating varnish (Item 37, Appendix B)
- Gray gloss enamel (Item 11, Appendix B)
- Electrical tape (Item 36, Appendix B)
- Rubber insulating paint (Item 28, Appendix B)
- Lubricating oil (Item 25, Appendix B)
- Iron blue pigment (Item 30, Appendix B)
- Gear lubricating oil (Item 22, Appendix B)
- Insulating paper (Item 29, Appendix B)
- 1-inch eye bolt (Item 3, Appendix B)
- Dry ice (Item 10, Appendix B)
- Safety wire (Item 38, Appendix B)

Equipment Condition

Reference

- Para 3-35
- Para 3-63

Condition Description

- Speed sensing alternator removed
- Traction-motor-gear unit removed from wheel-axle unit

**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**REMOVAL**

1. Remove traction motor (7) from gear unit (8) by the following:

a. Remove lockwire from three capscrews (1) and lockwashers (2). Remove hypoid oil pan (3).

b. Measure and record the following:

- (1) End play of intermediate shaft
- (2) Distance from intermediate shaft to face of pinion
- (3) Backlash of ring gear when moved into mesh

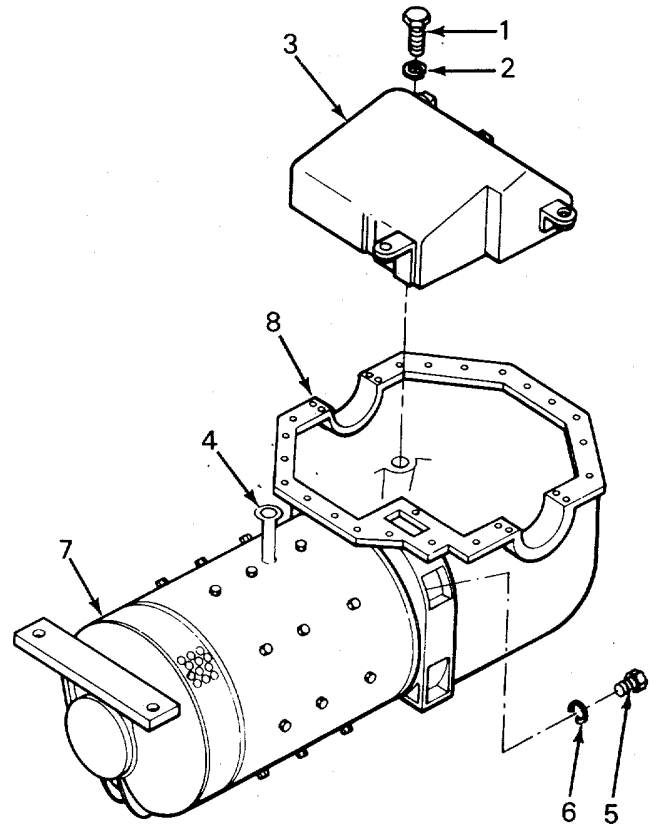
**WARNING**

Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.

c. Install a 1-inch eye bolt (4) into the hole provided in bottom of motor frame. Use a suitable lifting device and take up on eyebolt until weight is just taken up.

d. Use a punch and punch-mark motor and gearcase for proper installation. Reach through fan openings and remove 12 capscrews (5) and lockwashers (6).

e. Install two jack screws in the two tapped holes provided in the gearcase and jack motor (7) from gear unit (8).





**3-64. TRACTION MOTOR ASSEMBLY (cont)****DISASSEMBLY**

2. Install motor lifting bracket (9) and place motor on floor in a vertical position adequately supported on motor-nose suspension and suitable support device.

**NOTE**

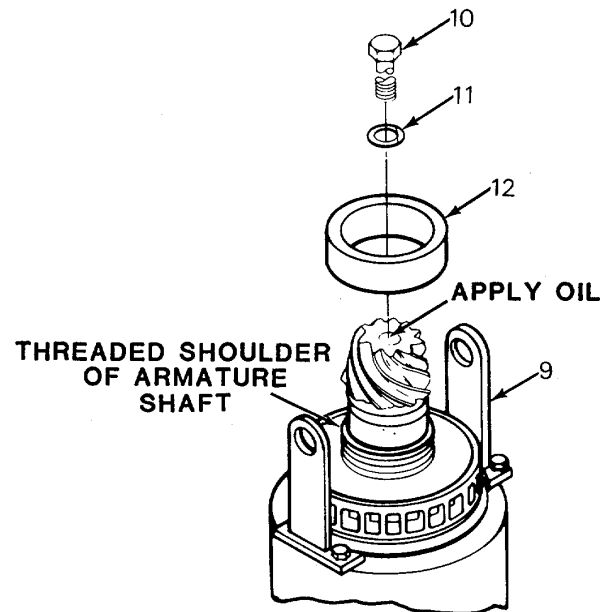
The disassembly tool kit and the following procedures are recommended for removal of the hypoid pinion. However, any tool that does not cause damage to the pinion or other parts, and any method that can be accomplished in a safe manner, may be used.

3. Remove bolt (10) and tab washer (11). Use a puller and remove oil sling (12) to expose armature shaft threads.
4. Check pinion bore for clean and smooth condition. Fill chamber in armature and pinion shaft to within 1 inch (25.4 mm) of top of pinion bore with oil. Do not trap air while filling.
5. Use the piston puller rod from disassembly tool kit as a pump in the armature-shaft chamber and purge chamber of air.

**WARNING**

To prevent the barrel from coming loose, causing injury to personnel, check that that it screws all the way down on the armature shaft threads. If unable to screw the barrel all the way down, remove the barrel and repair the damaged threads.

6. Remove pull rod, leaving piston in place, and screw the barrel of disassembly tool kit onto the armature shaft.
7. Screw cap assembly of disassembly tool kit into the barrel until 1/8-inch (3 mm) clearance is left between pinion and cap.
8. Insert a 1-inch (25.4 mm) diameter bar in hole provided in bolt on cap of disassembly tool kit and steady the cap. Position socket wrench on bolt.



### 3-64. TRACTION MOTOR ASSEMBLY (cont) DISASSEMBLY (cont)

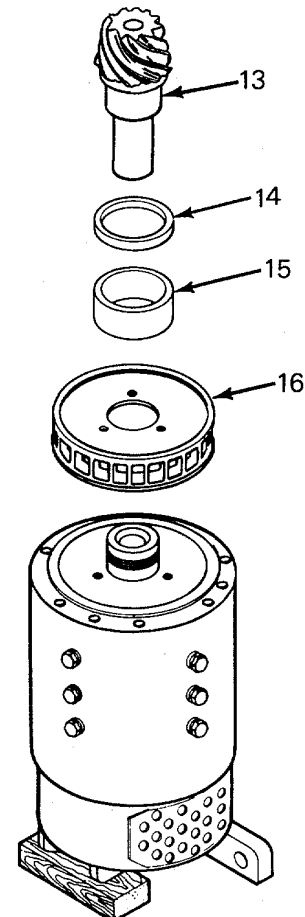
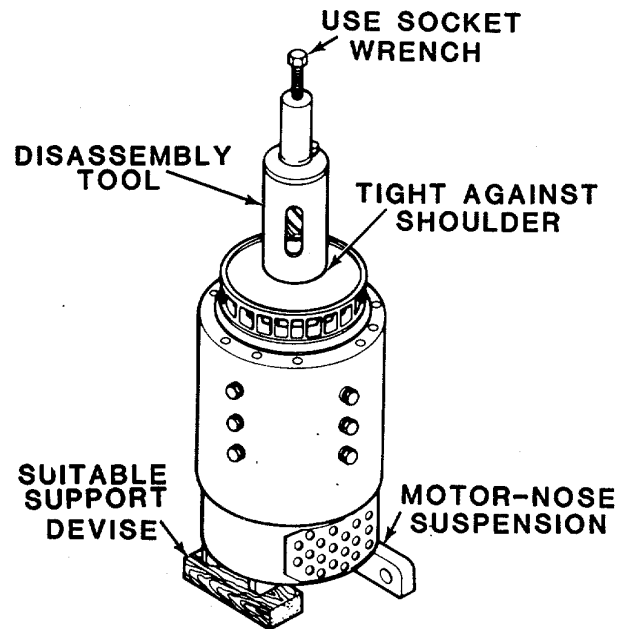
#### **WARNING**

Pinion gear will snap off suddenly under approximately 50-90 tons of pressure. Personnel must stand to either side of motor when pulling pinion gear. Injury or death could result.

#### **NOTE**

Pinion gear on the traction motor and ring gear in the gear box are a matched set and must be removed and installed together. If one is replaced, both must be replaced.

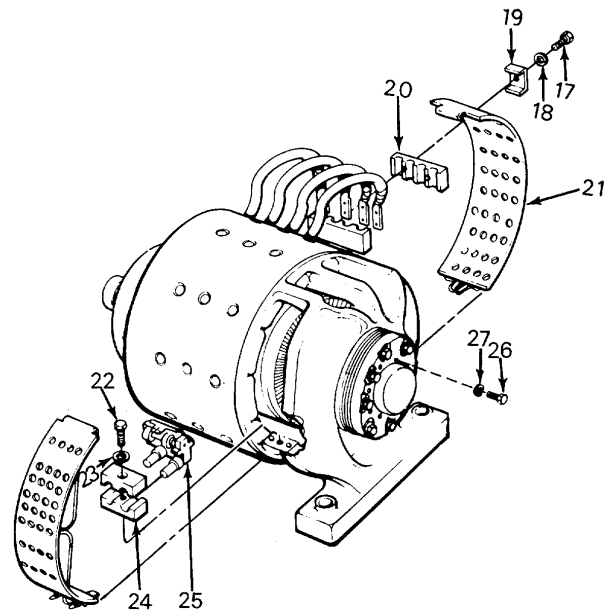
9. Pull up evenly on bolt to force piston down into pinion bore. When sufficient force has been built up, pinion will break loose from pinion bore. Approximately 50-90 tons pressure is required to break pinion loose.
10. Remove disassembly tool kit and remove hypoid pinion (13).
11. Use a puller and remove spacer (14) and inner bearing race (15).
12. Mark hub of fan (16) and head of armature (37) so fan can be mounted in the same location at assembly.
13. Place motor in horizontal position. Use puller from disassembly tool kit and remove fan (16) from armature (37).
14. Remove four capscrews (17), lockwashers (18), clamp (19), and wire bracket (20).
15. Remove two covers (21). Tag and disconnect brush holder leads. Remove four capscrews (22), lock-washers (23), clamps (24), and brush holders (25). Remove brushes from brush holders. Refer to TM 55-2210-224-12.
16. Wrap insulating paper around commutator to prevent damage.



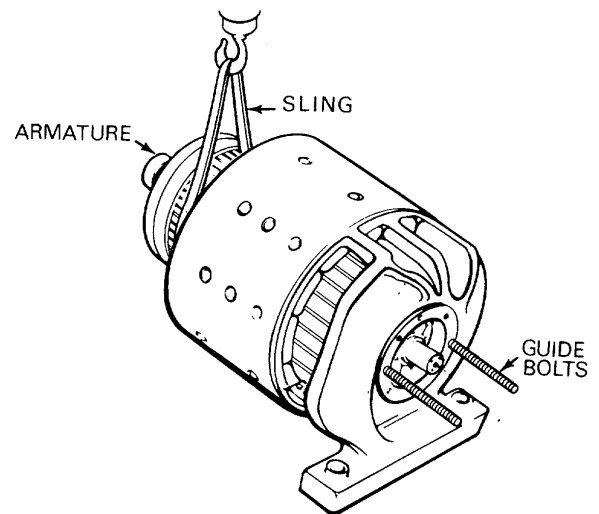
**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**DISASSEMBLY (cont)**

17. Remove eight capscrews (26) and lockwashers (27).
18. Install two 3/8-16 by 15-inch (381 mm) guide bolts through two holes in end plate (40) into bearing housing (35).
19. Install two jack bolts in the tapped holes provided and jack armature (37) out of motor housing (42) on the two guide bolts.



20. When armature (37) is 2 to 3 inches (50.8 to 76.2 mm) from the end of the frame, install a sling around armature. Use a suitable lifting device and support and remove armature. Remove the guide bolts from bearing housing (35).
21. Remove four flat-head screws (28), bearing cap (29), and gasket (30).
22. Straighten two tab bars (31) and remove four capscrews (32), tab bars, and clamping plate (33).
23. Use puller from disassembly tool kit and remove ball bearings (34) and bearing housing (35). Use a press and press ball bearings from bearing housing.



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**DISASSEMBLY (cont)**

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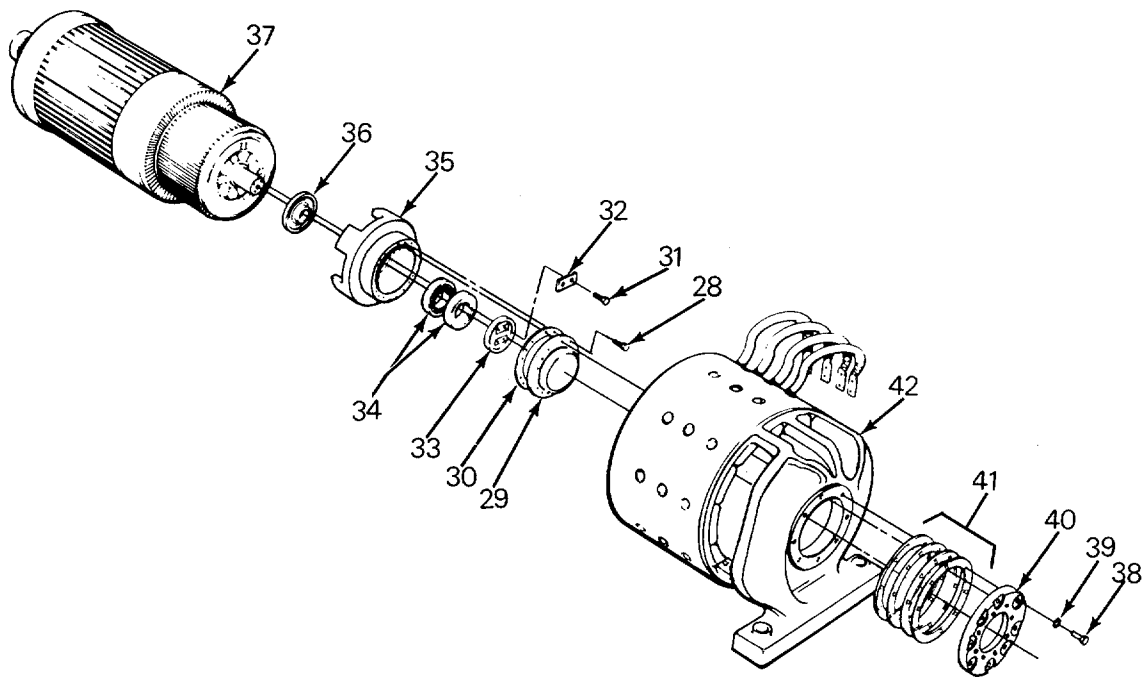
**WARNING**

Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.

**NOTE**

Some parts may have to be heated to release them from their shrink fit. When this becomes necessary, the use of a portable propane torch, a portable hydraulic press, and puller tools are recommended for disassembly.

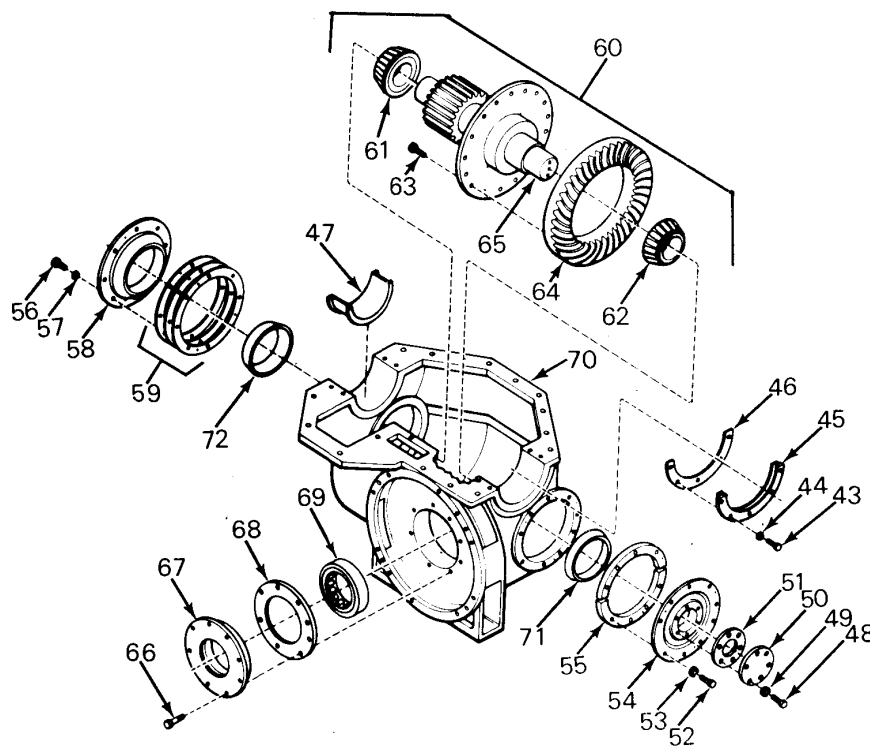
24. Use a torch and apply heat to expand seal collar (36) and slide off shaft of armature (37).
25. Remove eight capscrews (38), lockwashers (39), end plate (40), and shim pack (41) from motor housing (42).



### 3-64. TRACTION MOTOR ASSEMBLY (cont)

#### DISASSEMBLY (cont)

26. Disassemble gear unit (8) by the following:
- a. Remove 10 capscrews (43), lockwashers (44), 2 upper seal rings (45), and gaskets (46). Remove two upper axle linings (47).
  - b. Remove six capscrews (48), lockwasher (49), cover plate (50), and gasket (51).
  - c. Remove nine capscrews (52) and lockwashers (53). Place jacking screws in tapped holes in bearing housing (54) and remove bearing housing from gear box (70). Remove split spacer (55).
  - d. Remove nine capscrews (56) and lockwashers (57). Place jacking screws in tapped holes in bearing housing (58) and remove bearing housing from gear box (70). Remove shim pack (59). Keep shim pack together.
  - e. Use a suitable lifting device and remove intermediate shaft assembly (60) from gear box (70). Disassemble by the following:
    - (1) Use a suitable puller and remove bearing and roller assemblies (61) and (62) from intermediate shaft (65).
    - (2) Remove lockwire and nine bolts (63). Use jacking screws and remove hypoid gear (64) from intermediate shaft (65).
  - f. Remove lockwire and nine capscrews (66). Use jacking screws and remove bearing housing (67) and gasket (68). Use a suitable puller and remove bearing (69) from gear box (70).
  - g. Use a suitable puller and remove bearing races (71) and (72) from bearing housings (53) and (68).



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR**

27. Clean, inspect, and repair hypoid gear (64) by the following:

**WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  - ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**
- a. Use drycleaning solvent and clean hypoid gear (64). Dry with compressed air.
  - b. Magnaflux hypoid gear (64) and inspect for cracks. No cracks allowed.
  - c. Visually inspect hypoid gear (64) for broken, chipped, and pitted teeth. Maximum damage is 5% of total working surface of teeth.
  - d. Inspect outside bore of hypoid gear (64) Surface must be smooth. Use a fine grade of sandpaper and polish surface.
  - e. Replace hypoid gear (64) if damaged beyond repair.

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

28. Clean, inspect, and repair bearing assemblies (34), (61), (62), and (69) by the following:

**WARNING**

ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 50°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**

ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and remove grease from bearings, bearing cap (29), clamp plate (33), seal collar (36), end plate (37), and bearing housing (32). Dry with compressed air.
- b. Inspect parts for wear, cracks, and breaks.
- c. Inspect rollers for cracks and pits.
- d. Inspect parts for discoloration indicating overheating.
- e. Replace parts that are damaged.

**NOTE**

**Do not paint gasket surfaces.**

- f. Paint bearing housings with electrical insulating varnish.
- g. Replace gasket (30).

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

29. Clean, inspect, and repair armature (37) by the following:

**WARNING**

Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 50°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.

Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

**CAUTION**

Drycleaning solvent must not get on commutator, copper parts, coils, and windings. Damage to equipment will result.

**NOTE**

Damaged armature must be repaired at depot level maintenance facility.

- a. Blow carbon dust from armature assembly with compressed air. Direct air into the pockets and through the openings of the armature to remove internal accumulation of dirt.
- b. Use a wiping rag dampened with drycleaning solvent and wipe armature surface to remove external grease and dirt. Dry with compressed air.
- c. Remove heavy, caked deposits of dirt in ventilation holes of armature with a drill, reamer, or wire brush.
- d. Inspect for journal damage. If journal shows signs of bearing slippage, replace armature.
- e. Inspect pinion end of journal. Check that threads are not damaged. Check that surface where pinion gear mates is smooth. Use a fine grade of sand paper and polish surface.
- f. Inspect varnished surfaces of coil insulation. Replace insulation if blistered, flaked, or cracked.
- g. Check that bands are tight and secure and that soldering is intact.



**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- h. Use a dial indicator and check commutator for roughness or out-of-roundness. Commutator is out of round if there is a 0.002-inch (0.05 mm) variance within a six-bar span. Inspect surface for wear, burns, and pitting.
  - (1) Check that mica is undercut to a depth of 1/16 to 3/32 inch (1.6 to 2.4 mm). If mica depth is not within these limits, use an undercutting saw and regroove mica.
  - (2) Clean slots between copper bars to remove burrs.

**WARNING**

**Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- (3) Use dry, compressed air and remove loose mica and copper from commutator.

**NOTE**

**Do not paint commutator.**

- i. Paint surfaces of coil insulation with electrical insulating varnish.
30. Clean, inspect, and repair motor housing (42) by the following:

**WARNING**

ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**

ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use a wiping rag dampened with drycleaning solvent and remove dirt and foreign material from motor frame and field assembly. Dry with compressed air.
- b. Check that field coils, leads, and cable commutator are secure.

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

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- c. Check that shunt and interpole fields are tight.

**NOTE**

Do not paint machined surfaces.

- d. Paint insulation surfaces with electrical insulating paint.

- 31. Clean, inspect, and repair brush holders (25) by the following:

**WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and clean brush holders. Dry with compressed air.
- b. Inspect brush holders for wear, cracks, and breaks. Replace defective brush holder.
- c. Inspect insulators for breaks, cracks, burns, and dull surface. Replace defective insulators by pressing off stud and pressing new one on.
- d. Inspect studs for cracks and breaks. Replace defective studs by pressing out of brush holder and pressing new one in.
- e. Inspect spring assemblies for tension and check that braiding is not frayed. Replace defective spring assemblies.

**NOTE**

**Do not paint inside of brush holders.**

- f. Paint brush holders with clear acrylic lacquer.

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

32. Inspect gear box (70) by the following:

**WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and clean gear box (70). Dry with compressed air.
  - b. Check that gears have not been rubbing against gear box (70) by inspecting the inside metal band. Metal band should be intact and undamaged. Replace gear box that is damaged.
  - c. Paint outside surface of gear box (70) with black air drying insulating paint.
33. Check that traction motor leads are tight and secure. Replace insulation that is cracked or brittle with three layers of electrical tape using 1/2-inch (12.7 mm) lap. Paint with rubberized insulating paint.

**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

34. Clean, inspect, and repair remaining parts by the following:

**WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- a. Use drycleaning solvent and clean parts. Dry with compressed air.
- b. Inspect parts for cracks and breaks.
- c. Replace defective parts.
- d. Paint inside surface of covers (21) with electrical insulating varnish.
- e. Paint outside surface of motor housing (42) with rubberized insulating paint.
- f. Check that no machined surfaces are painted.

35. Refer to table 3-6 for traction motor data.

Table 3-6. Traction Motor Data

ITEM	SPECIFICATION
Classification	4 pole, dc, commutating-pole machine
Motor Speed (max. permissible)	4650 rpm
Resistance at 77F (25°C) (nominal)	
Existing Field	0.0142 ohm
Commutating Field	0.0150 ohm
Armature	0.0222 ohm

**3-64. TRACTION MOTOR ASSEMBLY (cont)****CLEANING, INSPECTION, AND REPAIR (cont)**

Table 3-6. Traction Motor Data (continued)

ITEM	SPECIFICATION
Standard Impedance (60 cycle, ac, armature assembled, brushes lifted)	
Maximum	Exciting Field at 9 amps 17.5 volts
Minimum	15 volts
Maximum	Commutating Field at 24 amps 18 volts
Minimum	16 volts
(60 Cycle, ac, armature removed)	
Maximum	Exciting Field at 20 amps 18.8 volts
Minimum	17.2 volts
Maximum	Commutating Field at 15 amps 7.7 volts
Minimum	7.1 volts
Pole Bores (measured between centers of opposite pole faces)	
Maximum	Exciting Field 11.76 in. (298.7 mm)
Minimum	11.74 in. (298.1 mm)
Maximum	Commutating Field 11.91 in. (302.5 mm)
Minimum	11.90 in. (302.2 mm)
Brush Data	
Pressure per brush	7-7/8 to 8-1/2 lb (3.5 to 3.8 kg)
Size (new)	5/8 in. x 1-3/4 in. x 2 in. lg (15.8 mm x 44.4 mm x 50.8 mm)
Minimum length (worn)	7/8 in. (22.2 mm)
Clearance (brush holder to commutator)	1/16 in. (1.58 mm)

**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

Table 3-6. Traction Motor Data (continued)

ITEM	SPECIFICATION
<b>Commutator Data</b>	
Type	Arch Bound
Diameter (new)	8-1/2 in. (215.9 mm)
Diameter (minimum worn)	8 in. (203.2 mm)
Side mica thickness	0.045 in. (1.14 mm)
Side mica grooving depth	3/64 in. (1.19 mm)
<b>Armature Bearing, Commutator End</b>	
Grease capacity (2/3 full)	5 oz (141.7 g)
Type lubricant	Ball and Roller Bearing Grease (RA-71005) (93508)
<b>Armature End Play</b>	
Normal adjustment	0.002 to 0.004 in. (0.05 mm to 0.10 mm)
Wear limit	0.010 in. (0.25 mm)
<b>High-Potential Test Voltages (at 60 cycles ac)</b>	

**CAUTION**

**To prevent damage to equipment increase slowly from zero to given value, hold for 60 seconds, and decrease slowly to zero.**

Motor with rewind armature and new field coils	2500 volts
Motor with old armature and field coils reconditioned	1750 volts

**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

Table 3-6. Traction Motor Data (continued)

ITEM	SPECIFICATION
Axle Bearings	
Diametrical clearance	
Minimum	0.020 in. (0.5 mm)
Maximum	0.060 in. (1.52 mm)
End Play	
Minimum	0.0625 in. (1.58 mm)
Maximum	0.150 in. (3.81 mm)
Temperature to heat bearing housing before assembly of ball bearings	158 to 176°F (70 to 80°C)
Temperature to heat housing and bearings assembly before mounting on armature shaft	195°F (90°C)
Torque to apply to clamping plate bolts when assembling bearings after bearing and shaft temperatures equalize	100 lb-ft (135.6 N.m)
Temperature to heat deflector when installing bearings	212°F (100°C)
Temperature to heat inner race and spacer when assembling on hypoid shaft	248°F (120°C)
Temperature above shaft temperature to heat armature fan before mounting	356°F (180°C)
Temperature to heat flinger when mounting	302°F (150°C)
Weights	
Motor only	1775 lb (805.1 kg)
Armature	600 lb (272.1 kg)
Motor, gear box, and accessories	3000 lb (1 360.8 kg)

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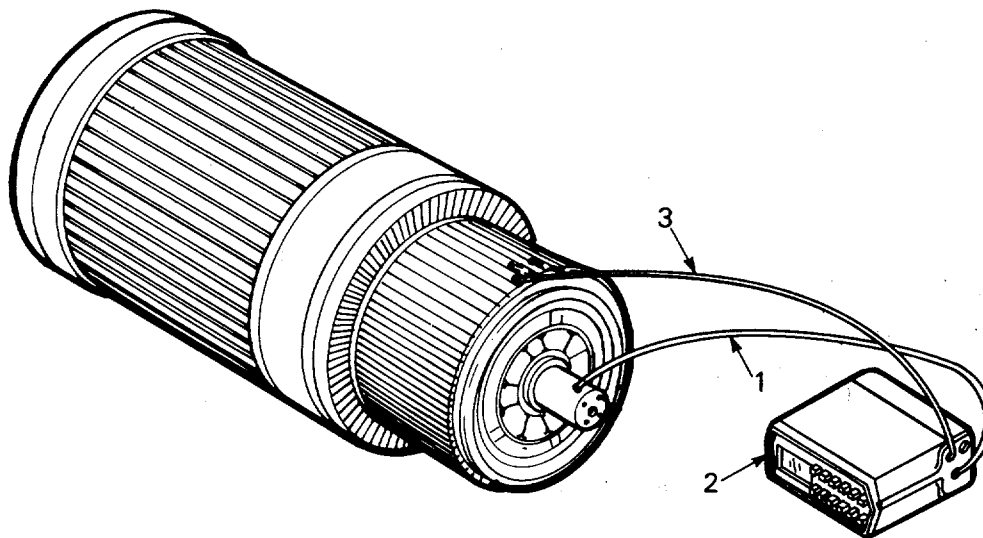
**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**TEST**

36. Perform armature and stator megohmmeter test by the following:

- a. Armature test.

**NOTE**

A minimum of 500 V at 1 megohm is required for this test.

- (1) Place lead (1) of megohmmeter (2) on shaft or core of the armature.
- (2) Place lead (3) of megohmmeter (2) on one of the commutator bars. Note indication on megohmmeter. Contact each successive bar around the commutator.

**WARNING**

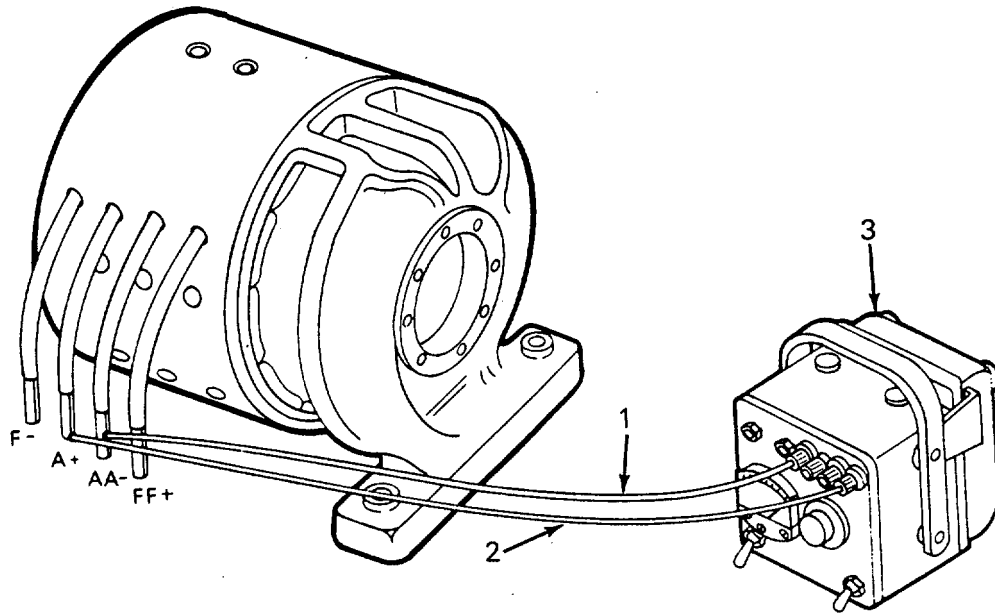
**Procedures specify the heating of parts to aid in disassembly and assembly. Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- (3) If an indication of less than 3 megohms is obtained, bake armature for 4 hours at 230° in a convection oven. Recheck after cooling armature to room temperature. If the indication is still low, replace the armature.



**3-64. TRACTION MOTOR ASSEMBLY (cont)****TEST (cont)**

## b. Stator Test.



- (1) Attach lead (1) of megohmmeter (3) to lead AA- on stator housing.
- (2) Attach lead (2) of megohmmeter (3) to lead A+ on stator housing and note indication on megohmmeter.
- (3) Attach lead (1) of megohmmeter (3) to lead FF+ on stator housing.
- (4) Attach lead (2) of megohmmeter (3) to lead F- on stator housing and note indication on megohmmeter.

**WARNING**

**Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

(5) If an indication of less than 3 megohms is obtained on the two sets of leads, bake stator for 4 hours at F230 (100°C) in a convection oven. Recheck megohm readings after cooling stator to room temperature. If the indications are still low, replace stator.

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**TEST (cont)**

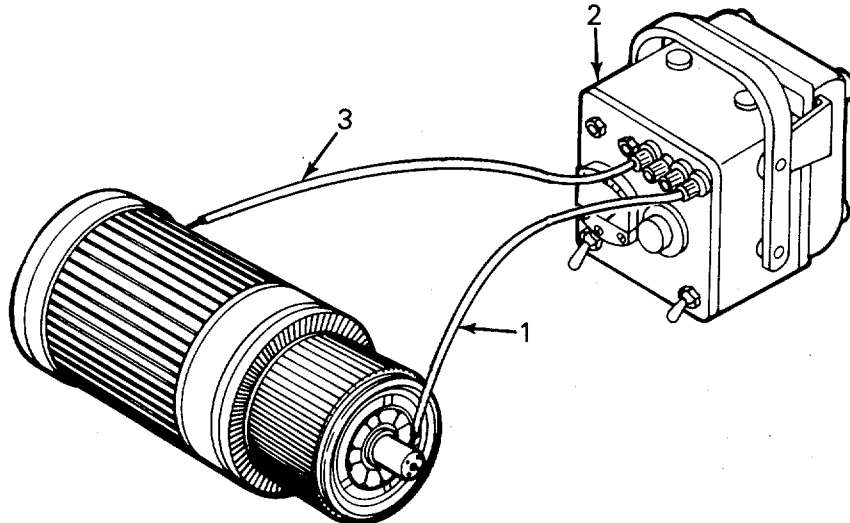
37. Perform a Bar-to-Bar resistance test by the following:

- a. Place lead (1) of multimeter (2) on the shaft or core of the armature.
- b. Place lead (3) of multimeter (2) on one of the commutator bars. Note and record indication on multimeter. Contact each successive bar around the commutator and record each indication.
- c. If the test shows resistance indication are 10 percent or more above the average recorded indication on 20 or more connections, TIG weld all coil leads to commutator neck connections. Resistance indications of 1/2 percent below the average or a full-scale meter deflection of the multimeter indicates a shorted coil to the armature.

**WARNING**

**Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- d. Below-average reading could indicate the presence of water in the coils. If below-average readings are obtained, bake armature in a convection oven for 4 hours at 250(110°C).
- e. Cool at room temperature and repeat step b.
- f. If readings are still low, replace armature.



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**ASSEMBLY**

38. Assemble gear unit (8) by the following:

**WARNING**

**Heated and cooled parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- a. Place bearing (69) in dry ice and freeze until will fit into gear box (70).
- b. Remove bearing (69) from dry ice and install in gear box (70). Position gasket (68) and bearing housing (67) and install nine capscrews (66). Lockwire capscrews.
- c. Place bearing races (72) and (71) in dry ice and freeze until the races will fit into their respective bearing housings. Place bearing housings (58) and (54) on induction heater and heat to  $210^{\circ}\text{C}$ .
- d. Remove bearing housing (58) from heater and bearing race (72) from dry ice. Place bearing race in bearing housing, tight against seat. Let cool to room temperature.
- e. Remove bearing housing (54) from heater and bearing race (71) from dry ice. Place bearing race in bearing housing, tight against seat. Let cool to room temperature.
- f. Assemble intermediate shaft assembly (60) by the following:
  - (1) Place hypoid gear (64) on an induction heater and heat to  $167^{\circ}\text{F}$  ( $75^{\circ}\text{C}$ ).
  - (2) Remove hypoid gear (64) from induction heater and install on intermediate shaft (65). Install 18 bolts (63). Lockwire bolts in pairs.
  - (3) Place bearing and roller assemblies (62) and (61) on induction heater and heat to  $210^{\circ}\text{C}$  above intermediate shaft temperature.
  - (4) Remove bearing and roller assemblies (62) and (61) from heater and install on intermediate shaft (65), tight against seats.
- g. Use a suitable lifting device and place intermediate shaft assembly (60) in gear box (70).
- h. Position shim pack (59) and bearing housing (58) on gear box (70) and install nine lockwashers (57) and capscrews (56). Be sure to use original shim pack.
- i. Guide intermediate shaft assembly (60) into both bearing housings. Install split spacer (55) and bearing housing (54).

**3-64. TRACTION MOTOR ASSEMBLY (cont)**

**ASSEMBLY (cont)**

- j. Install nine lockwashers (53) and capscrews (52).
  - k. Apply film of lubricating oil to bearings.
  - l. Position gasket (51) and cover plates (50) and install six lockwashers (49) and capscrews (48).
  - m. Install 2 upper axle linings (47), gaskets (46), and upper seal rings (45) and install 10 lockwashers (44) and capscrews (43).
39. Position shim pack (41) and end plate (40) on motor housing (42) and install eight lockwashers (39) and capscrews (38).

**WARNING**

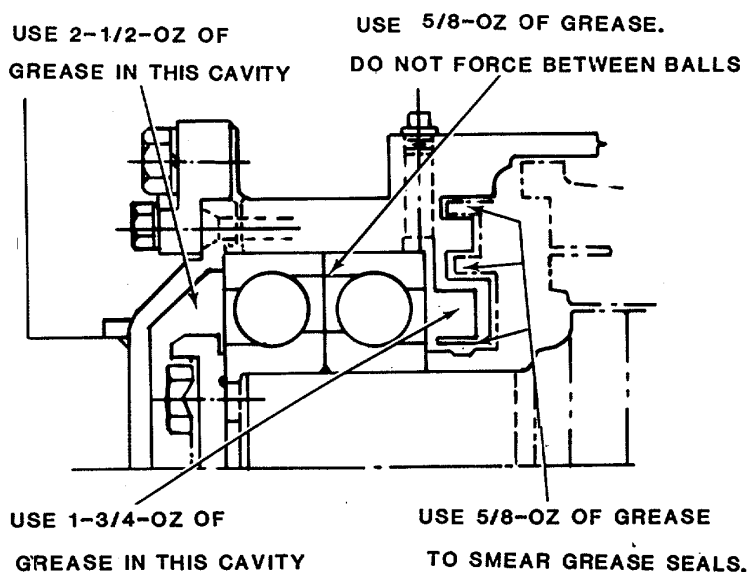
**Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

- 40. Place seal collar (36) on an induction heater. Heat collar to 275 (100°C).
- 41. Remove seal collar (36) from heater and install on shaft of armature (37), tight against shaft shoulder. Hold in place until cooled.
- 42. Check that bearing parts are thoroughly clean. Weigh 5 ounces of grease and distribute as shown.

**CAUTION**

**Do not exceed temperatures specified below, or grease may be damaged by oil bleeding from it.**

- 43. Place bearing housing (32) on induction heater. Heat housing to 158 to 176F (70 to 80°C).
- 44. Remove bearing housing (35) from heater and install two ball bearings (34), face-to-face with narrow shoulders of outer race together, into housing fit. Check that bearings seat against housing shoulder.



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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## ASSEMBLY (cont)

45. Place housing and bearing assembly on induction heater and heat assembly to 194°F (90°C).
46. Remove housing and bearing assembly from heater and install on shaft of armature (37). Check that inner race of bearing is tight against seal collar (36). Hold in place until cooled.
47. Install clamping plate (33), two tab bars (32), and four capscrews (31). Tighten capscrews uniformly to 90 ±10 lb-ft (122 ± 13.6 N.m). Lock capscrews by bending corners of tab bars against flat part of capscrew heads.
48. Position gasket (30) and grease-packed bearing cap (29) on bearing housing (35). Install four flat-head screws (28). Rotate bearing assembly by hand and check for freedom of rotation.
49. Position shim pack (41) and end plate (40) on motor housing (42) and install eight lockwashers (39) and capscrews (38).

**WARNING**

**Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

50. Use a suitable lifting device and place motor housing (42) in horizontal position on a suitable support device.
51. Wrap insulating paper around commutator of armature (37) to prevent damage. Install two 3/8-16 by 15-inch (381 mm) guide bolts into tapped holes in bearing housing (35).
52. Place a sling around the punchings of armature (37), next to fan end. Use a suitable lifting device and lift armature in a horizontal position until it is level with the bore of motor housing (42).
53. Guide armature (37) into motor housing (42). Take care not to damage commutator, and insert the two guide bolts through the two lower capscrew holes in end plate (40).

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**ASSEMBLY (cont)**

54. Install six lockwashers (27) and capscrews (26). Tighten capscrews evenly. Remove the two guide bolt and install remaining lockwashers and capscrews.
55. Remove insulating paper from commutator. Position four clamps (24) and brush holders (25) in motor housing (42) and install four lockwashers (23) and capscrews (22). Adjust brush holders to 1/16-inch (1.5 mm) clearance from commutator. Connect brush holder electrical leads and remove tags. Install two covers (21).
56. Position wire bracket (20) and clamp (19) and install four lockwashers (18) and capscrews (17).
57. Install brushes in four brush holders (25) and adjust for proper spring pressure. Refer to TM 55-2210-224-12.
58. Place motor (7) on floor in a vertical position supported on the motor-nose suspension and a suitable support device.

**WARNING**

**Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

59. Place fan (16) on an induction heater. Heat fan to ~~356~~<sup>356</sup>(180°C) above shaft temperature of armature (37).
60. Remove fan (16) from heater and install tight against armature head. Hold in place until cooled.
61. Place spacer (15) and inner bearing race (14) on an induction heater. Heat parts to ~~248~~<sup>248</sup>(20°C).
62. Remove spacer (15) and inner bearing race (14) from heater and install on hypoid pinion (13). Check that spacer is tight against pinion hub. Hold in place until cooled.

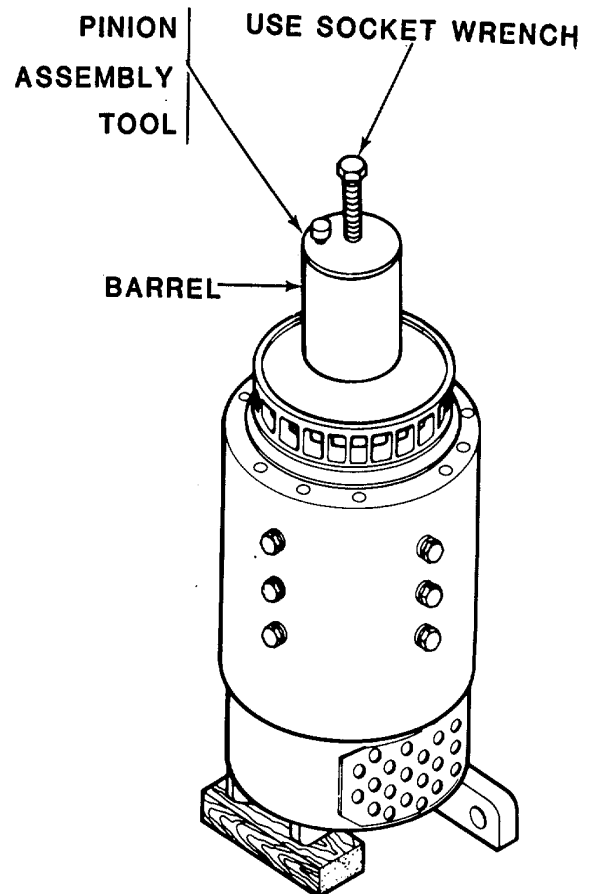
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**3-64. TRACTION MOTOR ASSEMBLY (cont)**


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**ASSEMBLY (cont)****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  - ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**
63. Use a wiping rag dipped in drycleaning solvent and remove all traces of oil or grease from pinion shaft and armature bore. Dry with compressed air.
  64. Insert hypoid pinion (13) in tapered bore of armature shaft. Rotate pinion in shaft for proper fit.
  65. Install pinion assembly tool as follows:
    - a. Screw beveled end of barrel on armature shaft.
    - b. Screw cap assembly into barrel until the large piston contacts the hypoid piston.
    - c. Remove bolt assembly. With assembly tool upright, fill chamber in cap with oil until it overflows through the drilled part inside.
    - d. Use a 1-inch (25.4 mm) diameter bar in hole provided in block of cap to steady cap assembly, and position socket wrench on bolt.



**3-64. TRACTION MOTOR ASSEMBLY (cont)****ASSEMBLY (cont)**

66. Press hypoid pinion (13) into armature shaft by tightening pressure bolt.

**NOTE**

**Do not mistake inner bearing race for shoulder on hypoid-pinion shaft when checking contact between pinion shoulder and armature shaft.**

67. Check seating of hypoid pinion (13) and armature shaft with 0.0015-inch (0.038 mm) feeler gage to make sure shoulder on pinion shaft is tight against armature shaft.

68. Remove assembly tool and recheck the seating.

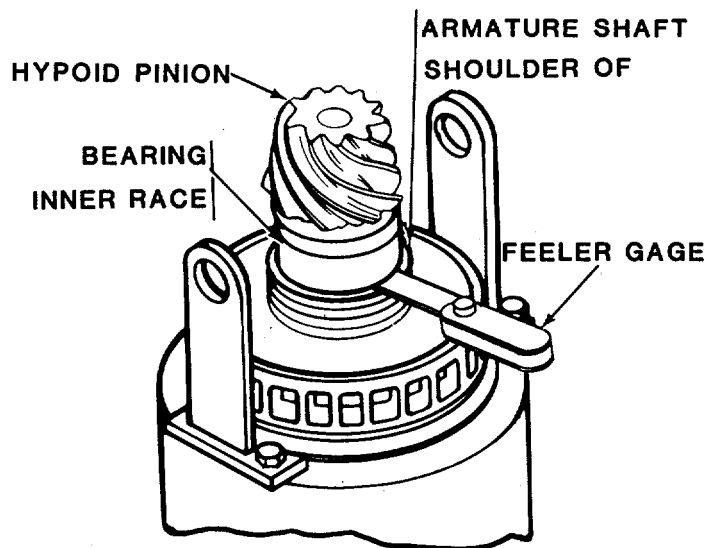
69. Install lockwasher (10) and bolt (11). Bend lockwasher to fit flat part of bolt.

**WARNING**

**Heated parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

70. Place oil slinger (12) on an induction heater. Heat slinger to 356°F (180°C).

71. Remove oil slinger (12) from heater and install on shaft of armature (37), over threads and tight against head of armature. Hold in place until cooled.

**INSTALLATION**

72. Install motor (7) on gear unit (8) by the following:

- a. Place gear box assembly on bench, inverted from normal position on truck. Remove motor lifting bracket (9).

**WARNING**

**Components of the traction motor are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

- b. Place a sling around motor (7). Use a suitable lifting device and lift motor level with gear unit (8).



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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**INSTALLATION (cont)****WARNING**

**Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100-138°F (38-59°C). If you become dizzy, get fresh air and get medical aid, immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**

- c. Use a wiping rag dipped in drycleaning solvent and thoroughly clean the rabbit fits of motor and gear case of dirt, oil, grease, and foreign matter. Be sure motor and gear case mounting faces are smooth and free from high spots.
- d. Check that the armature, fan, hypoid pinion, and pinion-end bearing inner race are installed in their proper places.
- e. Slowly guide motor into gear case. Take care that the hypoid pinion meshes properly with the hypoid gear.
- f. Install 12 lockwashers (6) and capscrews (5) through fan openings of gearcase. Tighten capscrews evenly. Use a 0.0015-inch (0.0381 mm) feeler gage around edge of motor frame and check that the mounting faces of motor and gearcase are in full contact.
- g. Use a pinion mounting distance gauge and check hypoid pinion (13) for proper location with respect to intermediate shaft center line. Each pinion has the plus or minus variation from nominal mounting distance etched on the end. The hypoid pinion location must be checked and possibly readjusted to proper distance if the following parts have been changed:
  - (1) The hypoid gears have been changed.
  - (2) A new armature has been installed, either with new or old hypoid gears.
  - (3) A new motor frame has been installed.
  - (4) A new commutator-end bearing has been installed.

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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

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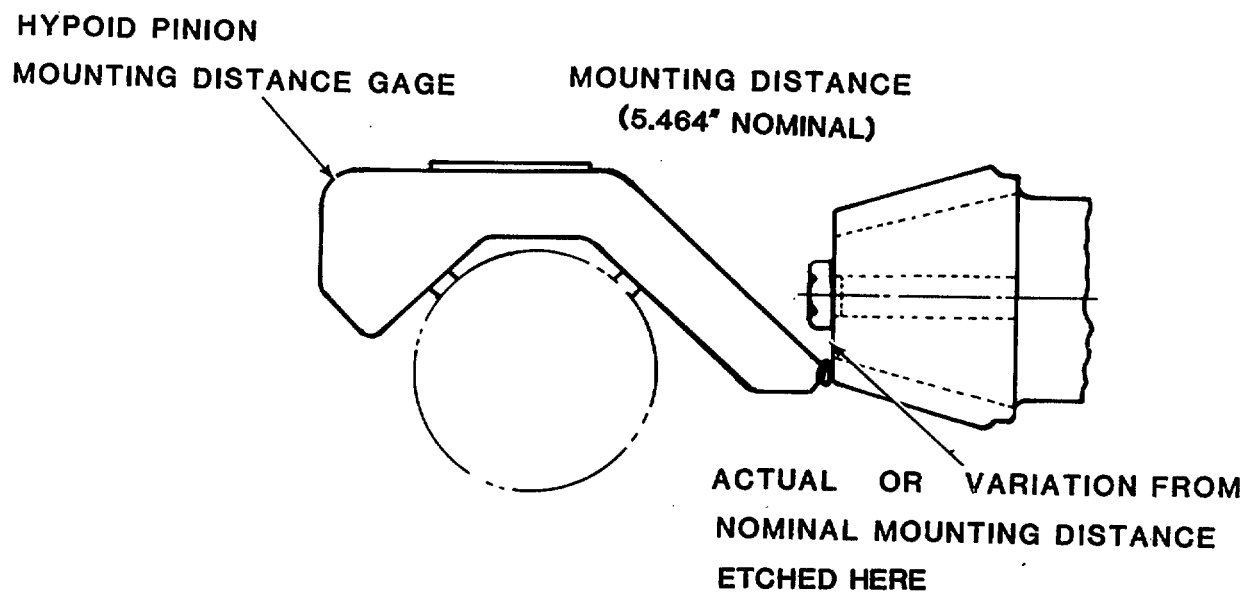
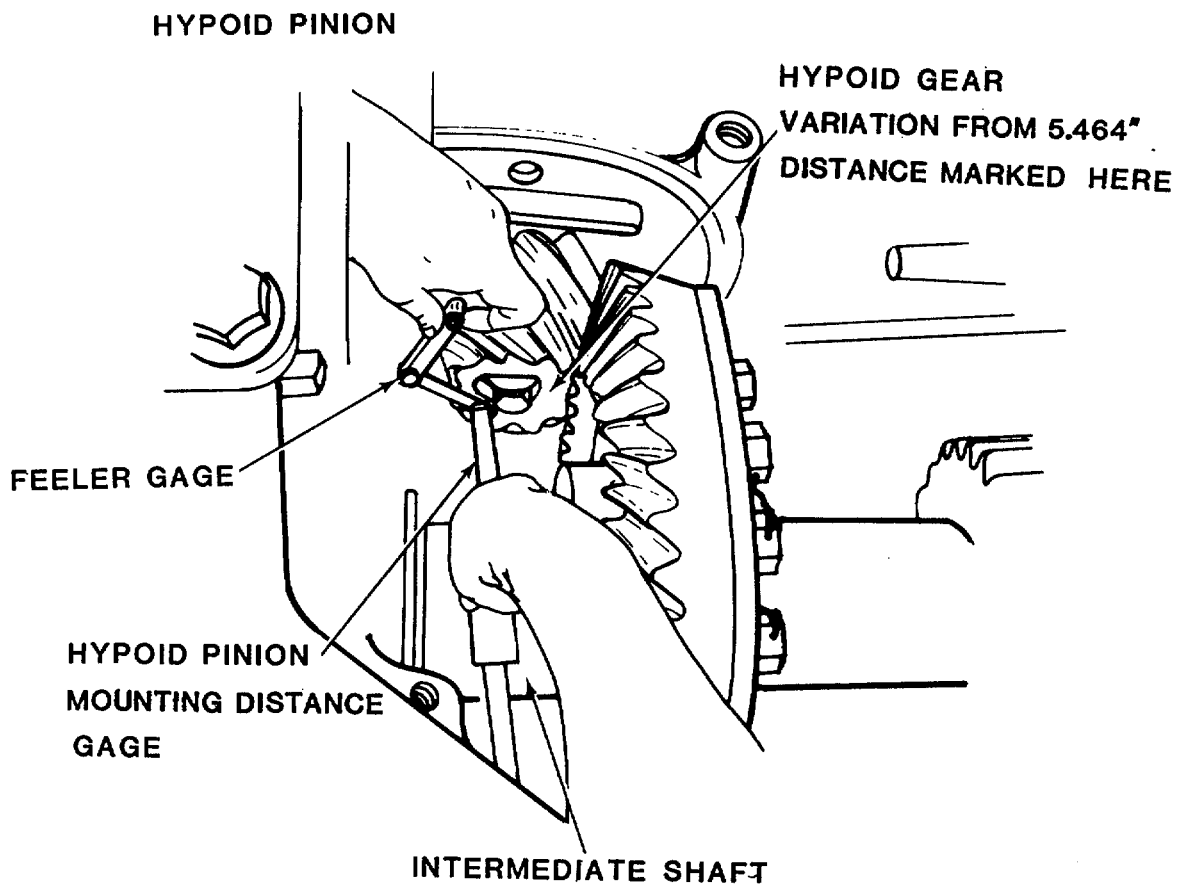
**INSTALLATION (cont)**

h. Relocate hypoid pinion (11) by the following:

- (1) Remove capscrews (51) and lockwashers (52). Remove bearing housing (53) and shim pack (55). Install bearing housing.
- (2) Place hypoid-pinion mounting gage in position. Move armature to obtain the proper mounting dimension; allow for the plus or minus variation in mounting dimension of the particular pinion.
- (3) Use a feeler gage and check and record the dimension between the motor frame and bearing housing (53). Install a shim pack (55) of that thickness. Install lockwashers (52) and capscrews (51).
- (4) Recheck mounting distance.
- (5) Below is an example of a relocation:
  - (a) The nominal mounting dimension to the center line of intermediate shaft for the hypoid pinion is 5.464 inches (138.785 mm). The clearance between the mounting distance gage and the hypoid pinion is 0.030 inch (0.762 mm) plus or minus the dimension marked on the end of the pinion.
  - (b) The illustration shows a hypoid pinion having plus 16 correction (0.016 inch, or 0.4064 mm), which means that the distance between the gage and the pinion (X dimension) must be set to 0.046 inch (1.1684 mm) for proper mounting of the pinion.
  - (c) The actual mounting dimension in this case is 5.464 plus 0.016, or 5.480 inches (138.785 plus 0.4064 mm, or 139.192 mm).
  - (d) Adjustment should be held to within ~~plus~~ minus 0.001 inch (0.0254 mm) of actual value.
- (6) After pinion has been set to proper mounting dimension, check the backlash of the hypoid gears with an indicator. The proper backlash is etched on the hypoid ring gear as shown. The backlash is obtained by shimming the intermediate shaft in the gear box. Set the indicator the value marked on the hypoid gear (for new gears only). Where worn hypoid gears are assembled, the backlash must be measured before disassembly, and the used gear should be adjusted to this value at assembly. Measure backlash as follows:
  - (a) Mount an indicator as shown, so that the pointer rests against the tooth face on the hypoid ring gear.
  - (b) Use a bar and force the intermediate shaft over to fully engage the hypoid gear and pinion and take up the end play of the intermediate shaft.
  - (c) While holding the motor armature shaft rigid, rock the ring gear back and forth and measure the backlash on the dial indicator.

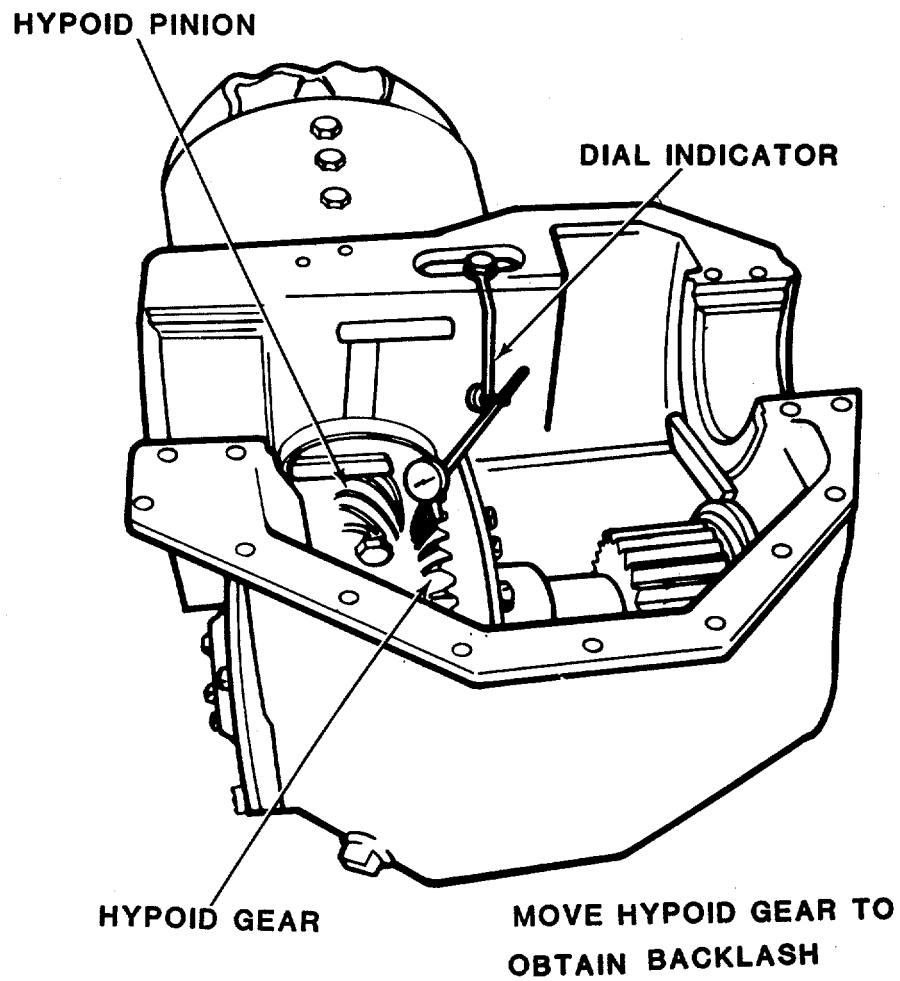
3-64. TRACTION MOTOR ASSEMBLY (cont)

INSTALLATION (cont)



3-64. TRACTION MOTOR ASSEMBLY (cont)

INSTALLATION (cont)



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**3-64. TRACTION MOTOR ASSEMBLY (cont)**

---

**INSTALLATION (cont)**

- i. Use iron blue pigment and check the tooth marking of the hypoid gear by rotating the gears back and forth over several teeth. A contact marking located slightly off center, toward the small end of the tooth, is desired.
  - j. If gear tooth marking is not as shown, and is a cross bearing (toward small end of the tooth on one side and large end on the other side), check for possible cause as follows:
    - (1) Check mounting dimension of hypoid pinion.
    - (2) Check backlash of hypoid gears.
    - (3) Check mounting surface gear box for damage such as high spots.
    - (4) Check motor frame mounting surface in the same manner.
  - k. After the hypoid pinion is adjusted to the proper mounting dimension and the tooth marking is satisfactory, add an 0.008-inch (0.203 mm) shim to shim pack (55) to correct for thermal expansion of the armature shaft.
  - l. Check that armature end play is between 0.002 and 0.004 inch.
72. Refer to paragraph 3-63 for installation of traction motor-gear unit to wheelaxle unit.
73. Remove 1-inch eye bolt (4). Position hypoid oil pan (3) in gear unit (8) and install three lockwashers (2) and capscrews (1). Lockwire capscrews.

**3-65. WHEEL**

This task covers:

Repair

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
 Wheel turning machine  
     Model 2012, Type A  
 DC welder 3431-00-276-0397

Material/Parts

Electrical tape (Item 36, Appendix B)

Equipment condition

Reference

Para 3-63  
 TM 5-2210-224-12

Condition Description

Brake lever equipment removed as required  
 Sander hose removed

**REPAIR**

**NOTE**

**Before wheel turning and recontouring are performed, wheel rim thickness and flange thickness must be measured to determine if the results will meet Association of American Railroad (AAR) Rule 41 specification requirements.**

1. Refer to TM 55-2210-224-12 for inspection procedures. Inspect wheels for wear, sharp flanges, shelling, cracks, and flat spots. Wheels will vary no greater than two tapes between wheels on same axle (1/4 inch (6.35 mm)) in circumference or 0.080 inch (2 mm) in diameter. Wheel size between different axles can vary up to 3/4 inch (19.05 mm) in diameter. Defects greater than those outlined above will require removal of wheel sets from truck assembly.

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**3-65. WHEEL (cont)**

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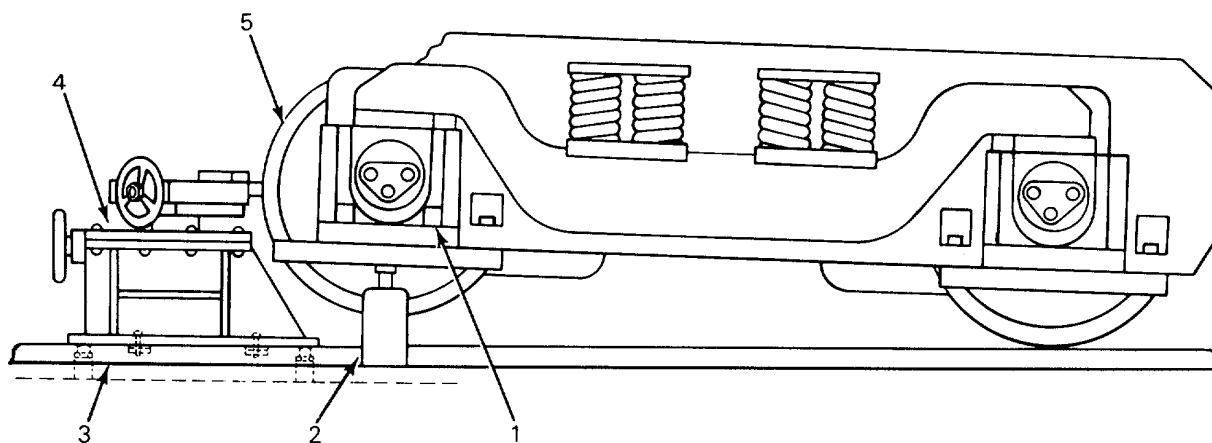
**REPAIR (cont)****WARNING**

When machining wheels of locomotive, be careful of hot, sharp chips. Wear adequate eye protection. Use leather welding gloves. Cover exposed skin areas. Do not use hand to remove shavings, even with leather gloves. Use a hook or welding rod.

2. Use a portable wheel lathe and turn wheel down as follows:

**NOTE**

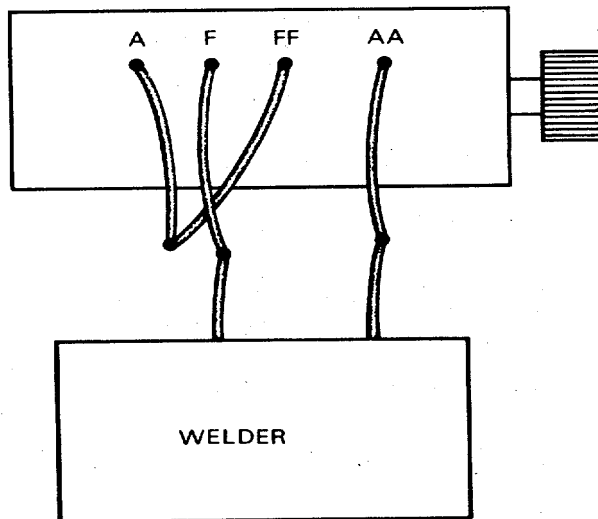
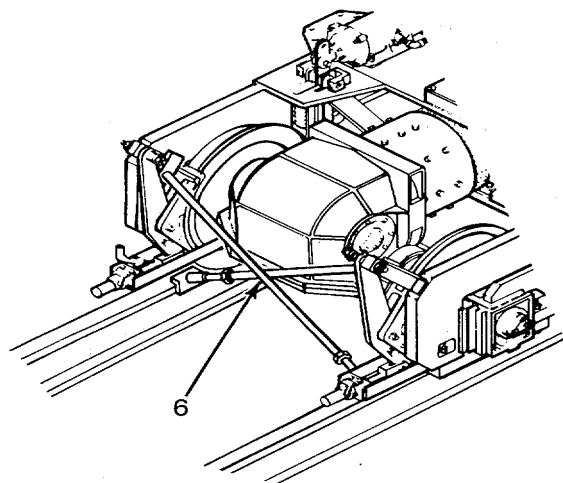
- ⌚ Lift must be accomplished with a 30-ton (27.1 metric tons) (minimum) jack.
  - ⌚ To be certain that axle is raised by pedestal assembly, two blocks approximately 3-1/2 inches (88.9 mm) high must be used on each wheel.
- a. Install two blocks (1) between bearing and pedestal binder on each side.



**3-65. WHEEL (cont)**

**REPAIR (cont)**

- b. Install 30-ton (27.1 metric ton) jack (2) on each side under roller bearing axle assembly and raise axle until wheel clear rail (3) by 1 inch (25.4 mm).
  - c. Disconnect traction motor leads from locomotive.
  - d. Connect traction motor leads to welder as shown below.
  - e. Install wheel turning machine (4) on rail in front of wheel (5) and lock in place.
  - f. Install adjusting poles (6) from opposite rail to machine edge and adjust to hold spread; then tighten clamping bolts and adjusting pole securely.
  - g. Start rotation of wheel and engage wheel turning machine with wheel. Turn wheel in accordance with FRA regulations.
3. After wheels are turned, disconnect traction motor leads from welder.
  4. Connect traction motor leads to locomotive and tape all leads.
  5. Remove adjusting poles (6) and wheel turning machine (4) from wheel (5) and rail (3).
  6. Lower jack (2) and remove from locomotive.
  7. Remove two blocks (1) from between bearings and pedestal binders.
  8. Inspect wheels in accordance with TM 55-2210-224-12.





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**3-66. COUPLER**

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This task covers:

- |                |               |             |                 |
|----------------|---------------|-------------|-----------------|
| a. Removal     | c. Cleaning   | e. Repair   | g. Installation |
| b. Disassembly | d. Inspection | f. Assembly |                 |
- 

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CI-E12  
Magnaflux

**Materials/Parts**

Drycleaning solvent (Item 34, Appendix B)  
Graphite grease (Item 16, Appendix B)  
Grease GAA (Item 13, Appendix B)

**Personnel Required**

2

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**REMOVAL****WARNING**

**Components of the coupler are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

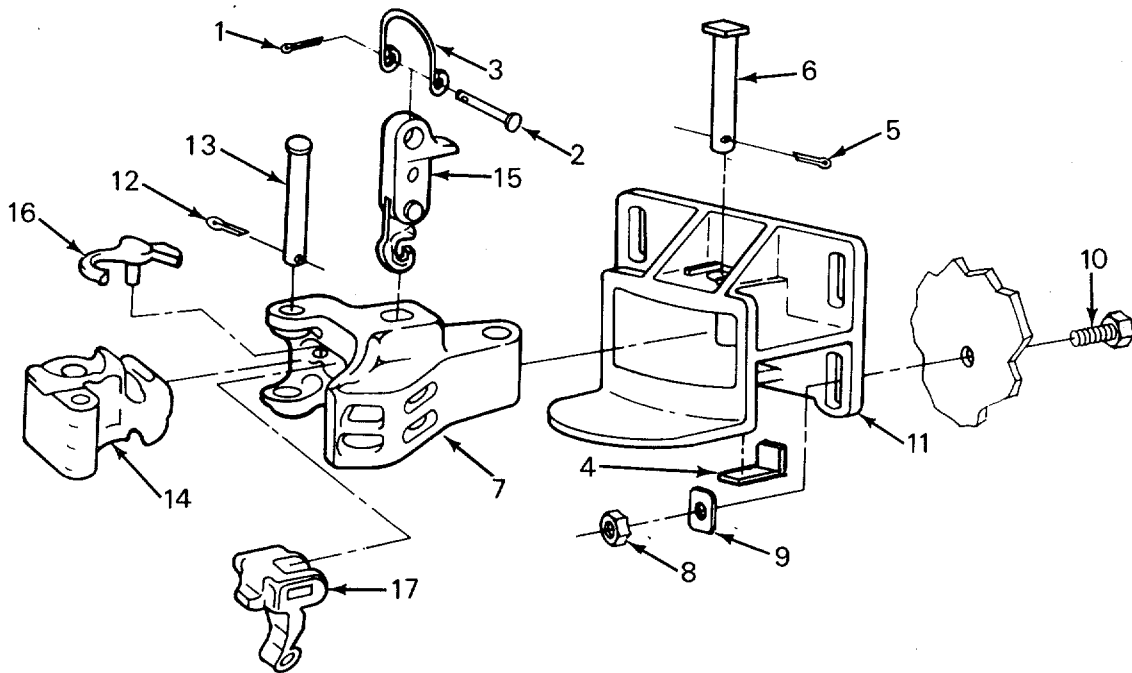
1. Remove cotter pin (1) and pin (2) from uncoupler clevis (3).
2. Use a suitable lifting device and support coupler (6).
3. Use a cutting torch and remove flange (4). Remove cotter pin (5) and toggle pin (6). Remove coupler (7).
4. Use a suitable lifting device and support yoke (11).
5. Remove four nuts (8), plate washers (9), and bolts (10). Remove yoke (14).

**DISASSEMBLY**

6. Remove cotter pin (12), knuckle pin (13), and knuckle (14).
7. Remove lock lifter (15), knuckle thrower (16), and knuckle lock (17).

## 3-65. COUPLER (cont)

## REMOVAL (cont)



## CLEANING, INSPECTION, AND REPAIR

**WARNING**

- ⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air immediately and get medical aid. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

8. Use drycleaning solvent and clean parts. Dry with compressed air.
9. Magnaflux pivot pin. Replace pin if cracked or if diameter is worn below 1-11/16 inches (42.8625 mm).
10. Inspect pocket of yoke (10) for rough surfaces. Remove roughness as required.
11. Magnaflux yoke (10). Replace if cracked. Inspect pin hole. Diameter of pin hole is 1-13/16 inches (46 mm) minimum and 2 inches (50.8 mm) maximum. Replace yoke in hole.

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**3-65. COUPLER (cont)**

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**REMOVAL (cont)**

12. Inspect remaining parts of coupler assembly for cracks, breaks, and other damage.
13. Repair consists of replacement of damaged parts.

**ASSEMBLY**

14. Install knuckle lock (17), knuckle thrower (16), and lock lifter (15).
15. Install knuckle (14), knuckle pin (13), and cotter pin (12).

**INSTALLATION****WARNING**

**Components of the draft gear and coupler are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

16. Use a suitable lifting device and position yoke (11) on locomotive frame. Install four bolts (10), plate washers (9), and nuts (8).
17. Use a suitable lifting device and position coupler (7) in yoke (11). Install toggle pin (6) and cotter pin (5). Use a welding machine and weld flange (4).
18. Position uncoupler clevis (3) on lock lifter (15) and install pin (2) and cotter pin (1).

## CHAPTER 4

## GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

## Section I. REPAIR PARTS, SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

**4-1. COMMON TOOLS AND EQUIPMENT**

For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your unit.

**4-2. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT**

Special tools, TMDE, and support equipment are listed and illustrated in TM 55-2210-224-24P.

**4-3. REPAIR PARTS**

Repair parts are listed and illustrated in the Repair Parts and Special Tools List TM 55-2210-224-24P covering intermediate general support maintenance for this equipment.

## Section II. GENERAL SUPPORT MAINTENANCE INSTRUCTION

**4-4. SCOPE**

This chapter contains maintenance procedures authorized at the general support maintenance category.

**4-5. TASK SUMMARY**

TASK PARA	PROCEDURES	PAGE NO.
4-6	Transition Relay Panel	4-2
4-7	Cooling Radiator	4-6
4-8	Air Compressor Assembly	4-9
4-9	Diesel Engine	4-32
4-10	Motor Mounts	4-35
4-11	Automatic Brake Valve	4-36
4-12	Independent Brake Valve	4-54
4-13	6-NFR Distributing Valve	4-60
4-14	No. 8 Vent Valve	4-71
4-15	A1 Charging Cutoff Rbt Valve	4-76
4-16	H-5 Relay Air Valve	4-83
4-17	Emergency Brake Valve	4-88
4-18	Strainer and Check Valve	4-92
4-19	Cutout Cock and Strainer	4-96

**4-6. TRANSITION RELAY PANEL**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Test        | c. Cleaning   | e. Repair   |
| b. Disassembly | d. Inspection | f. Assembly |

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

Test Equipment

10 to 6000 Hz signal generator  
 Variable dc voltage supply  
 75 ohm, 100W load resistor  
 150 ohm, 5 W resistor  
 10 to 6000 Hz frequency counter  
 Oscilloscope

Equipment Condition

Reference

Para 3-36

Condition Description

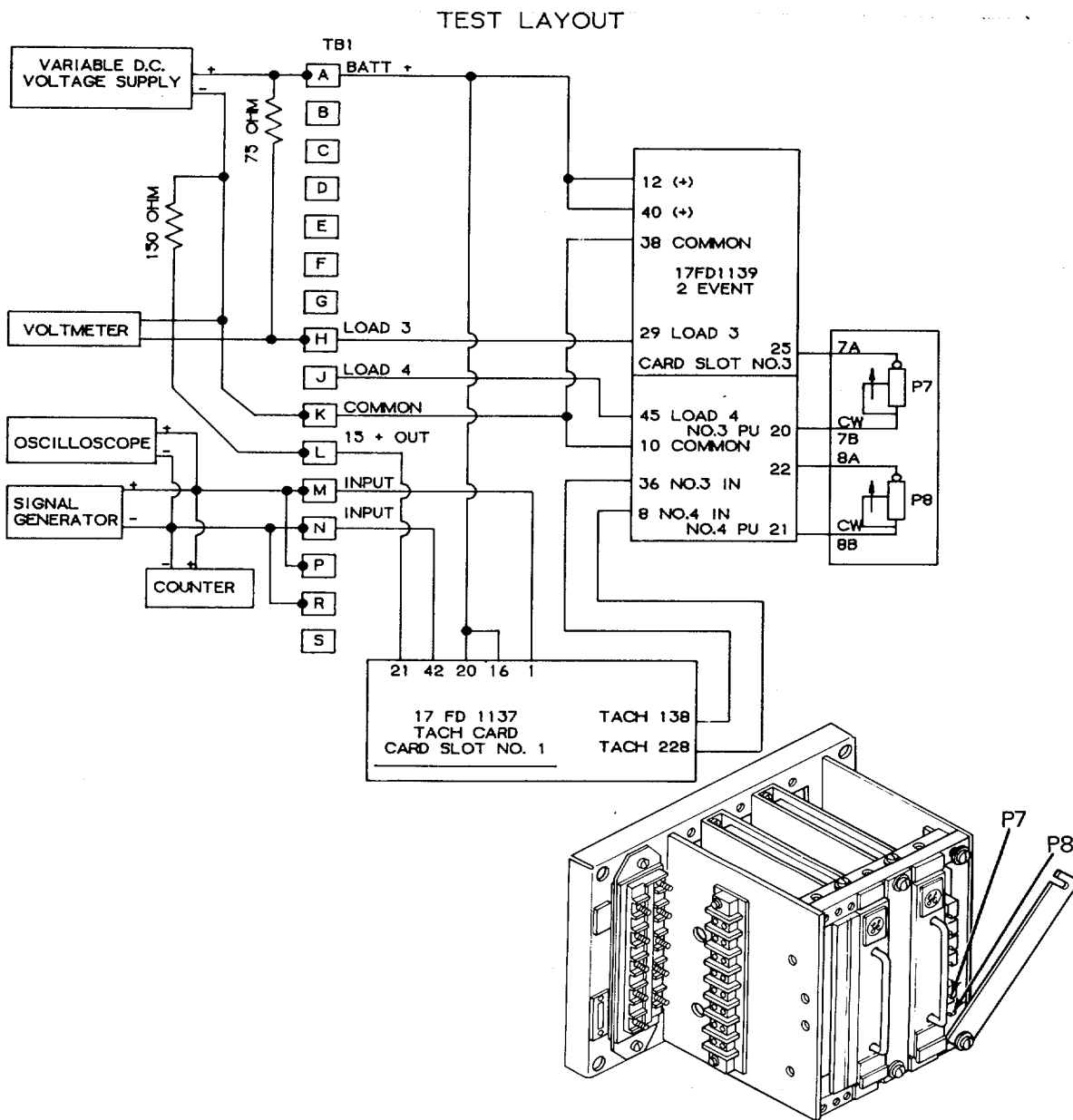
Transition relay panel removed

**TEST**

1. Test the transition relay panel as follows:
  - a. Connect jumpers between TB1-M and TB1-P and TB1-N and TB1-R.
  - b. Connect 75-ohm resistor between TB1-A and TB1-H.
  - c. Connect 150-ohm resistor between TB1-L and TB1-K.
  - d. Connect positive lead of variable dc voltage supply to TB1-A. Connect negative lead to TB1-K. Set output of voltage supply to 37.5 V dc.
  - e. Connect signal generator leads to TB1-P and TB1-R. Use an oscilloscope and a frequency counter and set the signal generator frequency to 10 Hz and amplitude to 20 V P-P.
  - f. Connect multimeter between TB1-H and TB1-K.

4-6. TRANSITION RELAY PANEL (cont)

TEST (cont)



- g. While observing multimeter, slowly increase frequency of signal generator until indication on multimeter jumps to 2 to 3 V dc. The frequency of the signal generator shall be between 194 and 200 Hz. If the frequency is incorrect, set signal generator frequency to 197 Hz and adjust P7 for proper indication.
- h. While observing multimeter, increase frequency of signal generator to 1000 Hz. The indication on the multimeter shall not increase.
- i. While observing multimeter, slowly decrease signal generator frequency until indication on multimeter falls to less than 0.1 V dc. The frequency of the signal generator shall be between 182 and 198 Hz. If the frequency is incorrect, set frequency to 190 Hz and adjust P8 for proper signal generator indication.

## 4-6. TRANSITION RELAY PANEL (cont)

### TEST (cont)

- j. In the above test, if the output at TB1-L is incorrect, tach receiver card 1137 is probably defective. If the output at TB1-L is correct but either output at TB1-H or TB1-J is incorrect and will not adjust, the two-channel speed-event card 1139 is probably defective.
- k. Disconnect test equipment.

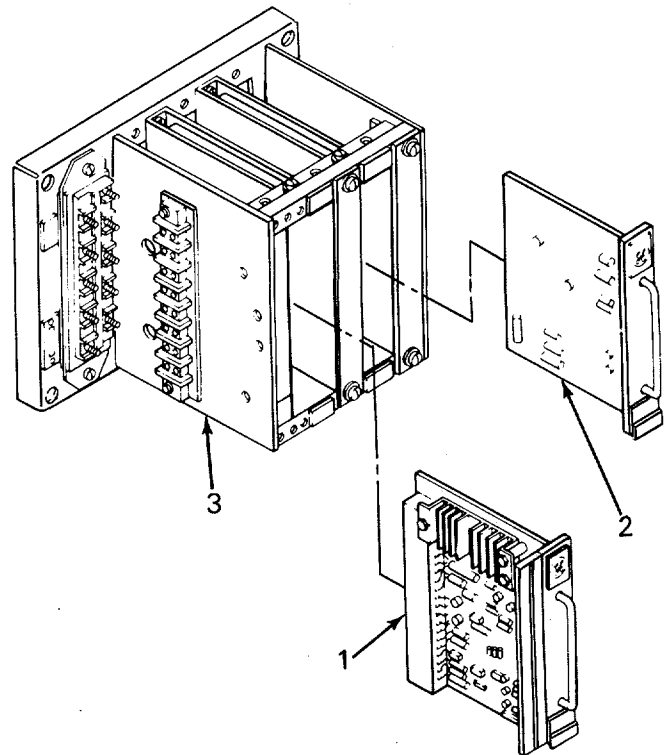
### DISASSEMBLY

2. Remove tach receiver card (1) and two-channel speed-event card (2) from relay panel(3).

### CLEANING, INSPECTION, AND REPAIR

#### WARNING

- ⌚ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
  - ⌚ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.
3. Use a clean wiping rag damped in drycleaning solvent and remove grease or oil from frame. Remove dust and dirt by blowing with dry compressed air.
  4. Inspect cards for cracks, breaks, or damage. Inspect protective coating for damage.



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**4-6. TRANSITION RELAY PANEL (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

5. Inspect frame for cracks, breaks, and damage. Inspect wiring for cracks, breaks, and damaged insulation.
6. Repair or replace damaged wires. Replace defective cards.

**ASSEMBLY**

7. Install tach receive card (1) in slot 1 and install two-channel speed-event card (2) in slot 3 relay panel (3).



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**4-7. COOLING RADIATOR**

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This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     |             |
- 

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
Stainless steel rod

Material/Parts

Alkali cleaning compound (Item 7, Appendix B)  
Tin alloy solder (Item 33, Appendix B)

Equipment Condition  
Reference  
Para 3-41

Condition Description  
Cooling radiator removed

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**DISASSEMBLY**

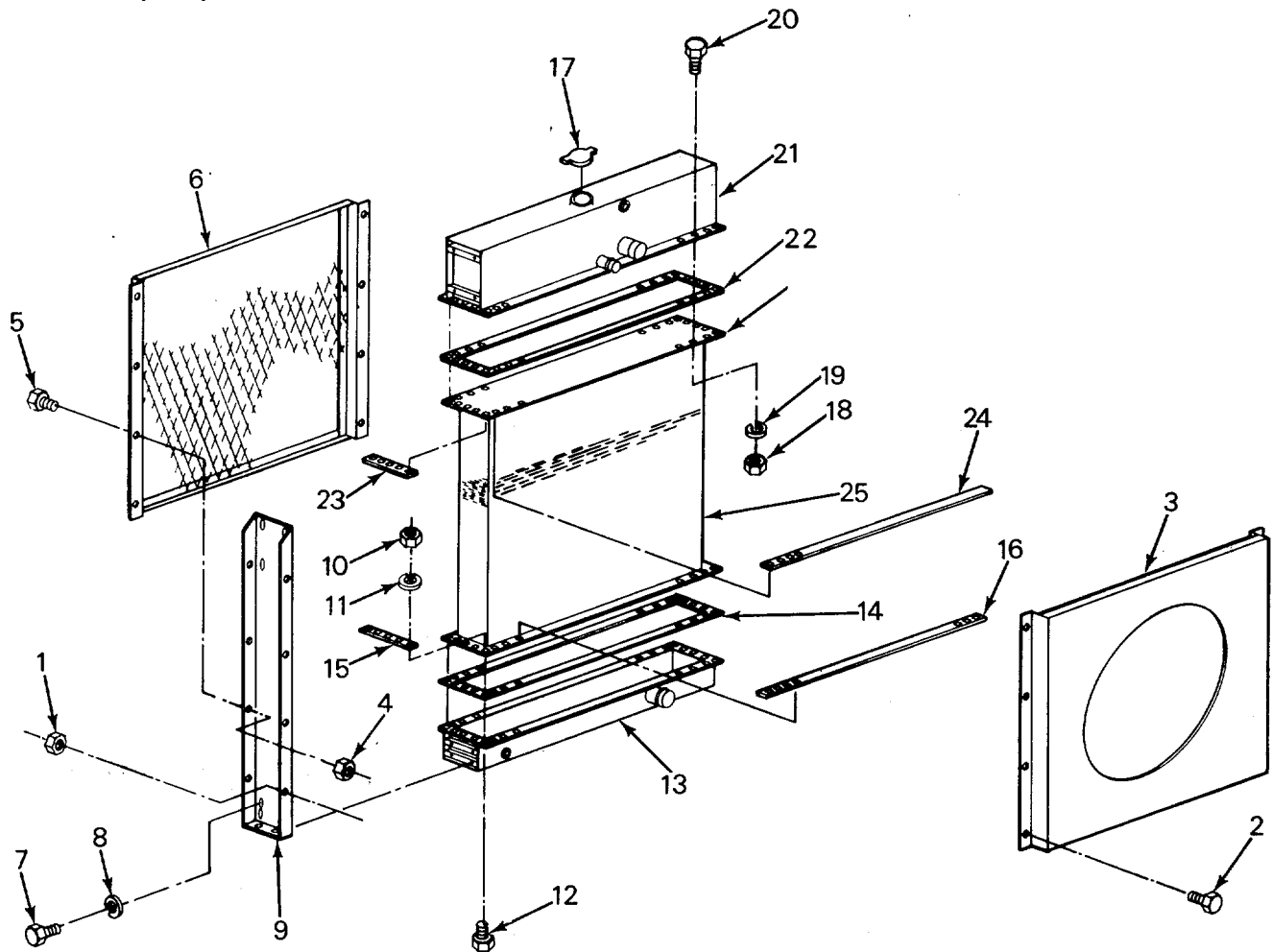
**NOTE**

**Check that cooling system is drained.**

1. Remove eight nuts (1), cap screws (2), and shroud (3).
2. Remove eight nuts (4), capscrews (5), and core guard (6).
3. Remove 12 capscrews (7) and lockwashers (8). Remove two side members (9).
4. Remove 54 nuts (10), lockwashers (11), and capscrews (12). Remove bottom header tank (13), gasket (14), two short header bars (15), and long header bars (16).
5. Remove radiator cap (17), 54 nuts (18), lockwashers (19), and capscrews (20). Remove top header tank (21), gasket (22), short header bars (23), and long header bars (24). Remove core (25).

## 4-7. COOLING RADIATOR (cont)

## DISASSEMBLY (cont)



## CLEANING, INSPECTION, AND REPAIR

6. Use a putty knife and remove old gasket material from header tank gasket surfaces.
7. Place core in a tank of hot alkaline cleaning compound and soak for 4 hours.
8. Remove core and steam clean. Rinse with clean water.
9. Use a putty knife and remove old gasket material from core gasket surfaces. 10. Insert a stainless steel rod through each core tube.

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**4-7. COOLING RADIATOR (cont))**

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**CLEANING, INSPECTION, AND REPAIR (cont)****WARNING**

**Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

11. Use compressed air and blow out each core tube. Rinse with clean water.
12. Visually examine core for cracks, breaks, or other damage.
13. Refer to paragraph 3-40 and perform a leak test.
14. Use duckbill pliers and straighten bent core fins. Use tin alloy solder to repair leaks in core fins.

**ASSEMBLY**

15. Position core (25) and install two long header bars (24), short header bars (23), gasket (22), and top header tank (21). Secure with 54 capscrews (20), lockwashers (19), and nuts (18). Install radiator cap (17).
16. Position two short header bars (15), long header bar (16), gasket (14), and bottom header tank (13). Install 54 capscrews (12), lockwashers (11), and nuts (10).
17. Position two side members (9). Install 12 lockwashers (8) and capscrews (7).
18. Position core guard (6) and install eight capscrews (5) and nuts (4)
19. Position shroud (3) and install eight capscrews (2) and nuts (1).

**4-8. AIR COMPRESSOR ASSEMBLY**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

INITIAL SETUP

Tools

Tool Kit SC4940-97-CL-E12  
 Magnetic particle tester  
 6635-00-306-6568  
 Feeler gage  
 Honing drill  
 Dial indicator 5210-00-640-0953  
 Torque wrench  
 Induction heater

Material/Parts

Dry ice (Item 10, Appendix B)  
 Drycleaning solvent (Item 34, Appendix B)  
 Lubricating oil (Item 21, Appendix B)  
 Grease BB (Item 14, Appendix B)

Test Equipment

Orifice holder  
 Micrometer 5210-00-267-3093

Equipment Condition

Reference  
 Para 3-42

Condition Description

Air compressor assembly removed

**DISASSEMBLY**

**WARNING**

- ⓘ Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- ⓘ Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.
- ⓘ

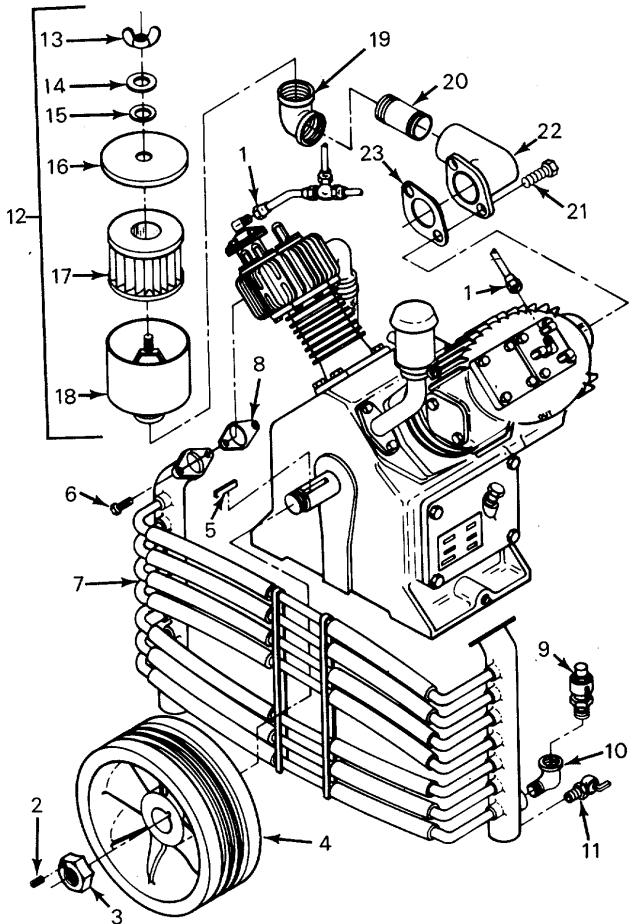
**NOTE**

Thoroughly clean exterior to prevent dirt from entering internal parts. 1. Use drycleaning solvent and remove dirt from exterior of air compressor. Dry with compressed air.

**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

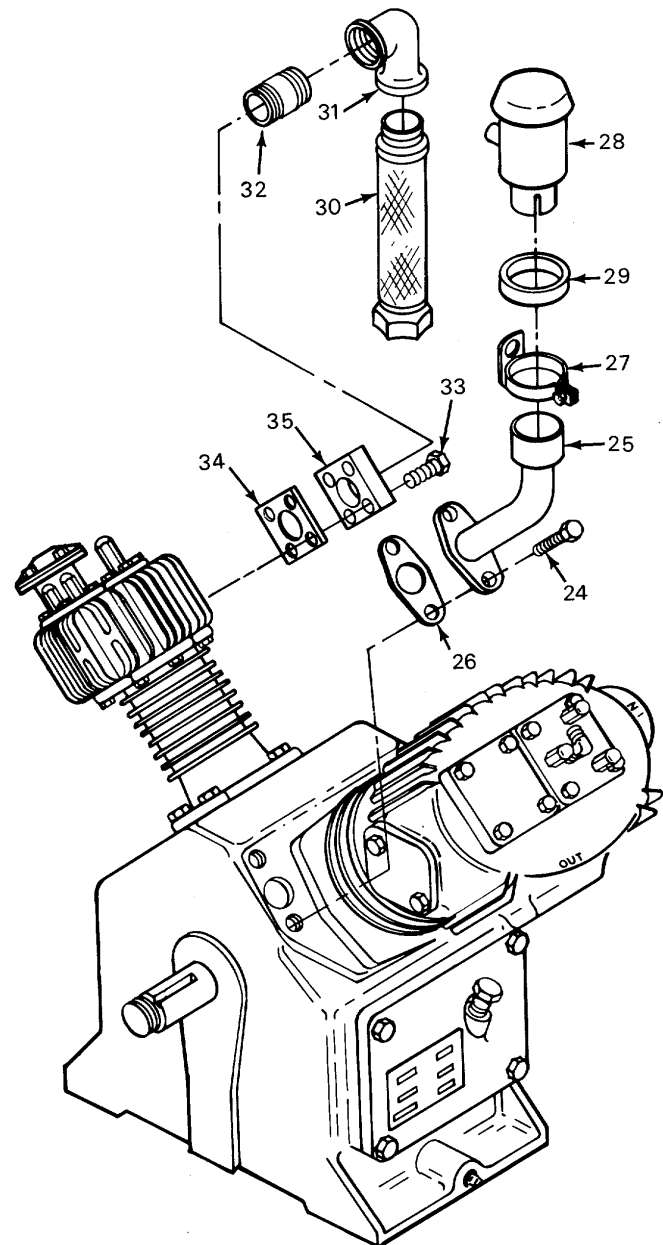
**DISASSEMBLY (cont)**

2. Remove unloader air line and fittings (1).
3. Loosen two setscrews (2) and remove nut (3). Use a puller and remove pulley (4) and square key (5).
4. Remove four capscrews (6), intercooler (7), and two gaskets (8). Remove safety valve (9), elbow (10), and two petcocks (11) from intercooler.
5. Remove air filter assembly (12) and disassemble by the following:
  - a. Remove wing nut (13), flat washer (14), cork gasket (15), and cover (16).
  - b. Remove air filter element (17) from body (18).
6. Remove elbow (19) and nipple (20). Remove two capscrews (21), suction manifold (22), and gasket (23).



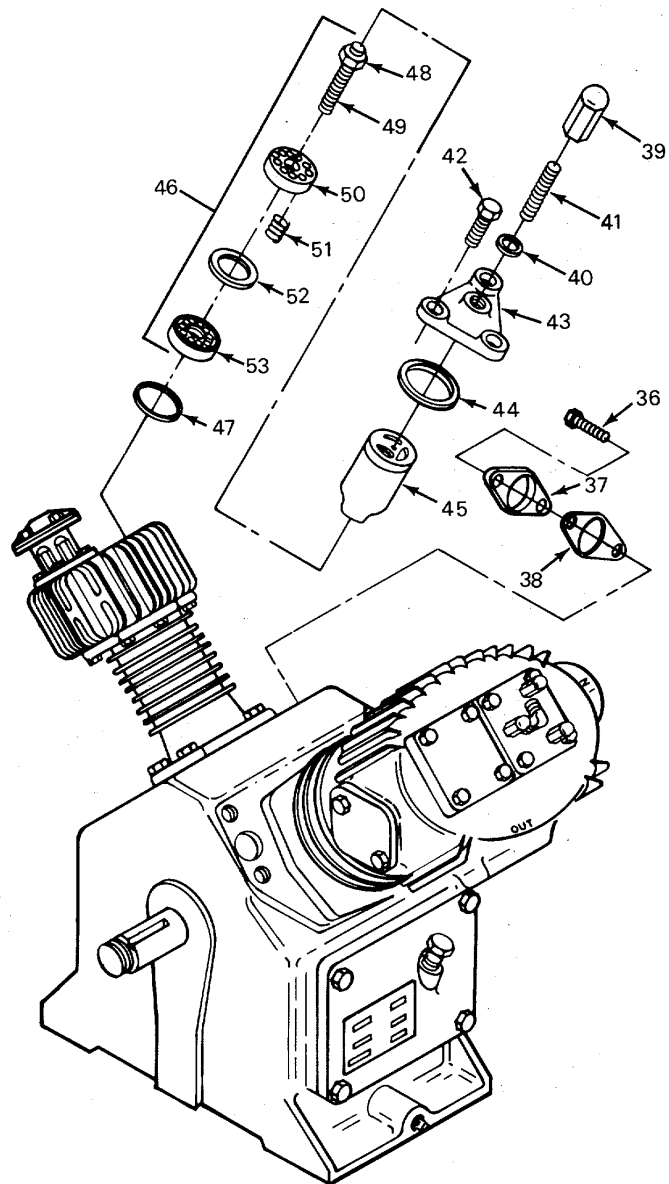
**4-8. AIR COMPRESSOR ASSEMBLY (cont)****DISASSEMBLY (cont)**

7. Remove two capscrews (24), breather tube assembly (25), and gasket (26). Loosen clamp (27) and remove breather (28), and felt gasket (29), and clamp.
8. Remove flex pipe (30), elbow (31), and nipple (32).
9. Remove four capscrews (33), flange (34), and gasket (35).



**4-8. AIR COMPRESSOR ASSEMBLY (cont)****DISASSEMBLY (cont)**

10. Remove two capscrews (36), flange (37), and gasket (38).
11. Remove acorn nut (39), gasket (40), and setscrew (41). Remove three capscrews (42), valve cover (43), seat gasket (44), valve clamp (45), high-pressure discharge valve (46), and ring gasket (47). Disassemble high-pressure discharge valve by the following:
  - a. Remove nut (48) and screw (49).
  - b. Separate valve bumper (50), three valve springs (51), valve disc (52), and valve seat (53).



**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

**DISASSEMBLY (cont)**

12. Remove three acorn nuts (54), gaskets (55), and setscrews (56).

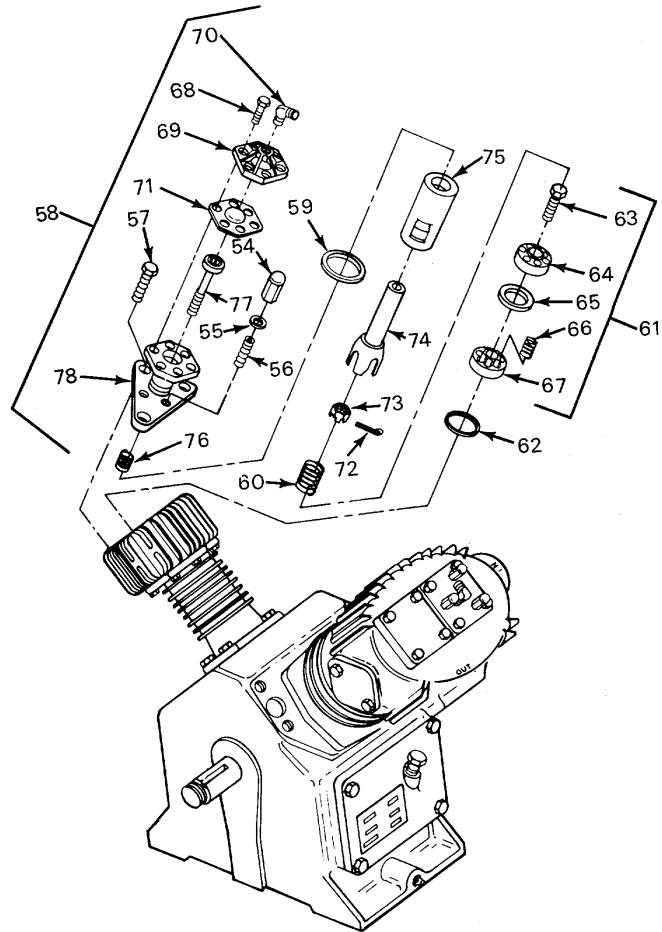
13. Remove three capscrews (57), valve cover assembly (58), seat gasket (59), low plunger spring (60), high-pressure unloader valve (61), and ring gasket (62).

a. Disassemble high-pressure unloader valve (61) by the following:

- (1) Remove screw (63).
- (2) Separate valve seat (64), valve disc (65), three valve springs (66), and valve bumper (67).

b. Disassemble valve cover assembly (58) by the following:

- (1) Remove six capscrews (68), diaphragm cap (69) elbow (70), and diaphragm (71).

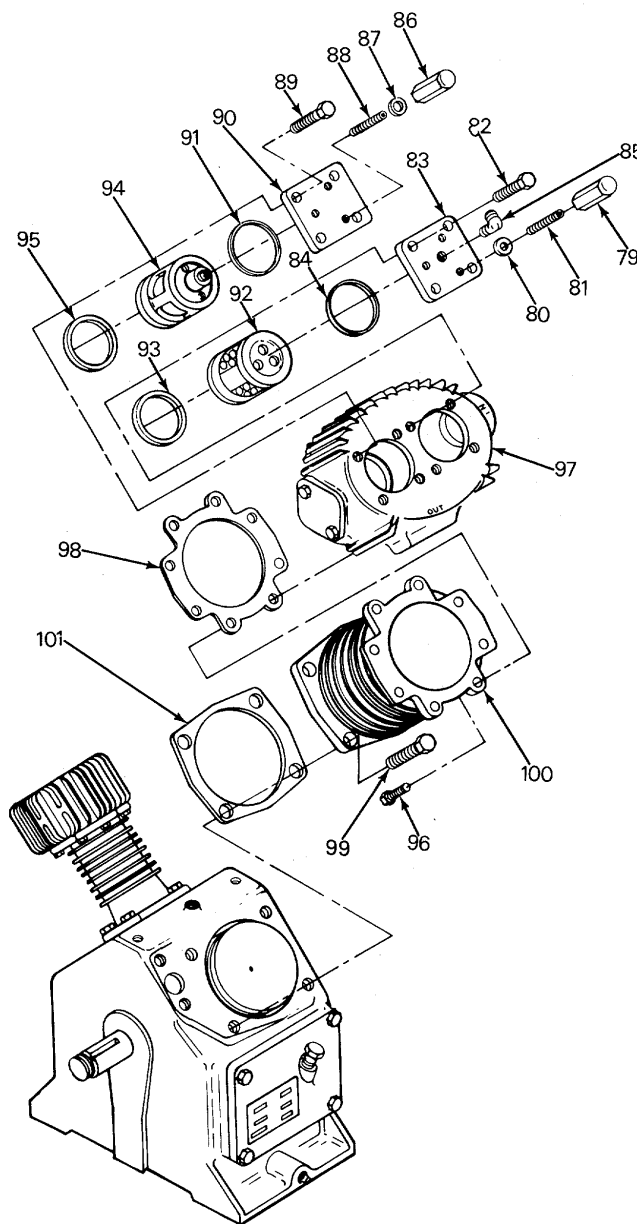


- (2) Remove cotter pin (72), nut (73), lower unloader plunger (74), valve clamp (75), upper plunger unloader spring (76), and upper unloader plunger (77) from valve cover (78).



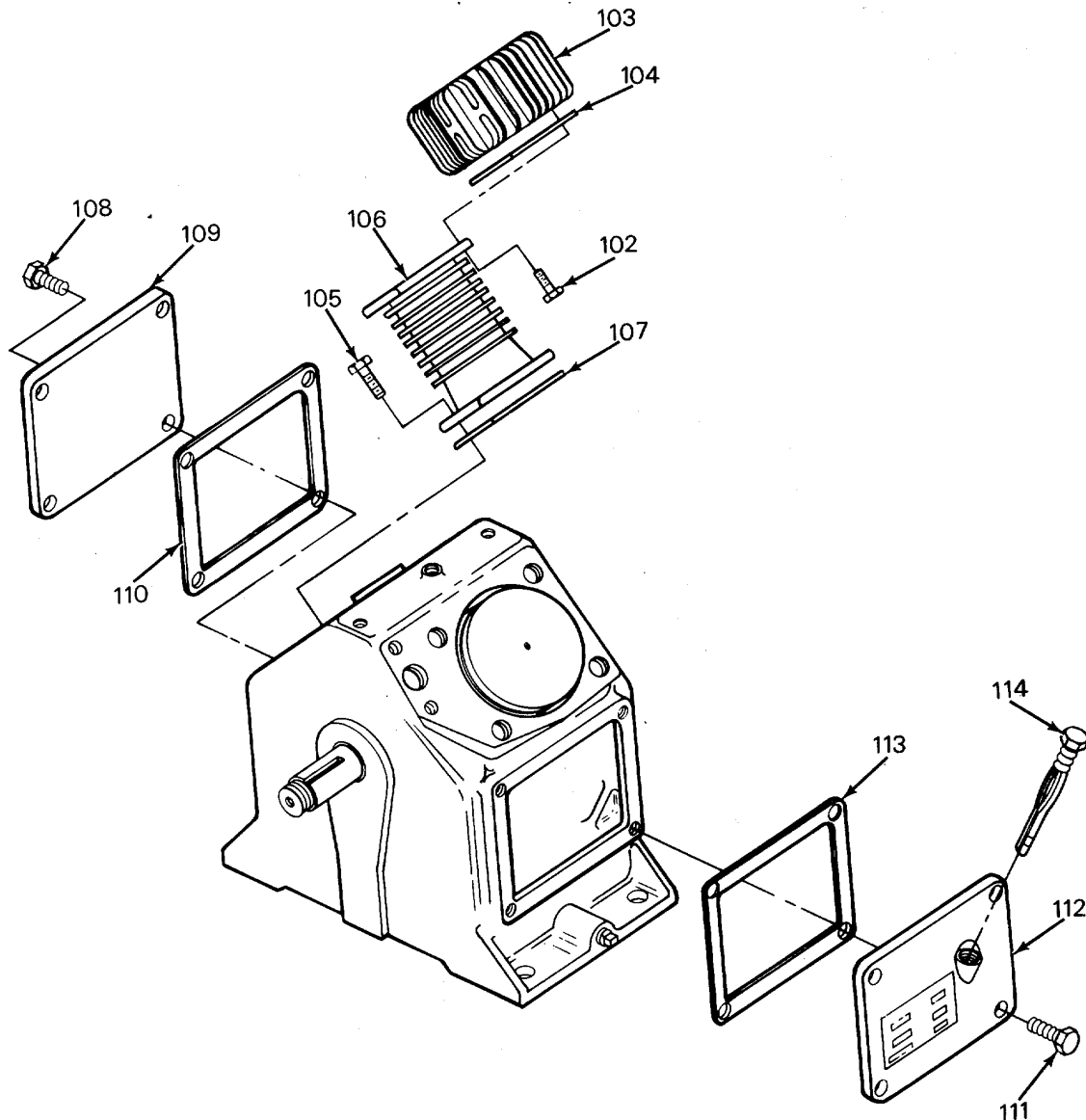
**4-8. AIR COMPRESSOR ASSEMBLY (cont)****DISASSEMBLY (cont)**

14. Remove three acorn nuts (79), gaskets (80), setscrews (81), four capscrews (82), low-pressure unloader valve cover (83), and ring gasket (84). Remove elbow (85) from low-pressure unloader valve cover.
15. Remove three acorn nuts (86), gaskets (87), setscrews (88), four capscrews (89), low-pressure discharge valve cover (90), and ring gasket (91).
16. Remove low-pressure discharge valve (92) and ring gasket (93). Refer to step 33 for disassembly of discharge valve.
17. Remove low-pressure unloader valve (94) and ring gasket (95). Refer to step 34 and disassemble low-pressure unloader valve.
18. Remove eight capscrews (96) and remove low-pressure cylinder head (97) and gasket (98).
19. Remove four capscrews (99), low-pressure cylinder (100), and gasket (101).



**4-8. AIR COMPRESSOR ASSEMBLY (cont)****DISASSEMBLY (cont)**

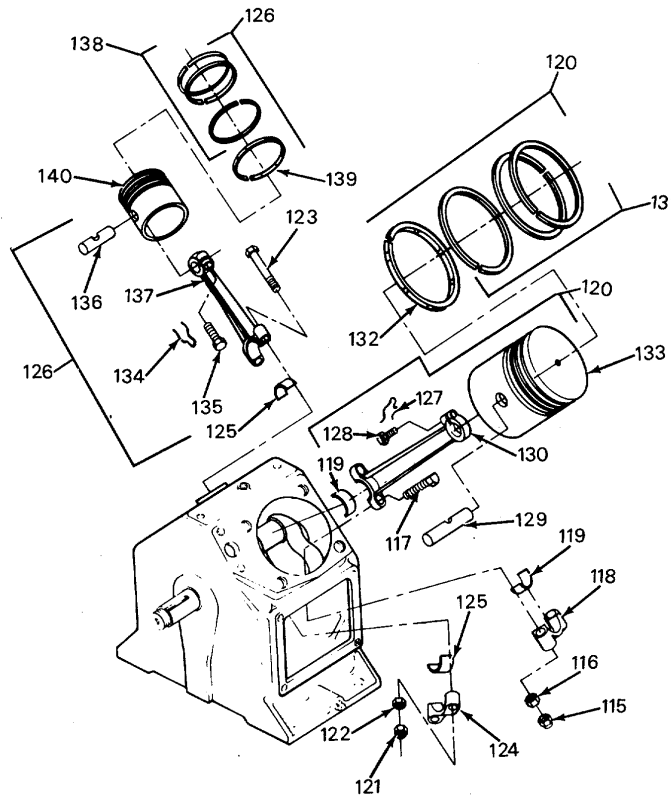
20. Remove eight capscrews (102) and remove high-pressure cylinder head (103) and gasket (104).
21. Remove four capscrews (105), high-pressure cylinder (106), and gasket (107).
22. Remove four capscrews (108), inspection plate (109), and gasket (110).
23. Remove four capscrews (111), inspection plate (112), and gasket (113). Remove oil level gage (114) from inspection plate.



**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

**DISASSEMBLY (cont)**

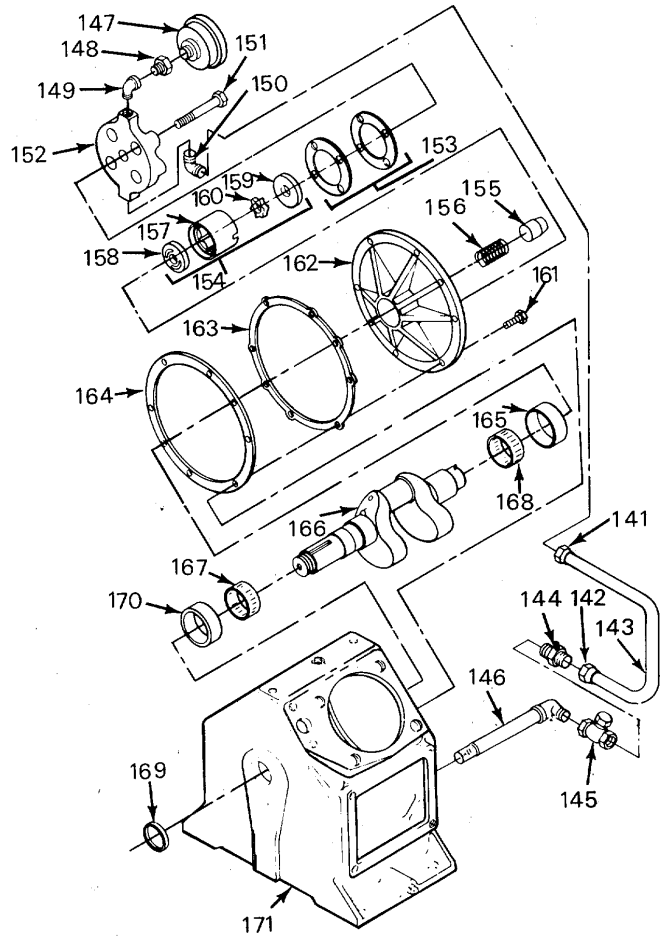
24. Remove two locknuts (115), nuts (116), connecting rod bolts (117), bearing cap (118), and two bearing halves (119). Remove low-pressure piston assembly (120).
25. Remove two locknuts (121), nuts (122), connecting rod bolts (123), bearing cap (124), and two bearing halves (125). Remove high-pressure piston assembly (126).
26. Disassemble low-pressure piston assembly (120) by the following:
  - a. Remove lockwire (127).
  - b. Remove capscrew (128), piston pin (129), and connecting rod (130).
  - c. Remove three compression rings (131) and oil ring (132) from piston (133).
27. Disassemble high-pressure piston assembly (126) by the following:
  - a. Remove lockwire (134).
  - b. Remove capscrews (135), piston pin (136), and connecting rod (137).
  - c. Remove three compression rings (138) and oil ring (139) from piston (140).



**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

**DISASSEMBLY (cont)**

28. Disconnect oil line fittings (141) and (142). Remove oil line (143), adapter (144), check valve (145), and oil tube and screen (146). Remove oil pressure gage (147), adapter (148), street elbow (149), and tube elbow (150).
29. Remove six capscrews (151) and remove cover (152), two gaskets (153), oil pump (154), plunger (155), and spring (156). Separate oil pump housing (157), cam (158), spacer (159), and gear (160).
30. Remove six capscrews (161), end plate (162), shim pack (163), and gasket (164). Keep shim pack together for assembly. Use a puller and remove bearing race (165) from end plate.
31. Remove crankshaft (166) with bearings (167) and (168). Use a puller and remove bearings from crankshaft.
32. Remove oil seal (169). Use a puller and remove bearing race (170) from housing (171).

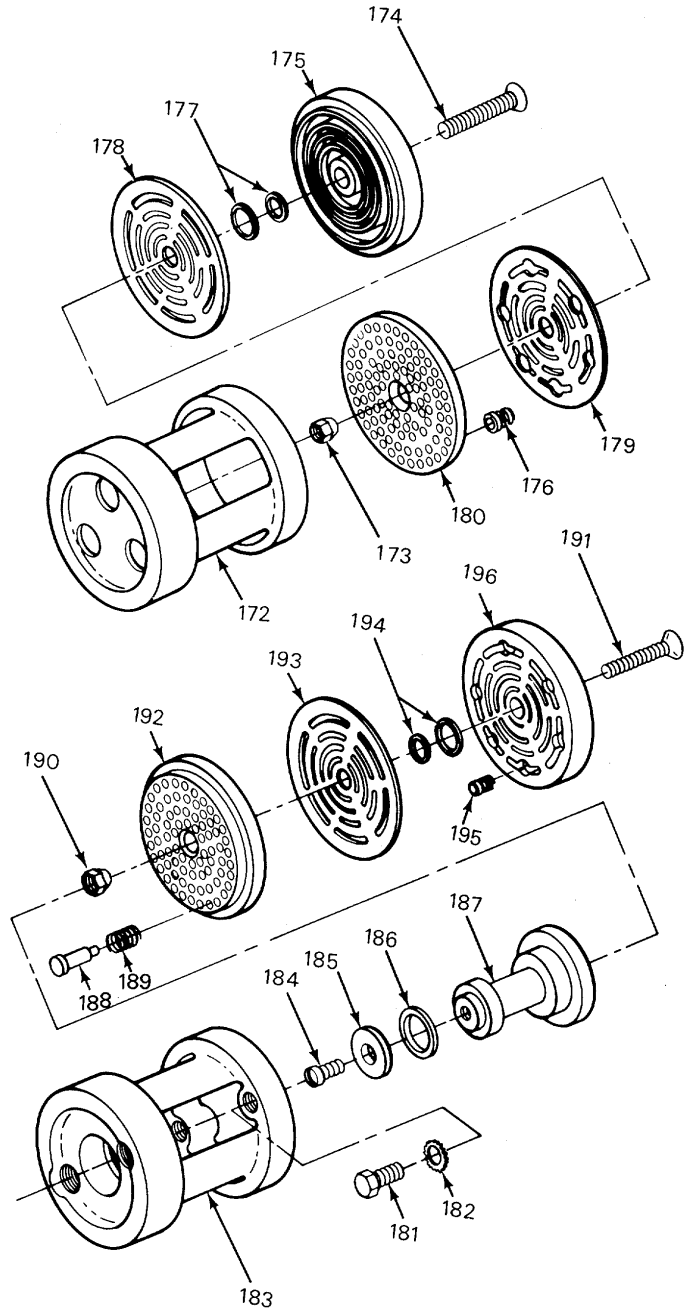


4-8. AIR COMPRESSOR ASSEMBLY (cont)

DISASSEMBLY (cont)

33. Disassemble low-pressure discharge valve (92) by the following:

- a. Remove valve clamp (172).
- b. Remove nut (173) and separate flat head screw (174), bumper (175), six valve springs (176), left guide (177), damping plate (178), valve disc (179), and valve seat (180).



34. Disassemble low-pressure unloader valve (94) by the following:

- a. Remove two capscrews (181) star washers (182), and valve clamp (183).
- b. Remove screw (184),retainer (185), seal (186), and unloader plunger (187).
- c. Remove four finger pins (188) and springs (189).
- d. Remove nut (190) and separate flat-head screw (191), suction valve seat (192), valve seat (193), lift guide (194), three valve springs (195), and bumper (196).

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- 35. Use drycleaning solvent and remove dirt, grease, and oil from low-pressure cylinder head (97), high-pressure cylinder head (103), low-pressure cylinder (100), high-pressure cylinder (106), inspection plates (109) and (112), and piston pins (129) and (136). Dry with compressed air.
- 36. Magnaflux low-pressure cylinder head (97), high-pressure cylinder head (103), low-pressure cylinder (100), high-pressure cylinder (106), inspection plates (109) and (112), and piston pins (129) and (136) and check that there are no cracks. Replace damaged parts.
- 37. Clean, inspect, and repair crankshaft (166) by the following:
  - a. Use drycleaning solvent and remove grease, dirt, and oil from crankshaft (166). Check that oil passages are free of obstruction. Dry with compressed air.
  - b. Magnaflux crankshaft (166) and check that there are no cracks. Check that crankshaft is not bent or broken.
  - c. Check that oil seal surfaces are not grooved and ball bearing seats are not worn.
  - d. Inspect ends of crankshaft (166). Check that there is no damage to surfaces, threads, or keyway.
  - e. Check that oil relief valve seat is not scored.
  - f. Use a micrometer and measure crankpin diameter. Refer to table 4-1 for dimensions.

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- g. Install crankshaft (166) between centers in a lathe and check runout. Maximum runout is 0.001 inch (0.0254 mm).
  - h. Replace damaged crankshaft (166).
38. Clean, inspect, and repair low-pressure cylinder (100) and high-pressure cylinder (106) by the following:
- a. Use drycleaning solvent and remove dirt, grease, and oil from low-pressure cylinder (100) and high-pressure cylinder (106). Dry with compressed air.
  - b. Check that ring travel surface is not scored and does not have ridges.
  - c. Use a honing drill and hone cylinder walls to a bright, smooth finish (25 to 40 micro-inches and a cross hatch pattern of 25 to 35 degrees).
  - d. Inspect perpendicularly of low-pressure cylinder (100) and high-pressure cylinder (106) with flange face by the following:
    - (1) Install low-pressure cylinder (100) and high-pressure cylinder (106) in a lathe or boring mill.
- NOTE**
- If cylinder flanges are machined, check that cylinder length is not shortened beyond the minimum limit. This is determined by installing piston in upper dead center position and ensuring piston is flush or below top face of cylinder.**
- (2) Use an inside micrometer and measure both ends of cylinder bore for taper. Maximum variance is 0.002 inch (0.0508 mm). If variance exceeds maximum, machine cylinder flanges.
  - e. Use a feeler gage and measure cylinder-to-piston clearance. Refer to table 4-1 for clearance dimensions. If cylinder-to-piston clearance is not within limits, replace piston with a new, standard size piston. Recheck cylinder to piston clearance. If not within limits, replace low-pressure cylinder (100) and high-pressure cylinder (106) with a new, standard size cylinder.
  - f. Replace damaged low-pressure cylinder (100) or high-pressure cylinder (106).
39. Clean, inspect, and repair pistons (133) and (140) by the following:
- a. Use drycleaning solvent and remove dirt, grease, and oil. Dry with compressed air.
  - b. Magnaflux pistons (133) and (140) and check that there are no cracks.
  - c. Check that piston ring grooves are square and do not have ridges.

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- d. Use a feeler gage and measure clearance between ring sides and grooves. Clearance is 0.002 to 0.004 inch (0.0508 to 0.1016 mm).
- e. Use a micrometer and measure piston skirts. Refer to table 4-1 for diameter limits.

**CAUTION**

**Do not use a stone or emery cloth to remove minor scuff marks or scratches from pistons (133) and (140). Damage to pistons will result.**

- f. Use a file and remove minor scuff marks and scratches from pistons (133) and (140).
  - g. Replace damaged pistons (133) and (140).
40. Clean, inspect, and repair connecting rods (130) and (137) by the following:
- a. Use drycleaning solvent and remove dirt, grease, and oil from connecting rods (130) and (137). Check that oil passages are free of obstruction. Dry with compressed air.
  - b. Magnaflux connecting rods (130) and (137) and check that there are no cracks.
  - c. Inspect connecting rod bolts (117) and (123) and nuts (116) and (122) and check that threads are not damaged. Check that nuts turn freely on bolts.
  - d. Check that connecting rods (130) and (137) are fitted to crankpin of crankshaft (166) by the following:
    - (1) Apply a film of light oil on crankpin.
    - (2) Install connecting rods (130) and (137) and torque nuts (116) and (122) to 75 to 80 lb-ft. Check that nuts are lined up to meet cotter pin holes in bolts.
    - (3) Install a 0.001-inch (0.0254 mm) feeler gage between bearing caps (118) and (124) and crankpin. Check that feeler gage extends entire width of rod cap bearing surface.
    - (4) Turn connecting rods (130) and (137) 1 inch (25.4 mm) at piston pin end and check that connecting rod turns freely.
    - (5) Remove 0.001-inch (0.0254 mm) feeler gage and install 0.003-inch (0.0762 mm) feeler gage. Repeat step (3) above.
    - (6) Turn connecting rods (129) and (136) 1 inch (25.4 mm) at piston pin end and check that connecting rod turns tightly.



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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- (7) Remove 0.003-inch (0.0762 mm) feeler gage
  - (8) Turn connecting rods (130) and (137) and check that connecting rod turns easily.
  - e. Use a feeler gage and measure side clearance of connecting rods (130) and (137). Refer to table 4-1 for side clearance limits.
  - f. Replace damaged connecting rod (130) and (137).
41. Clean, inspect, and repair oil pump (154) by the following:
- a. Use drycleaning solvent and remove dirt and oil from oil tube and screen (146). Dry with compressed air.
  - b. Check that oil tube and screen (146) is not or damaged. Replace damaged screen.
  - c. Check that oil pump housing (157) and gear (160) are not worn or damaged.
  - d. Replace damaged parts.
42. Magnaflux housing (171) and check that housing is not cracked or broken. Replace damaged housing. Check that main bearing housing is not cracked or broken.
43. Clean, inspect, and repair intercooler (7) by the following:
- a. Use drycleaning solvent and remove dirt and loose paint from intercooler (7). Dry with compressed air.
  - b. Use duckbill pliers and straighten bent fins.
  - c. Perform a leak test and check that intercooler (7) does not leak. Replace damaged intercooler.
  - d. Apply air pressure to intercooler safety valve and check that intercooler safety valve opens at 60 psi (420 kPa). Replace damaged intercooler safety valve.
44. Clean, inspect, and repair air filter assembly (12) by the following:
- a. Use drycleaning solvent and remove dirt and oil from exterior of air filter assembly (12). Dry with compressed air.
  - b. Wash air filter element (17) in drycleaning solvent. Dry with compressed air.
  - c. Immerse air filter element in crankcase oil. Drain off excess oil.

**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

**CLEANING, INSPECTION, AND REPAIR (cont)**

- 45. Check that oil line (142) is not bent. Replace damaged oil line.
- 46. Check that fittings are serviceable.
- 47. Clean or replace metallic filter material in breather (28) as required.
- 48. Refer to table 4-1 for air compressor data. Measure parts and check that parts do not exceed condemnable limits. Replace damaged parts.

Table 4-1. Air Compressor Data

Displacement Compressor bhp (rated speed 140 psi (965.3 kPa))	153 cfm at 1000 rpm 40 at 1000 rpm
Ring side clearance (compression)	0.0020 to 0.0040 inch (0.0508 to 0.1016 mm)
Ring gap (oil)	0.004 to 0.014 inch (0.1016 to 0.3556 mm)
Ring side clearance (oil)	0.0020 to 0.0040 inch (0.0508 to 0.1016 mm)
Piston pin to bushing clearance	0.0013 to 0.0020 inch (0.0330 to 0.0508 mm)
Piston pin diameter	1.0082 to 1.0080 inches (25.608 to 25.603 mm)
Piston pin bushing bore diameter	1.0095 to 1.0100 inches (25.6413 to 25.6540 mm)
Insert to crankpin (high and low)	0.001 to 0.003 inch (0.0254 to 0.0763 mm)
Crankpin diameter (high and low)	2.6230 to 2.6225 inches (66.6242 to 66.6115 mm)
Rod side clearance (high and low)	0.010 to 0.025 inch (0.254 to 0.635 mm)
Crankshaft diameter (at main bearing)	2.502 to 2.501 inches (63.550 to 63.5254 mm)
Piston pin to bushing clearance	0.0013 to 0.0020 inch (0.033 to 0.05 mm)
Piston pin diameter	1.0082 to 1.0080 inches (25.608 to 25.603 mm)
Piston pin bushing bore diameter	1.0095 to 1.0100 inches (25.641 to 25.654 mm)

**Table 4-1. Air Compressor Data (continued)**

High-pressure cylinder:	
Cylinder bore	4.249 to 4.250 inches (107.924 to 107.950 mm)
Piston ring land diameter	4.2295 to 4.2245 inches (107.429 to 107.302 mm)
Piston to cylinder clearance	0.0195 to 0.0255 inch (0.4953 to 0.6477 mm) (at ring land)
Piston skirt diameter	4.2475 to 4.2465 inches (107.886 to 107.861 mm)
Piston to cylinder clearance	0.0015 to 0.0035 inch (0.0381 to 0.0889 mm) (at skirt)
Ring gap (compression)	0.004 to 0.014 inch (0.1016 to 0.3556 mm)
Low-pressure cylinder: Cylinder bore diameter	
	7.499 to 7.500 inches (190.474 to 190.500 mm)
Piston ring land diameter	7 .471 to 7.466 inches (189.763 to 189.636 mm)
Piston to cylinder clearance	0.028 to 0.034 inches (0.711 to 0.863 mm) (at ring land)
Piston skirt diameter	7.489 to 7.488 inches (190.220 to 190.195 mm)
Piston to cylinder clearance	0.010 to 0.012 inch (0.254 to 0.304 mm) (at skirt)
Ring gap (compression)	0.008 to 0.028 inch (0.203 to 0.711 mm)
Ring side clearance (compression)	0.002 to 0.0045 inch (0.05 to 0.114 mm)
Ring gap (oil)	0.008 to 0.028 inch (0.203 to 0.711 mm)
Ring side clearance (oil)	0.0021 to 0.0045 inch (0.053 to 0.114 mm)
Main bearing inside diameter	2.5000 to 2.5002 inches (63.500 to 63.505 mm)
Housing bore (main bearing) diameter	4.998 to 4.999 inches (126.9492 to 126.9746 mm)
Main bearing outside diameter	5.001 to 5.000 inches (127.0254 to 127.0000 mm)
Main bearing end clearance	0.003 to 0.004 inch (0.07620 to 0.1016 mm)
Connecting rod piston pin bore to diameter (high and low)	1.010 to 1.008 inches (25.6540 to 25.6032 mm)
Connecting rod crankpin insert bore to diameter (high and low)	2.750 to 2.749 inches (69.8500 to 69.8246 mm)

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**ASSEMBLY (cont)**

49. Assemble low-pressure unloader valve (94) by the following:
  - a. Assemble bumper (196), three valve springs (195), lift guide (194), valve seat (193), and suction valve seat (192). Secure with flat-head screw (191) and nut (190). Torque nut to 2.25 + 0.5 lb-ft (3.15 +0.35 N.m)
  - b. Position four springs (189), finger pins (188), unloader plunger (187), seal (186), and retainer (185). Secure with screw (184). Torque screw to 16 +1 lb-ft (22.4 +1.4 N.m).
  - c. Install valve clamp (183), two star washers (182), and capscrews (181).
50. Assemble low-pressure discharge valve (92) by the following:
  - a. Assemble valve seat (180), valve disc (179), damping plate (178), left guide (177), six valve springs (176), and bumper (175). Secure with flat head screw (174) and nut (173). Torque nut to 35 +3 lb-ft (49 +4.2 N.m).
  - b. Install valve clamp (172).

**WARNING**

**Procedures specify the heating and cooling of parts to aid assembly. The heated or cooled parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

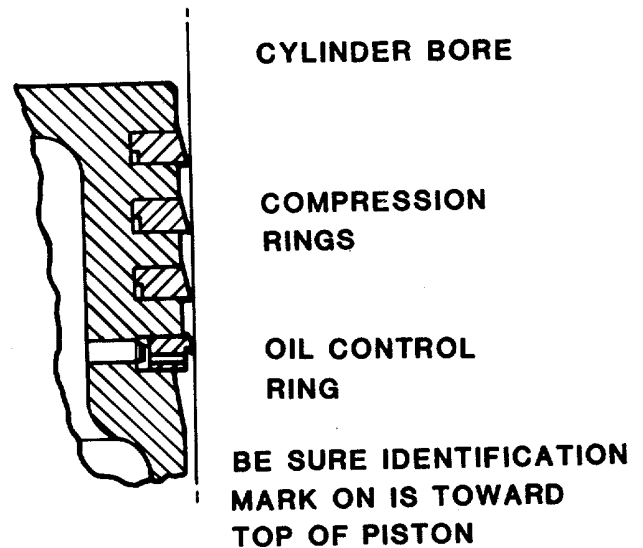
51. Place end plate (162) on induction heater and heat to 2120F (1000C). Place bearing races (165) and (170) in dry ice.
52. Remove end plate (162) from heater and bearing race (165) from dry ice. Install bearing race in end plate.
53. Remove bearing race (170) from dry ice and install in housing (171).
54. Apply sealer compound to outside diameter of oil seal (169). Install oil seal in housing (171), with lip toward bearing race. Install oil seal carefully to avoid damage to lip.
55. Place bearings (168) and (167) on an induction heater and heat to 250°F (120°C). Remove bearings from heater and install on crankshaft (166). Position crankshaft in housing (171).

**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

**ASSEMBLY (cont)**

- 56. Position gasket (164), shim pack (163), and end plate (162) on housing (171) and install six capscrews (161). Torque capscrews to 72.5 +2.5 lb-ft (101.5 +3.5 N.m). Refer to table 4-1 and check for end clearance of bearing (167). If tolerance is not correct, remove end plate and add or remove shims as necessary to meet the requirement.
- 57. Assemble oil pump (154) by assembling gear (160), spacer (159), cam (158), and oil pump housing (157).
- 58. Install spring (156), plunger (155) oil pump (154), two gaskets (153), and cover (152). Secure with six capscrews (151). Torque capscrews to 7 +1 lb-ft (9.8 +1.4).
- 59. Install tube elbow (150), street elbow (149), adapter (148), and oil pressure gage (147).
- 60. Install oil tube and screen (146), check valve (145), and adapter (144). Position oil line (143) and connect oil line fittings (142) and (141).
- 61. Assemble high-pressure piston assembly (126) by the following:

**PISTON RING ARRANGEMENT**



- a. Install oil ring (139), and three compression rings (138) on piston (140). Stagger the ring gaps.
- b. Position connecting rod (137) in piston (140) and install piston pin (136). Install capscrew (135). Torque capscrew to 37.5 +2.5 lb-ft (52.5 +3.5 N.m). Install lockwire (134).

- 62. Assemble low-pressure piston assembly (120) by the following:
  - a. Install oil ring (132) and three compression rings (131) on piston (133). Stagger the ring gaps.
  - b. Position connecting rod (130) in piston (133) and install piston pin (129). Install capscrew (128). Torque capscrew to 37.5 +2.5 lb-ft (52.5 +3.5 N.m). Install lockwire (127).

**4-8. AIR COMPRESSOR ASSEMBLY (cont)****ASSEMBLY (cont)****NOTE**

The small projections on bearing halves (125) and (119) must fit in the corresponding recesses in the rods and caps with corresponding numbers on the same side. Tighten nuts (122) and (116) evenly until proper torque is attained.

63. Install two bearing halves (125) in bearing cap (124) and connecting rod (137).

**CAUTION**

Precautions for cleanness shall be observed with the following parts to avoid possible scoring of rings, piston, and cylinder. Oil the rings and cylinder walls thoroughly during assembly. Check that the ring gaps are staggered.

64. Position high-pressure cylinder (106) upside down and install high-pressure piston assembly (126) in cylinder.
65. Position gasket (107) and high-pressure cylinder (106) with high-pressure piston assembly (126) on housing (171). Check that connecting rod (137) engages crankshaft (166). Install four capscrews (105). Torque capscrews to 145 +5 lb-ft (203 +7 N.m). Position bearing cap (124) on crankshaft and install two connecting rod bolts (123) and nuts (122). Torque nuts to 77.5 +2.5 lb-ft (105 +7 N.m). Install locknuts (121).
66. Install two bearing halves (119) in bearing cap (118) and connecting rod (130).
67. Position low-pressure cylinder (100) upside down and install low-pressure piston assembly (120) in cylinder.
68. Position gasket (101) and low-pressure cylinder (100) with low-pressure piston assembly (120) on housing (171). Check that connecting rod (130) engages crankshaft (166). Install four capscrews (99). Torque capscrews to 145 +5 lb-ft (203 +7 N.m). Position bearing cap (118) and install two connecting rod bolts (117)-and nuts (116). Torque nuts to 77.5 +2.5 lb-ft (105 +7 N.m). Install locknuts (115).
69. Position gasket (104) and high-pressure cylinder head (103) on high-pressure cylinder (106) and install eight capscrews (102). Torque capscrews to 62.5 +2.5 lb-ft (87.5 +3.5 N.m).
70. Position gasket (98) and cylinder head (97) on low-pressure cylinder (100) and install eight capscrews (96). Torque capscrews to 62.5 +2.5 lb-ft 87.5 +3.5 to N.m).

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**ASSEMBLY (cont)**

71. Turn crankshaft (166) and check that the crankshaft, high-pressure piston assembly (126), and low-pressure piston assembly (120) turn freely with no binding.
72. Use a small amount of grease to hold in place and install ring gasket (95) on low-pressure unloader valve (94). Slowly lower unloader valve into low-pressure cylinder head (97). After the valve is in place, rotate to check that it is seated and free.
73. Use a small amount of grease to hold in place and install ring gasket (93) on low-pressure discharge valve (92). Slowly lower discharge valve into low-pressure cylinder head (97). After the valve is in place, rotate to check that it is seated and free.
74. Position ring gasket (91) and low-pressure discharge valve cover (90) and install four capscrews (89). Install three setscrews (88), gaskets (87), and acorn nuts (86). Torque nuts to 16 +1 lb-ft (22.4 +1.4 N.m).
75. Position ring gasket (84) and low-pressure unloader valve cover (83) and install four capscrews (82). Install elbow (85), three setscrews (81), gaskets (80), and acorn nuts (79). Torque nuts to 16 +1 lb-ft (22.4 +1.4 N.m).
76. Assemble valve cover assembly (58) by the following:
  - a. Position upper unloader plunger (77), upper plunger unloader spring (76), valve clamp (75), and lower unloader plunger (74) in valve cover (78). Install nut (73) and cotter pin (72).
  - b. Position diaphragm (71), elbow (70), and diaphragm cap (69) on valve cover (78) and install six capscrews (68).
77. Assemble high-pressure unloader valve (61) by the following:
  - a. Assemble valve bumper (67), three valve springs (66), valve disc (65), and valve seat (64).
  - b. Secure with screw (63).
78. Use a small amount of grease to hold in place and install ring gasket (62) on high-pressure unloader valve (61). Slowly lower unloader valve into high-pressure cylinder head (103). After the valve is in place, rotate to check that it is sealed-and free.
79. Position low plunger spring (60), seat gasket (59), and valve cover assembly (58) and install three capscrews (57). Install three setscrews (56), gaskets (55) and acorn nuts (54).

**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**ASSEMBLY (cont)**

80. Assemble high-pressure discharge valve (46) by the following:
  - a. Assemble valve seat (53), valve disc (52), three valve springs (51), and valve bumper (50).
  - b. Secure with screw (49) and nut (48).
81. Use a small amount of grease to hold in place and install ring gasket (47) on high-pressure discharge valve (46). Slowly lower discharge valve into high-pressure cylinder head (103). After valve is in place, rotate to be sure it is-seated and free.
82. Position valve clamp (45), seat gasket (44), and valve cover (43) and install three capscrews (42). Install setscrew (41), gasket (40), and acorn nut (39).
83. Position gasket (38) and flange (37) on housing (171) and install two capscrews (36).
84. Position gasket (35) and flange (34) on high-pressure cylinder head (103) and install four screws (33). Install nipple (32) in flange and install elbow (31) and flex pipe (30).
85. Install felt gasket (29) and clamp (27) on breather (28). Position breather on breather tube assembly (25) and tighten clamp. Position gasket (26) and breather tube assembly on housing (171) and install two capscrews (24).
86. Position gasket (23) and suction manifold (22) on low-pressure cylinder head (97) and install two capscrews (21), nipple (20) and elbow (19).
87. Position gaskets (113) and (110) and inspection plates (112) and (109) on housing (171) and install eight capscrews (111) and (108). Install oil level gage (114) in inspection plate (112).
88. Assemble air filter assembly (12) by the following:
  - a. Install air filter element (17) in body (18).
  - b. Position cover (16), cork gasket (15), and flat washer (14) on body (18) and install wing nut (13).
  - c. Install air filter assembly (12) on elbow (19).
89. Position two gaskets (8) and intercooler (7) on high-pressure cylinder head (103) and low-pressure cylinder head (97) and install four capscrews (6). Install two pet cocks (11), elbow (10), and safety valve (9) on intercooler.



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**4-8. AIR COMPRESSOR ASSEMBLY (cont) ASSEMBLY (cont)**

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**WARNING**

**Procedures specify the heating and cooling of parts to aid in assembly. The heated or cooled parts may cause injury to personnel if hand protection is not worn when handling. Wear protective gloves for maximum protection.**

90. Place pulley (4) on an induction heater and heat to 250°F (210°C).
91. Install square key (5) on shaft of crankshaft (166). Remove pulley (4) from heater and install on shaft of crankshaft over square key. Install nut (3) and tighten two setscrews (2). Torque setscrews to 16 +1 lb-ft (22.4 +1.4 N.m).
92. Position unloader air line and connect fittings (1).

**TEST**

93. Perform an orifice test by the following:

**CAUTION**

**When performing orifice test, check that oil pressure is never less than 15 psi (105 kPa). Damage to air compressor can result.**

- a. Connect an orifice holder with 17/64-inch (6.75 mm) orifice in air reservoir drain cock. Use orifice with square edges bored through plate 1/16 inch (1.59 mm) thick.
- b. Refer to TM 55-2210-224-12 and start engine and run until it is at normal working temperature.
- c. Close outlet valve from reservoirs, open drain cock, and leave open for all tests.
- d. Operate air compressor at least 2 minutes at low speed (300 rpm) and take a pressure reading. Record air compressor speed (rpm) and corresponding pressure.
- e. Operate air compressor at least 2 minutes at high speed (600 rpm) and take a pressure reading. Record air compressor speed (rpm) and corresponding pressure.
- f. Operate air compressor 15 minutes (drain cock open) and repeat steps d and e.

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**4-8. AIR COMPRESSOR ASSEMBLY (cont)**

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**TEST (cont)**

- g. Refer to table 3-6 and compare speed-pressure readings.

**NOTE**

**If pistons, cylinders, rings, piston pins, connecting rods, or bearings are replaced, orifice test must be repeated.**

- h. Remove cylinder heads and inspect cylinder walls. Check that there is no scoring.

**4-9. DIESEL ENGINE**

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This task covers:

- a. Removal
  - b. Installation
- 

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
 Suitable lifting device

Personnel Required

3

Equipment Condition Reference

Condition Description

Para 3-7	Engine hood removed
Para 3-37	Main generator disconnected from engine
Para 3-40	Cooling fan removed
TM 55-2210-224-12	Fuel lines removed from engine
TM 55-2210-224-12	Heater lines and fittings removed from engine
Para 4-10	Motor mounts disconnected from engine

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**REMOVAL**

**NOTE**

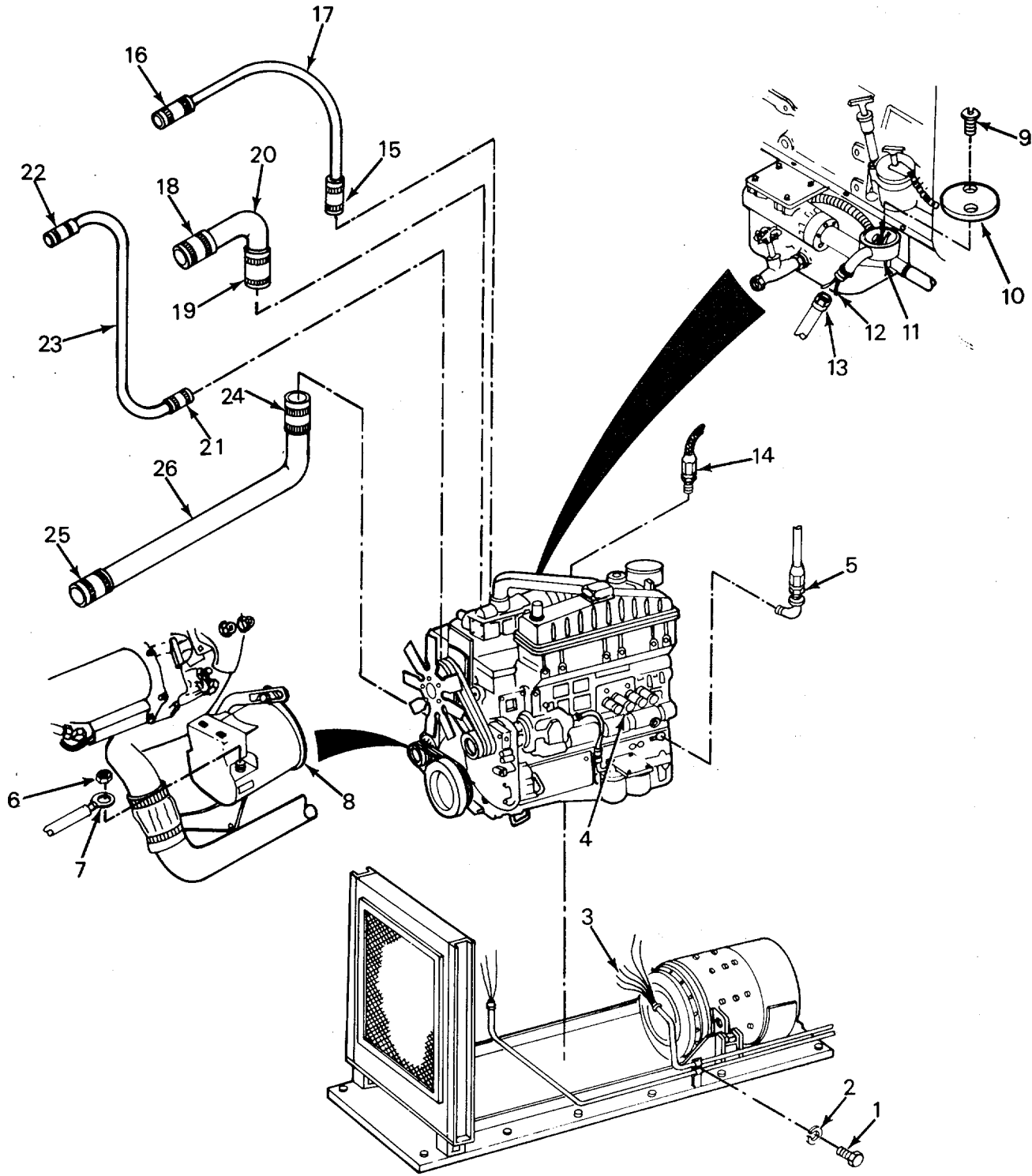
**Before removing diesel engine, check that water and oil have been drained and battery switch is set to OPEN position.**

1. Prepare left side of diesel engine for removal by the following:
  - a. Remove screw (1) and lockwasher (2).
  - b. Tag and disconnect solenoid valve wiring (3) from terminal strip (4).
  - c. Disconnect engine oil pressure gage line (5) from engine block and position line out of the way.
2. Prepare right side of diesel engine for removal by the following:
  - a. Remove two nuts (6) and tag and disconnect wiring (7) from engine alternator (8).
  - b. Remove two screws (9) and cover (10) from electrical box (11) on engine water heater and tag and disconnect wiring (12) and remove conduit (13).
  - c. Disconnect capillary tubing (14) from engine water manifold and position tubing out of the way.

4-9. DIESEL ENGINE (cont)

REMOVAL (cont)

- d. Loosen hose clamps (15) and (16) and remove expansion water pipe (17).
- e. Loosen hose clamps (18) and (19) and remove outlet water pipe (20).



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**4-9. DIESEL ENGINE (cont)**

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**REMOVAL (cont)**

- f. Loosen hose clamps (21) and (22) and remove expansion water pipe (23).
  - g. Loosen hose clamps (24) and (25) and disconnect inlet water pipe (26) from radiator.
3. Station a person on each side of locomotive to observe lifting operation and to check that no binding occurs.
  4. Use a suitable lifting device and slowly lift diesel engine from locomotive. Lower to ground and set on a suitable support.

**INSTALLATION**

5. Station a person on each side of locomotive to observe installation operation and to check that no binding occurs.
6. Use a suitable lifting device and slowly lift diesel engine above locomotive. Slowly lower to deck. Support rear of engine with a suitable support device.
7. Install right side of diesel engine by the following:
  - a. Install inlet water pipe (26) on radiator and tighten hose clamps (25) and (24).
  - b. Install expansion water pipe (23) and tighten hose clamps (22) and (21).
  - c. Install outlet water pipe (20) and tighten hose clamps (19) and (18).
  - d. Install expansion water pipe (17) and tighten hose clamps (16) and (15).
  - e. Connect capillary tubing (14) to engine water manifold.
  - f. Install conduit (13) to electrical box (11) and connect wiring (12) to engine water heater and remove tags. Position cover (10) and install two screws (9).
  - g. Connect wiring (7) to engine alternator (8) and install two nuts (6). Remove tags.
8. Prepare left side of diesel engine for installation by the following:
  - a. Connect engine oil pressure gage line (5) to engine block.
  - b. Connect solenoid valve wiring (3) to terminal strip (4) and remove tags.
  - c. Install lockwasher (2) and screw (1).

**4-10. MOTOR MOUNTS This task covers:**

This task covers:

a. Removal

b. Inspection

c. Installation

**INITIAL SETUP****Tools**

Tool kit SC4940-97-CL-E12

Suitable lifting device

**REMOVAL**

1. Remove two cotter pins (1), nuts (2), flat washer (3), pads (4), and capscrews (5).

**WARNING**

**Components of this locomotive are heavy and may be awkward to handle. Use correct lifting procedures, indicated lifting devices, and/or assistance from other personnel to avoid injury.**

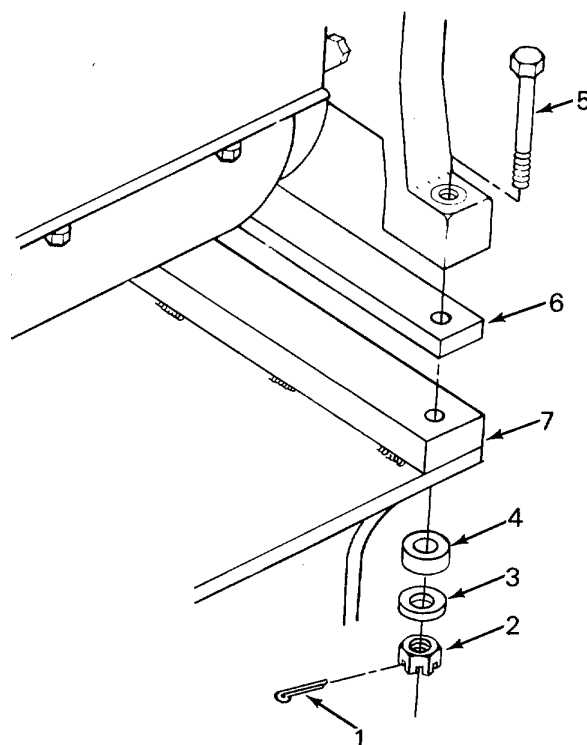
2. Use a suitable lifting device and raise engine enough to remove pad (6) from mount (7).

**INSPECTION**

3. Check that pad (6) and pads (4) are not cracked, distorted, or damaged. Replace damaged parts

**INSTALLATION**

4. Position pad (6) on mount (7) and lower engine into place.
5. Install two capscrews (5), pads (4), and flat washers (3). Secure with two nuts (2) and cotter pins (1).



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## 4-11. AUTOMATIC BRAKE VALVE

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This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |
- 

### INITIAL SETUP

#### Tools

Tool kit SC4940-97-CL-E12

#### Test Equipment

4C Test rack  
4C-36 Test plate PC 560958  
Gasket PC 557395

#### Material/Parts

Dry-cleaning solvent (Item 34, Appendix B)  
Pneumatic grease (Item 18, Appendix B)  
Emery cloth (Item 5, Appendix B)  
Powder graphite (Item 12, Appendix B)  
Lubricating oil (Item 21, Appendix B)  
Lime-base grease (Item 17, Appendix B)  
Wiping rags (Item 32, Appendix B)

#### Equipment Condition Reference

Para 3-45

#### Condition Description

Automatic brake valve removed

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### DISASSEMBLY

#### **WARNING**

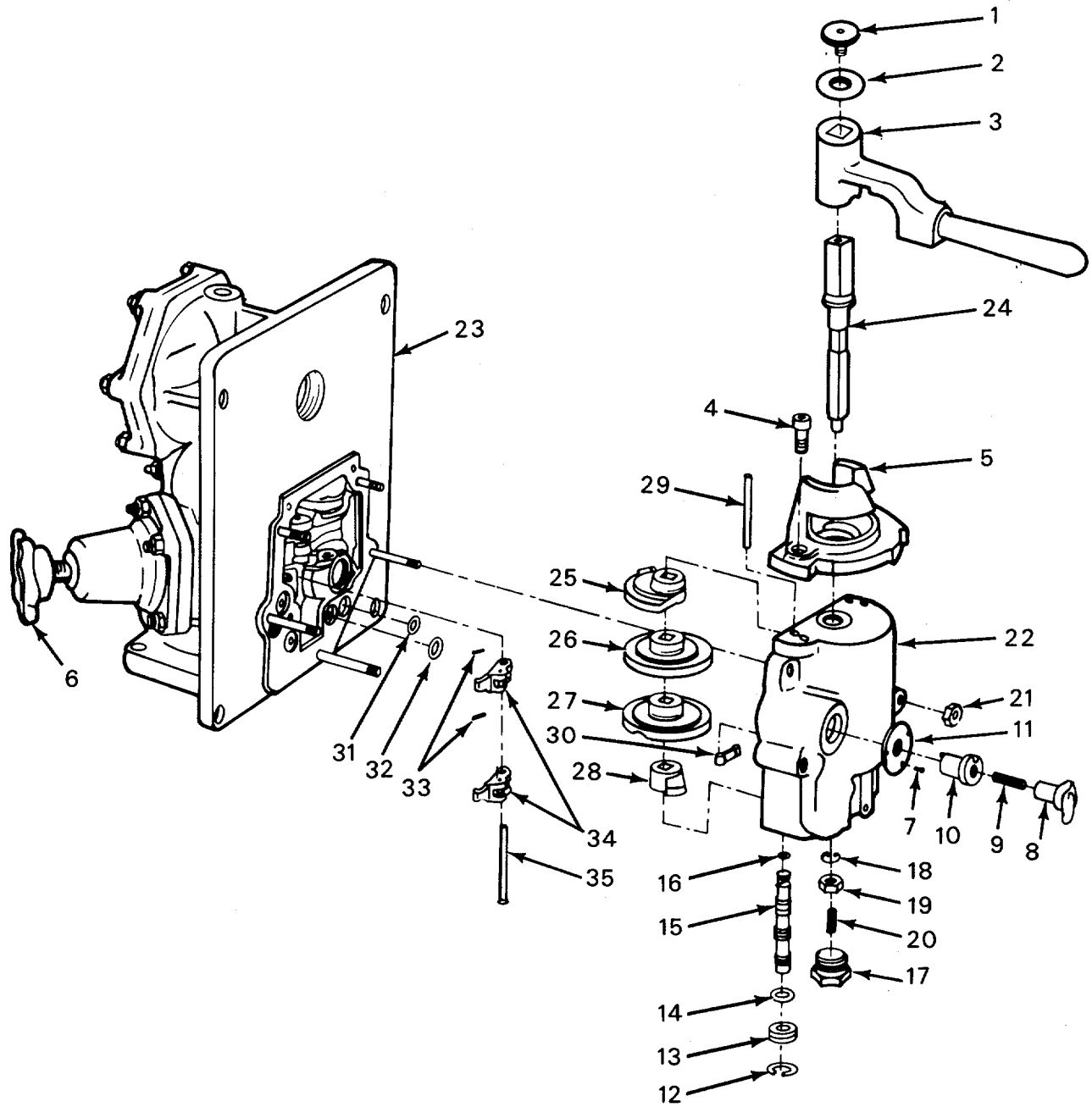
**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

#### **NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Place handle (3) in HANDLE OFF position. Remove retaining socket-head screw (1) and flat washer (2) and remove handle.
2. Remove two socket-head screws (4) and quadrant (5) from cam housing (22).
3. Turn regulating valve adjusting handle (6) and release tension on adjusting spring (68). 4. Set cutoff valve control knob (8) to OUT.

4-11. AUTOMATIC BRAKE VALVE (cont) DISASSEMBLY (cont)





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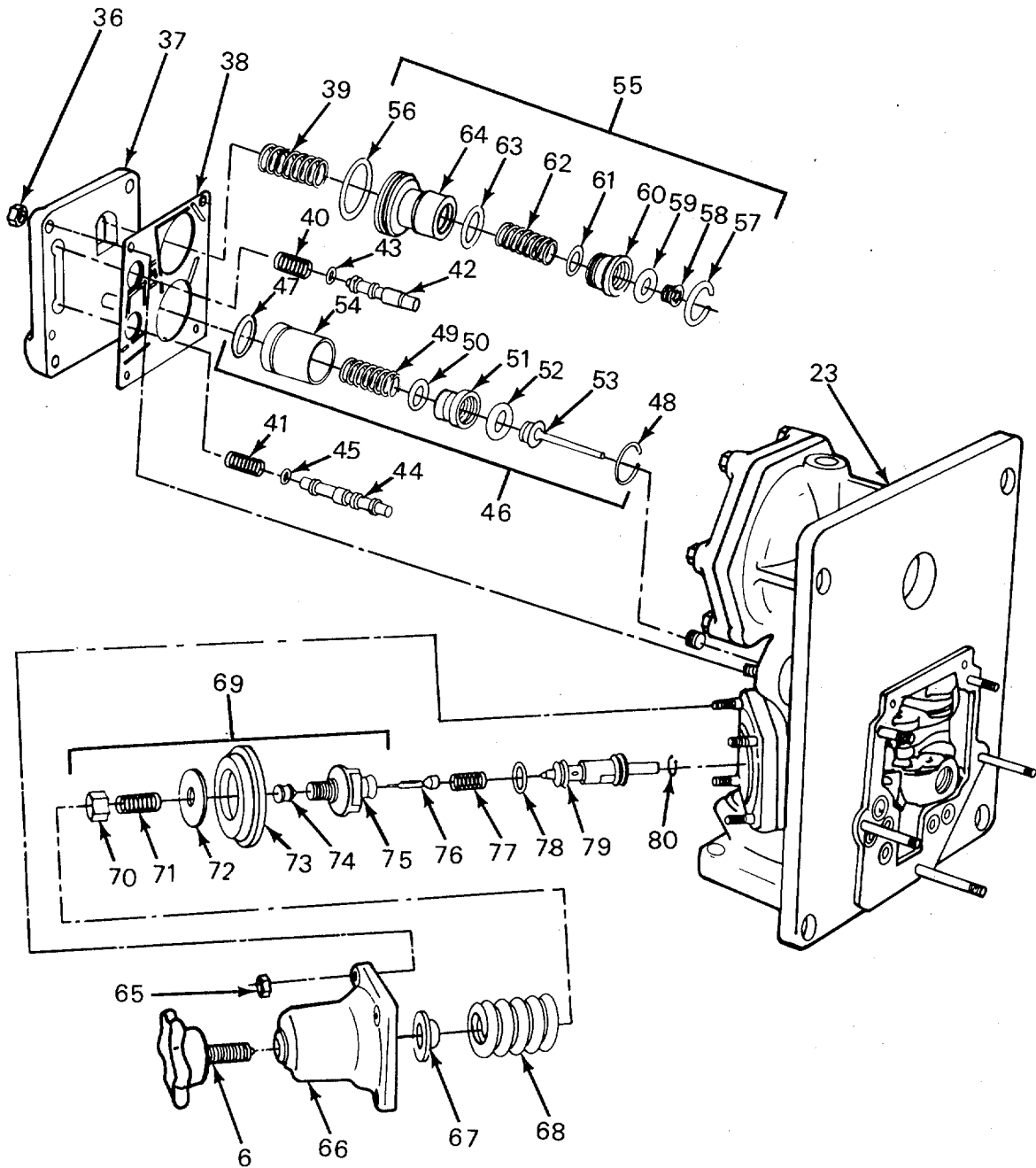
**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**DISASSEMBLY (cont)**

5. Remove three screws (7), cutoff valve control knob (8), spring (9), cutoff pilot valve operating shaft (10), and insignia plate (11).
6. Remove retaining ring (12) and remove cutoff pilot valve position selector plug (13). Remove O-ring (14) from plug.
7. Remove cutoff valve (15). Remove five O-rings (16) from valve.
8. Remove two spillover check valve capnuts (17).
9. Remove two retaining rings (18) by inserting a 1/16-inch (1.6 mm) rod into hole at side of two spillover check valve capnuts (17). Press inward on retaining ring and remove retaining rings.
10. Remove two check valves (19) and springs (20).
11. Remove five nuts (21) and separate cam housing (22) from brake valve body (23).
12. Remove cam shaft (24).
13. Remove emergency valve cam (25), regulating valve cam (26), suppression valve cam (27), and vent valve cam (28). 14. Remove pin (29) and cam dog (30).
15. Remove four O-rings (31) and O-ring (32) from mounting face of brake valve body (23).
16. Remove two cylindrical spring pins (33) and remove two cam dogs (34) from cam pin (35).
17. Remove four nuts (36), cover (37), and gasket (38).
18. Remove cutoff valve spring (39), emergency valve spring (40), and suppression valve spring (41).
19. Remove emergency valve (42). Remove four O-rings (43) from emergency valve.
20. Remove suppression valve (44). Remove five O-rings (45) from suppression valve.
21. Remove vent valve assembly (46).
22. Disassemble vent valve assembly (46) by removing O-ring (47), retaining ring (48), spring (49), O-ring (50), housing (51), seal (52), and retainer (53) from vent valve cage (54).
23. Remove cutoff valve assembly (55).

4-11. AUTOMATIC BRAKE VALVE (cont) DISASSEMBLY (cont)



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**4-11. AUTOMATIC BRAKE VALVE (cont)**

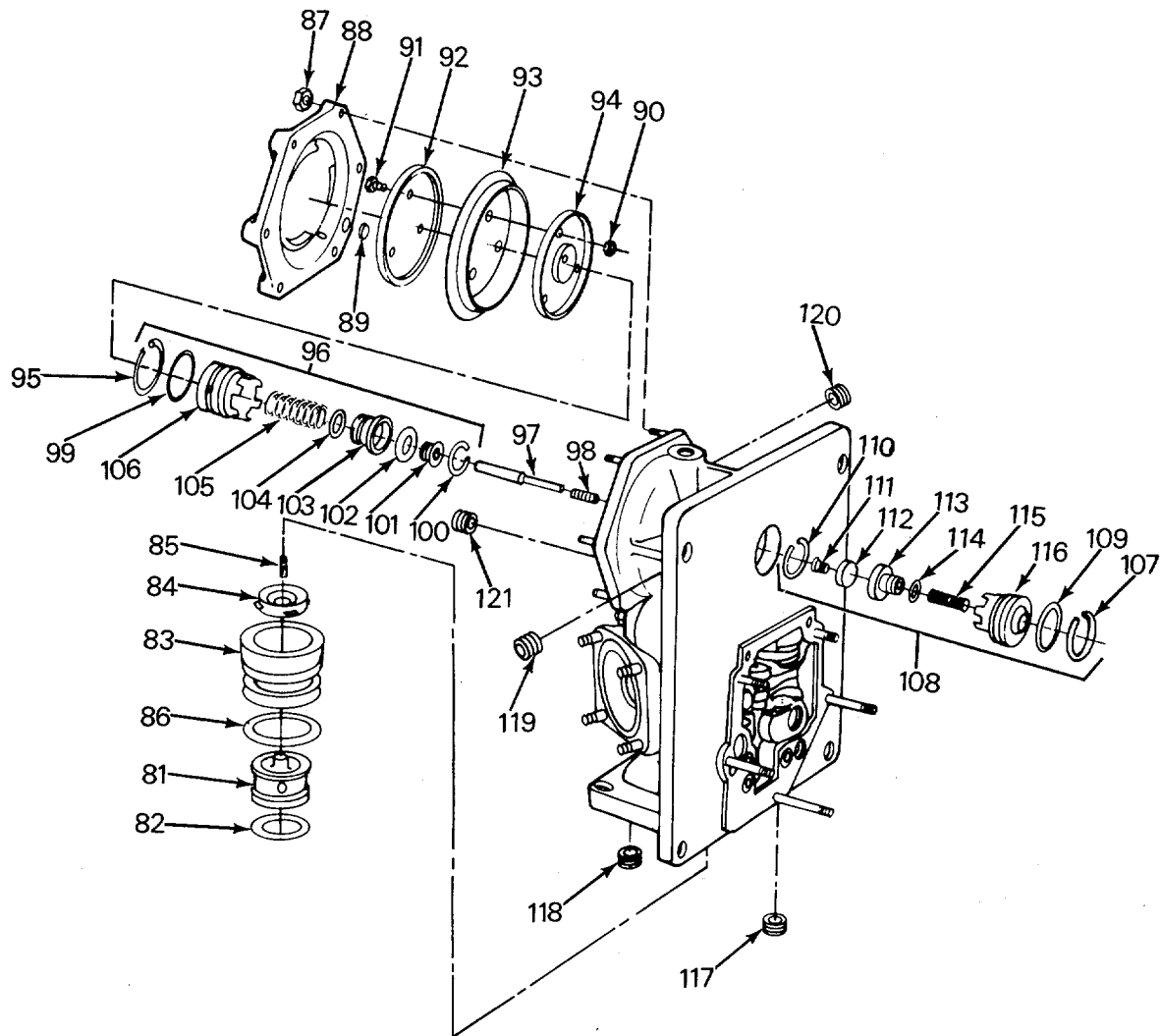

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**DISASSEMBLY (cont)**

24. Disassemble cutoff valve assembly (55) by removing O-ring (56), retaining ring (57), retainer (58), seal (59), housing (60), O-ring (61), spring (62), and O-ring (63) from cutoff valve cage (64).
25. Remove four nuts (65) and regulating valve spring housing (66).
26. Remove spring seat (67) and adjusting spring (68).
27. Remove exhaust valve assembly (69).
28. Disassemble exhaust valve assembly (69) by removing exhaust valve spring seat (70), spring (71), follower (72), diaphragm (73), spring seat (74), and exhaust valve seat (75).
29. Remove inlet valve (76) and spring (77). Remove regulating valve inlet valve (78). Remove two O-rings (79) from regulating valve inlet valve.
30. Remove retaining ring (80) from bushing in brake valve body (23).
31. Insert a 10-24 machine screw into equalizer reservoir cutoff valve piston (81) and remove equalizer reservoir cutoff valve piston from brake valve body (23).
32. Remove O-ring (82) from equalizer reservoir cutoff valve piston (81).
33. Remove cutoff valve seat (83), check valve (84), and spring (85). Remove two O-rings (86) from cutoff valve seat.
34. Remove six nuts (87), valve cover (88), and gasket (89). NOTE Use elongated slot to remove diaphragm.
35. Remove three retaining screws (90), three nuts (91), upper follower (92), diaphragm (93), and lower follower (94).
36. Remove retaining ring (95), exhaust valve assembly (96), diaphragm stem (97), and spring (98).
37. Disassemble exhaust valve assembly (96) by removing O-ring (99), retaining ring (100), retainer (101), valve seal (102), housing (103), O-ring (104), and spring (105) from exhaust valve cage (106).
38. Remove retaining ring (107).
39. Remove supply valve assembly (108).
40. Disassemble supply valve assembly (108) by removing O-ring (109), retaining ring (110), retainer (111), seal (112), housing (113), O-ring (114), and spring cage (115) from supply valve cage (116).

4-11. AUTOMATIC BRAKE VALVE (cont)

DISASSEMBLY (cont)



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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

Dry-cleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.

41. Use a cloth dampened with dry-cleaning solvent and remove grease and oil from exterior of cam housing (22) and brake valve body (23).

**WARNING**

Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

42. Use dry-cleaning solvent and clean metal parts. Dry with compressed air.
43. Inspect metal parts for cracks, breaks, cuts, or other damage. Replace damaged parts.
44. Check that springs are not rusted, distorted, or have taken a permanent set. Replace damaged springs.
45. Refinish faces of rubber check valves by lapping on a piece of medium weight emery paper.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)****WARNING**

- **Dry-cleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Use only with effective chip guarding the personal protective equipment (goggles/shield, gloves, etc.).**

**CAUTION**

**Do not use metallic tools to clean chokes. The use of metallic tools will change size of chokes, resulting in failure of brake valve system.**

**NOTE**

**To avoid misplacement of chokes, remove and replace one choke plug at a time.**

46. Clean, inspect, and repair choke plugs (117), (118), (119), (120), and (121) by the following:
  - a. Remove a choke plug and place in dry-cleaning solvent.
  - b. Inspect passage for cleanness. Use compressed air and remove foreign matter.
  - c. Remove each choke plug from dry-cleaning solvent and dry with compressed air. Check that choke plug is clean and unrestricted.
  - d. Lightly coat threads of each choke plug with compound consisting of one part graphite and two parts oil. Install choke plugs (117) thru (121).
47. Use pneumatic grease and lubricate O-rings, O-ring grooves in cutoff valve (15), suppression valve (44), vent valve cage (54), cutoff valve cage (64), inlet valve (76), exhaust valve cage (106), supply valve cage (116), and bushings into which spool valves and cages enter. Use a clean wiping rag and remove excess lubricant.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

48. Lubricate check valves (19) and (84) by placing them in a box with dry graphite and shaking the box. Remove check valves. Wipe excess graphite off on a piece of clean wiping rag.

**CAUTION**

**Do not lubricate new style emergency and suppression cams and cam dog rollers which have sandblasted surfaces. These must remain clean and dry to retain rolling friction.**

49. Lubricate cams and cam dogs with lime-base grease.

**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel. 50. Check that choke plugs (117) thru (121) are installed in their proper locations.**

51. Assemble supply valve assembly (108) by the following:

- a. Install seal (112) into housing (113) and secure with retainer (111).
- b. Install O-ring (114) on housing (113).
- c. Install housing (113) and spring cage (115) in supply valve cage (116) and secure with retaining ring (110).
- d. Install O-ring (109) on supply valve cage (116).

52. Install supply valve assembly (108) in brake valve body (23) and secure with retaining ring (107).

53. Assemble exhaust valve assembly (96) by the following:

- a. Install valve seal (102) in housing (103) and secure with retainer (101).
- b. Install O-ring (104) on housing (103).
- c. Install spring (105) and housing (103) in exhaust valve cage (106) and secure with retaining ring (100).
- d. Install O-ring (99) on exhaust valve cage (106).

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**ASSEMBLY (cont)**

54. Install diaphragm stem (97) in exhaust valve assembly (96). Install spring (98) on diaphragm stem.
55. Install spring (98), diaphragm stem (97), and exhaust valve assembly (96) in brake valve body (23) and secure with retaining ring (95).
56. Assemble lower follower (94), diaphragm (93), and upper follower (92) and secure with three nuts (91) and retaining screws (90). Install in brake valve body (23). Check that ball socket joint of diaphragm stem (97) is in slot of upper follower.
57. Install gasket (89) and valve cover (88) and secure with six nuts (87).
58. Install two O-rings (86) on cutoff valve seat (83).
59. Place a small amount of grease on end of spring (85) and install spring in brake valve body (23).
60. Install check valve (84) in cutoff valve seat (83) and install cutoff valve seat in brake valve body (23). Check that spring (85) is in place.
61. Install O-ring (82) on equalizer reservoir cutoff valve piston (81) and install equalizer reservoir cutoff valve piston in cutoff valve seat (83).
62. Install retaining ring (80) in bushing of brake valve body (23).
63. Install two O-rings (79) on regulating valve inlet valve (78).
64. Install regulating valve inlet valve (78), spring (77), and inlet valve (76) in brake valve body (23).
65. Assemble exhaust valve assembly (69) by the following:
  - a. Install spring seat (74) and spring (71) in exhaust valve seat (75).
  - b. Install diaphragm (73) and follower (72) on exhaust valve seat (75) and secure with exhaust valve spring seat (70). Tighten exhaust valve spring seat to 37.5 +2.5 lb-ft (54 +7 N.m).
66. Install exhaust valve assembly (69), adjusting spring (68), and spring seat (67) into regulating valve spring housing (66) and secure to brake valve body (23) with four nuts (65).
67. Assemble cutoff valve assembly (55) by the following:
  - a. Install seal (59) in housing (60) and secure with retainer (58).
  - b. Install O-ring (61) on housing (60).



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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**ASSEMBLY (cont)**

- c. Install spring (62) and housing (60) in cutoff valve cage (64) and secure with retaining ring (57).
  - d. Install O-rings (63) and (56) on cutoff valve cage (64).
68. Install cutoff valve assembly (55) in brake valve body (23).
69. Assemble vent valve assembly (46) by the following:
- a. Install seal (52) in housing (51) and secure with retainer (53).
  - b. Install O-ring (50) on housing (51).
  - c. Install spring (49) and housing (51) in vent valve cage (54) and secure with retaining ring (48).
  - d. Install O-ring (47) on vent valve cage (54).
70. Install vent valve assembly (46) in brake valve body (23).
71. Install four O-rings (43) on emergency valve (42).
72. Install hardened tip end of emergency valve (42) in brake valve body (23) and press into place.
73. Install five O-rings (45) on suppression valve (44).
74. Install hardened tip end of suppression valve (44) in brake valve body (23) and press into place.
75. Install gasket (38) on brake valve body (23).
76. Install suppression valve spring (41), emergency valve spring (40), and cutoff valve spring (39) on their respective valves.
77. Install cover (37) on brake valve body (23) and secure with four nuts (36).
78. Install one cam dog (34) on cam pin (35) and install cam pin into cam pin hole in brake valve body (23). Press cam pin in until pin protrudes from upper end of pinhole. Install other cam dog in brake valve body and press cam pin through cam dog. Secure with two cylindrical spring pins (33).
79. Install cam shaft (24) 1 inch (25.4 mm) into cam housing (22). 80. Install emergency valve cam (25), regulating valve cam (26), suppression valve cam (27), and vent valve cam (28) in brake valve body (23). Press cam shaft (24) through cams.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**ASSEMBLY (cont)**

81. Install pin (29) in cam housing (22).
82. Install cam dog (30) in cam housing (22). Pass pin (29) through cam dog.
83. Install O-ring (32) and four O-rings (31) into grooves in brake valve body (23).
84. Install quadrant (5) in cam housing (22) and secure with two socket-head screws (4).
85. With brake valve body (23) in vertical position, turn cam shaft (24) in cam housing (22) to HANDLE OFF position. This will permit cam dog (30) to drop into indent in regulating valve cam (26).
86. Secure brake valve body (23) to cam housing (22) with five nuts (21).
87. Install two springs (20) and check valves (19) into two spillover check valve capnuts (17) and secure with two retaining rings (18).
88. Install two spillover check valve capnuts (17) into cam housing (22).
89. Install five O-rings (16) on cutoff valve (15).
90. With milled slot in cutoff valve (15) facing upward, insert cutoff valve into bottom of cam housing (22) until milled slot is in center of bushing.
91. Install cutoff pilot valve operating shaft (10) into cam housing (22). The eccentric cam of cutoff valve operating shaft must go into milled slot in cutoff valve (15) so that top of cutoff valve operating shaft is flush with insignia plate mounting face of cam housing.
92. Turn slot of cutoff pilot valve operating shaft (10) to line up with any notch on insignia plate mounting face of cam housing (22).
93. Install spring (9) in cutoff valve operating shaft (10).
94. Install insignia plate (11) on cutoff valve control knob (8) and install cutoff valve control knob on cutoff pilot valve operating shaft (10). Check that cutoff valve control knob locks in position.
95. Secure insignia plate (11) with three screws (7).
96. Check that cutoff valve control knob (8) moves freely. Leave cutoff valve (15) in OUT position.
97. Install O-ring (14) on cutoff pilot valve position selector plug (13).

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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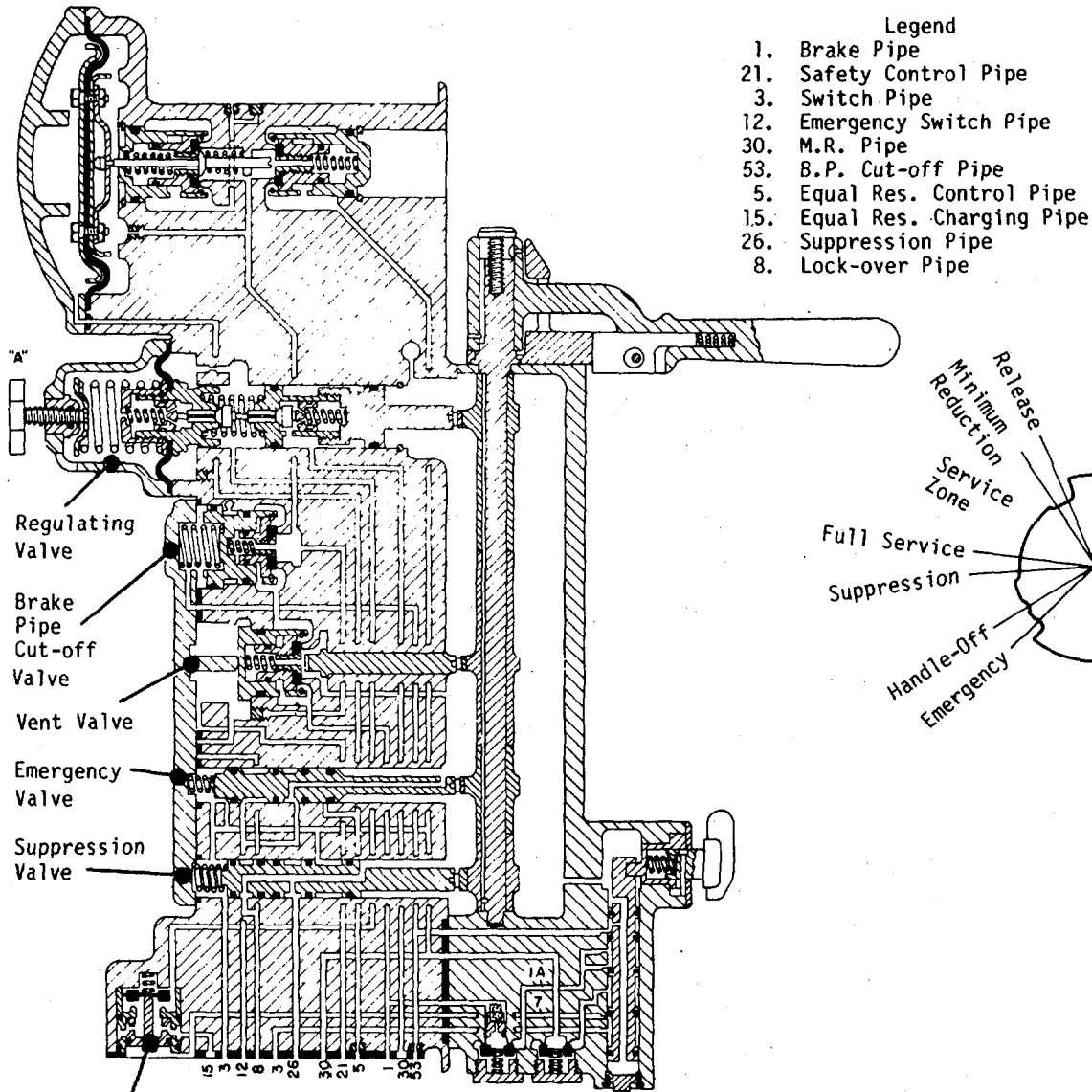
**ASSEMBLY (cont)**

98. Install cutoff pilot valve position selector plug (13) and secure with retaining ring (12). Check that circular projection on one face of cutoff pilot valve position selector plug extends into spool valve chamber.
99. Turn in regulating valve adjusting handle (6).
100. Install handle (3) on cam shaft (24) in HANDLE-OFF position and secure with flat washer (2) and retaining socket-head screw (1). Place handle in RELEASE position.

**TEST**

101. Test the automatic brake valve, in accordance with New York Air Brake Company Test Specification T-2646-C. The automatic brake valve function as follows:
- a. RELEASE Position. This is the position of the automatic brake valve for charging the brake pipe and brake system and for releasing an automatic brake application. In this position the valve functions as follows:
- (1) Main reservoir air enters port 30 and flows as follows:
- (a) To the supply portion in the relay valve.
  - (b) To the supply portion in the regulating valve.
  - (c) To the spool of the suppression valve, where it is trapped.
  - (d) To the spring chamber of both the emergency valve spool and the suppression valve spool. Air ~~spores~~ is trapped in the spring chamber of the emergency valve spool.
  - (e) Through the suppression valve spool to passage 3, where it is directed to the spool of the cutoff pilot valve; through the valve to passage 7; and to the underside of the emergency reservoir cutoff pilot valve. Air pressure raises the piston of the valve and unseats it.
  - (f) To spillover check valve A, through the valve, to the spool of the cutoff pilot valve, where it is trapped.
- (2) Equalizing reservoir air pressure is developed as follows:
- (a) Regulating valve pressure setting is adjusted by turning adjustment handle A. This opens the supply seat of the valve, and main reservoir air pressure enters the equalizing reservoir charging passage and flows to the equalizing reservoir cutoff valve.
  - (b) Equalizing reservoir air pressure flows through the equalizing reservoir cutoff valve and out port 15.

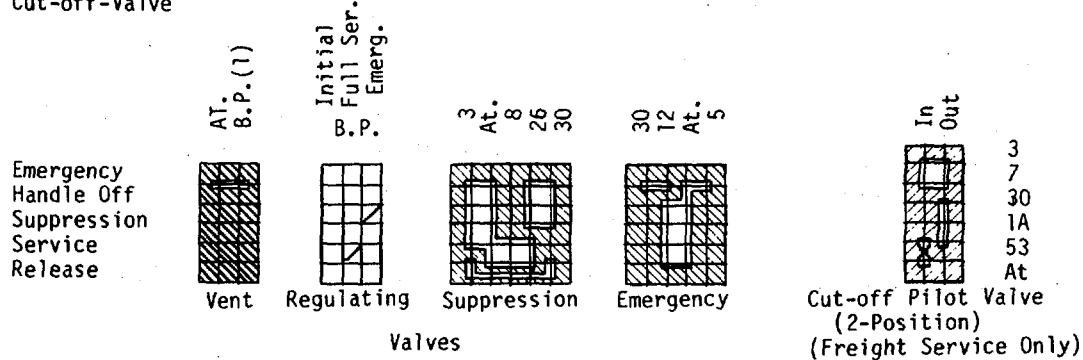
4-11. AUTOMATIC BRAKE VALVE (cont) TEST (cont)



- Legend
- 1. Brake Pipe
  - 21. Safety Control Pipe
  - 3. Switch Pipe
  - 12. Emergency Switch Pipe
  - 30. M.R. Pipe
  - 53. B.P. Cut-off Pipe
  - 5. Equal Res. Control Pipe
  - 15. Equal Res. Charging Pipe
  - 26. Suppression Pipe
  - 8. Lock-over Pipe

Equalizing Reservoir Cut-off-Valve

Regulating Valve-Set By Adjustment "A"



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**4-11. AUTOMATIC BRAKE VALVE (cont) TEST (cont)**

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- (c) From port 15, equalizing reservoir air pressure flows to the equalizing reservoir, to the air gages, and to port 5.
  - (d) Equalizing reservoir air pressure is directed through an orifice from the charging passage to the diaphragm of the regulating valve.
  - (e) Through port 5, the equalizing reservoir air pressure is directed to the outer side of the relay valve diaphragm.
- (3) Brake pipe air pressure is developed as follows:
- (a) Equalizing reservoir air pressure on the outer side of the relay valve diaphragm forces the diaphragm and valve stem inward. Inward movement of the valve stem opens the supply valve seat, and main reservoir air enters the brake pipe charging passage.
  - (b) The brake pipe charging pressure flows to the brake pipe cutoff valve, which opens when the charging air pressure is about 25 psi (172 kPa). Air then flows around the sealed vent valve, into the brake pipe passage, and out port 1.
  - (c) Brake pipe charging air pressure is also directed through an orifice to the inner face of the relay valve diaphragm, where it develops a counteracting force to the equalizing reservoir force on the outer face of the diaphragm. When these forces are equal, brake pipe charging cuts off.
  - (d) Brake pipe air pressure is also connected through a passage in the brake valve to spillover check valve B on the bottom of the handle portion, where it is made available to the spool of the cutoff pilot valve in passage 1A.
- (4) Lap position is maintained as follows:
- (a) When the equalizing reservoir charging air pressure in pipe 15 and on the inner face of the regulating valve diaphragm are equal to the adjustment spring tension of the regulator valve, the valve spool moves toward the adjustment spring. This moves the supply valve against its seat and stops charging of the equalizing reservoir. This is selfflapping. If a leak in the equalizing reservoir occurs, the diaphragm pressure weakens and the regulator valve moves to supply and the equalizing reservoir pressure is brought back up to make the adjustment spring tension. This is equalizing reservoir pressure maintaining.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**TEST (cont)**

- (b) Brake pipe charging continues until pressure on the inner face of the relay valve diaphragm matches the pressure of equalizing reservoir control pipe 5 on the outer face of the diaphragm. The valve stem is then drawn back, away from the supply seat, allowing it to close and stop brake pipe charging. The valve self-laps. If a leak in the brake pipe occurs, the pressure on the inner face of the diaphragm weakens and the equalizing reservoir pressure on the outer face of the diaphragm moves the relay valve to supply until the brake pipe pressure once again matches the equalizing reservoir pressure. This is brake pipe pressure maintaining.
- b. SERVICE Position. As the handle is moved from RELEASE position toward SERVICE position, the brake pipe pressure reduction is gradually increased until in FULL SERVICE position a full service brake pipe reduction is obtained.
- (1) Equalizing reservoir air pressure reduces as follows:
    - (a) When handle is moved into the SERVICE zone, the regulating valve cam rotates to a lower grind and allows the regulating valve spool to move toward the handle shaft. This action opens the exhaust seat of the regulating valve and weakens the adjustment spring tension.
    - (b) Equalizing reservoir air flows from the equalizing reservoir to the regulating valve exhaust port, through pipe 15 and the equalizing reservoir cutoff valve in the brake valve. The equalizing reservoir pressure will be reduced at a controlled rate as the regulating valve vents. Air pressure on the regulating valve diaphragm will also be reduced at the same rate.
    - (c) Handle movement into the service zone will also rotate suppression valve cam to move suppression valve spool inward to an intermediate position. In this position, passage and port 3 air pressure will be vented through the valve spool. Venting of passage 3 air pressure will result in venting of passage 7, through cutoff pilot valve. Air pressure holding up the check of the equalizing reservoir cutoff valve will be removed and the check will seal. Air pressure from the equalizing reservoir can pass toward the regulating valve to exhaust, allowing graduated exhaust of equalizing reservoir pressure as the brake valve handle is advanced through the service zone. The equalizing reservoir cutoff valve will not allow an increase in equalizing reservoir pressure as the brake valve handle is moved toward release until the handle is returned fully to RELEASE position.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**TEST (cont)**

- (2) Brake pipe air pressure reduces as follows:
  - (a) Pressure reduction in the equalizing reservoir will be felt on the outer side of the relay valve diaphragm. With the inner face of the diaphragm at brake pipe pressure, the pressure difference will force the diaphragm outward, pulling the valve stem with it.
  - (b) The valve stem will open the exhaust seat of the relay valve. Brake pipe air pressure will be vented out relay valve exhaust port, causing a brake pipe pressure reduction at service rate.
  - (c) Brake pipe air pressure will continue to vent until pressure on the inner face of relay valve diaphragm and in the brake pipe balances with the pressure of the equalizing reservoir. Relay valve will then assume lap position.
  - (d) Equalizing reservoir air pressure can be reduced in steps, by handle movement, in about 2-psi (14 kPa) increments until a pressure reduction of 23 to 26 psi (159 to 179 kPa) is attained at FULL SERVICE position.
- (3) Lap position will be maintained as follows:
  - (a) Reduction of equalizing reservoir air pressure through regulating valve exhaust will continue until pressure on the valve diaphragm balances with the adjusting spring tension which has been weakened by handle cam movement.
  - (b) The valve will then move to close the exhaust seat and assume lap position.
- (4) Release of service brake application functions as follows:
  - (a) Movement of brake handle toward RELEASE position will cause regulating valve cam on the handle to move the regulating valve assembly toward the adjustment spring, increasing the spring tension and opening the supply seat of the valve.
  - (b) Equalizing reservoir charging air pressure will increase at the regulating valve; however, it will not increase in equalizing reservoir charging pipe 15 because the check on the equalizing reservoir cutoff valve remains seated until the brake valve handle is placed in RELEASE position.

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**4-11. AUTOMATIC BRAKE VALVE (cont)**

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**TEST (cont)**

- c. **SUPPRESSION Position.** This portion of the brake handle is provided for reset of a safety control penalty brake application. Although this position is to the right of FULL SERVICE position, no further reduction of equalizing reservoir pressure will be made beyond that already attained at FULL SERVICE.
- (1) When brake handle is placed in SUPPRESSION position, suppression valve spool will be displaced fully inward by the handle cam.
  - (2) Main reservoir air pressure will be trapped in the spring chamber of the spool and port 3 will continue to be vented.
  - (3) Main reservoir air pressure will be directed to port 26 and suppression pipe port 8; the lock-over pipe will be blocked by the valve spool in suppression position.
  - (4) Air pressure on port 26 is used to suppress the safety control brake application valve, and blocking of port 8 will reset the safety control brake application valve.
- d. **HANDLE-OFF Position.** This position is provided to allow the brake valve to be cut out when the locomotive is trailing.
- (1) In HANDLE-OFF position, suppression valve is positioned as it is in SUPPRESSION position. The regulating valve cam, however, is moved to allow the regulating valve spool to move fully away from its adjustment spring tension.
  - (2) If the brake valve handle is placed in HANDLE-OFF position and removed, equalizing reservoir air pressure will be reduced to atmosphere and safety control will be suppressed, allowing the brake valve to be cut out and left unattended.



**4-12. INDEPENDENT BRAKE VALVE**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Test Equipment

AB Test rack  
 AB-144 Test plate (complete)  
 PC560954  
 Gasket PC557237

Equipment Condition Reference

Para 3-46

Material/Parts

Dry-cleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Wiping rags (Item 32, Appendix B)

Condition Description

Independent brake valve removed

**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel. NOTE**

- Before disassembly, plae handle in RELEASE position.
- When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Pull handle retaining pin assembly (23) straight out and remove handle assembly (1).
2. Remove three screws (2) and separate quick-release valve body (3) from valve body (20). Remove gasket (4).

**4-12. INDEPENDENT BRAKE VALVE (cont)**

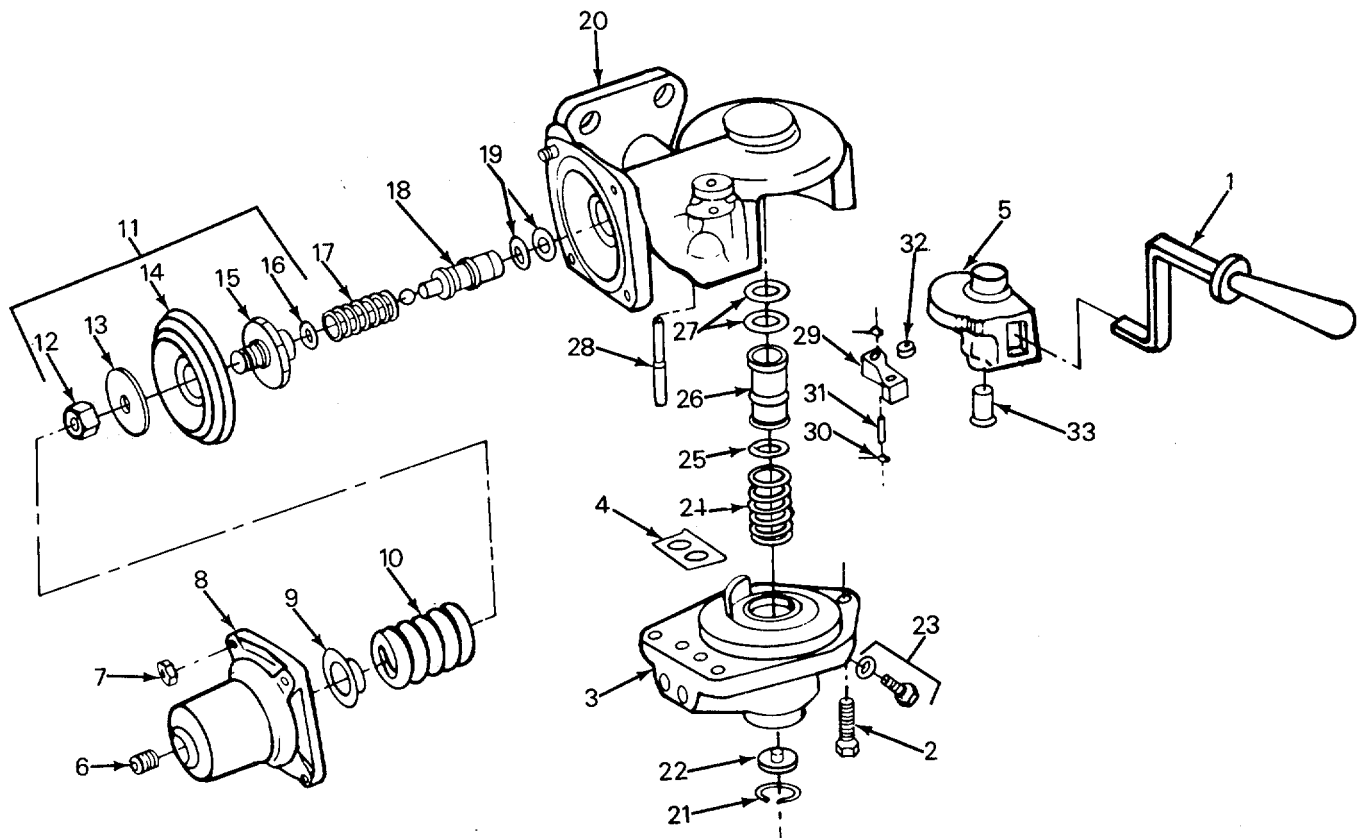
**DISASSEMBLY (cont)**

3. Remove cam (5).
4. Turn adjusting screw (6) counterclockwise and relieve tension on regulating valve spring (10).

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

5. Remove four nuts (7), spring housing (8), spring seat (9), regulating valve spring (10), and exhaust valve seat assembly (11).
6. Disassemble exhaust valve seat assembly (11) by removing nut (12), follower (13), diaphragm (14), exhaust valve seat (15), and O-ring (16).



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**4-12. INDEPENDENT BRAKE VALVE (cont)**

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**DISASSEMBLY (cont)**

7. Remove exhaust valve spring (17) from valve body (20).
8. Remove inlet-exhaust valve (18) from valve body (20). Remove two O-rings (19) from inlet-exhaust valve.
9. Remove retain~~er~~ ring (21), spring seat (22), and handle retaining pin assembly (23) from quick-release valve body (3).
10. Remove quick-release spring (24), O-ring (25), and quick-release valve (26). Remove two O-rings (27) from quick release valve.
11. Remove cam dog pin (28) and remove cam dog (29).
12. Remove two cotter pins (30), roller pin (31), and roller (32) from cam dog (29).
13. Remove brake valve push pin (33) from cam (5).

**CLEANING, INSPECTION, AND REPAIR****WARNING**

**Dry-cleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**

14. Use a cloth dampened with dry-cleaning solvent and remove grease and oil from exterior and interior of quick release valve body (3) and valve body (20).

**WARNING**

**Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

15. Use dry-cleaning solvent and clean metal parts. Dry with compressed air
16. Inspect metal parts for cracks, breaks, cuts, or other damage. Replace damaged parts.

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**4-12. INDEPENDENT BRAKE VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

17. Check that spings have not rusted or distorted or have taken a permanent set. Replace damaged springs.
18. Inspect roller (32) and roller pin (31) for flat spots. Replace damaged parts.
19. Inspect handle retaining pin assembly (23) for a broken spring or flat spot on end of pin. Replace damaged parts.
20. Check that roller contact surface on cam (5) and cam contact surface on roller (32) are clean and dry to maintain rolling friction between the two surfaces.
21. Use pneumatic grease and lubricate O-rings, O-ring grooves in spool valves, and bushings into which spool valves enter. Use a clean wiping rag and remove excess lubricant.

**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

22. Install brake valve push pin (33) in cam (5).
23. Install roller (32) and roller pin (31) in cam dog (29) and secure with two cotter pins (30).
24. Install cam (5) and cam dog (29) in valve body (20) and secure with cam dog pin (28).
25. Install two O-rings (27) and O-ring (25) on quick-release valve (26).
26. Install handle retaining pin assembly (23), spring seat (22), and retainer ring (21) in quick-release valve body (3).
27. Install gasket (4) on valve body (20).
28. Install quick-release valve (26) and quick-release spring (24) on quick-release valve body (3).
29. Install quick-release valve body (3) on valve body (20) and secure with three screws (2).
30. Install two O-rings (19) on inlet-exhaust valve (18).
31. Install inlet-exhaust valve (18) in quick-release valve body (3).
32. Install exhaust valve spring (17) over ball end of inlet-exhaust valve (18).

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**4-12. INDEPENDENTBRAKE VALVE (cont)**

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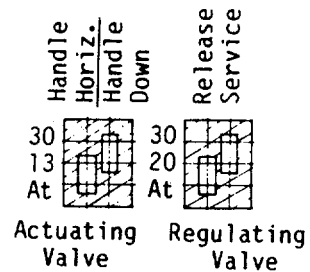
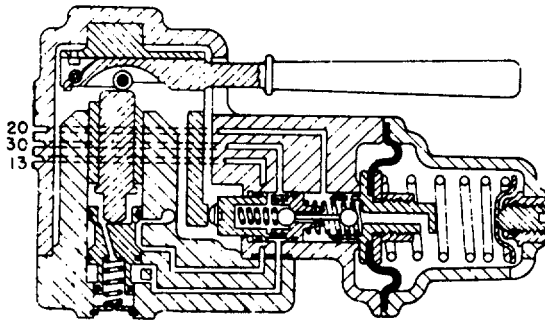
**ASSEMBLY (cont)**

33. Assemble exhaust valve seat assembly (11) by the following:
  - a. Install O-ring (16) on exhaust valve seat (15).
  - b. Install exhaust valve seat (15) on diaphragm (14) and follower (13) and secure with nut (12).
34. Install exhaust valve seat assembly (11) in quick-release valve body (3). Check that exhaust valve spring (17) is positioned in bore of exhaust valve seat (15).
35. Install regulating valve spring (10) over nut (12).
36. Install spring seat (9) on end of regulating valve spring (10).
37. Install spring housing (8) on quick-release valve body (3) and secure with four nuts (7). Turn adjusting screw (6) clockwise.
38. Check that cam (5) is in RELEASE position. Install handle assembly (1) in slot of cam.
39. Pull back on handle retaining pin assembly (23) and check that full travel of handle is into cam. Release handle retaining pin assembly. TEST
40. Test the independent brake valve in accordance with New York Air Brake Company Test Specification T-2403-C. The independent brake valve function as follows:
  - a. Make adjustment of delivery pressure at the adjusting screw on the control spring housing. If a higher pressure is desired, increase the compression on the spring so that a higher delivery pressure will be required to lap the valve portion. If a lower pressure is desired, decrease the compression on the spring so that a lower delivery pressure will be required to lap the valve portion.
  - b. The independent brake valve shall function as follows:
    - (1) The independent brake valve has two positions: RELEASE and FULL APPLICATION.
    - (2) When the handle is moved from RELEASE position toward FULL APPLICATION position, the valve functions as follows:
      - (a) The valve handle actuate a cam which, in turn, positions a supply and exhaust valve assembly, first to seat the exhaust valve and then to unseat the supply seat.
      - (b) Main reservoir air will flow past the unseated supply valve from port 30 to port 20. Port 20 from the brake valve is connected to port No. 2a on the 6-NFR distributing valve via the No. 24-A double check valve.

**4-12. INDEPENDENT BRAKE VALVE (cont)**

**TEST (cont)**

- (c) Pressure developed in port 20 will actuate the relay valve to develop pressure in the brake cylinders. As air pressure develops in port 20, it also develops on the inner face of the diaphragm in the independent brake valve.
- (d) The buildup of pressure on the diaphragm is opposed by spring pressure on the opposite side; and when the air pressure and spring become balanced, the valve assembly will move to its lap position in which the supply valve becomes seated to terminate further flow of main reservoir air to port 20.
- (3) Pressing the independent brake handle when the handle is in RELEASE position will cause release of any automatic brake application existing on the locomotive. The valve functions as follows:
  - (a) Main reservoir air will flow into port 13 which, in turn, is connected to port 10 of the H-5 relay air valve.
  - (b) When air pressure in port 10 exceeds the strength of the valve return spring, port 11 is connected to 9 and atmosphere.
  - (c) Air in application chamber port 2A is exhausted through port 2 at H-5 relay air valve port 9.
  - (d) Air in the brake cylinder will, in turn, be vented at the 6-NFR distributing valve BC exhaust.
  - (e) Pressing of the independent brake handle with it somewhere in the application zone will release the automatic application only to the value corresponding to the position of the handle in the application zone.



**4-13. 6-NFR DISTRIBUTING VALVE This task covers:**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12  
 Plug gage 56204  
 Gage block  
 Micrometer 5120-00-267-3093  
 Depth gage  
 Flat gage 42044  
 AB test rack  
 Adapter kits

Equipment Condition  
Reference

Para 3-47

Material/Parts

Dry-cleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Emery cloth (Item 5, Appendix B)  
 Powder graphite (Item 12, Appendix B)  
 Lubricating oil (Item 24, Appendix B)  
 Triple valve oil (Item 26, Appendix B)  
 Marking pigment (Item 30, Appendix B)  
 Lapping compound 1000 grit (Item 8, Appendix B)

Condition Description

6-NFR distributing valve removed

**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel. NOTE**

- The 6-NFR distributing valve provides increased sensitivity of brake application and release, ensuring reliability of operation in long, multiple-unit consists, and also acts as a safety valve to limit brake cylinder pressure to required standards, regardless of brake pipe pressure employed.
- When removing or repairing brake valves or components, check air lines and pipes for corrosion, breaks, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove three bolts (1), top cover (2), and gasket (3).

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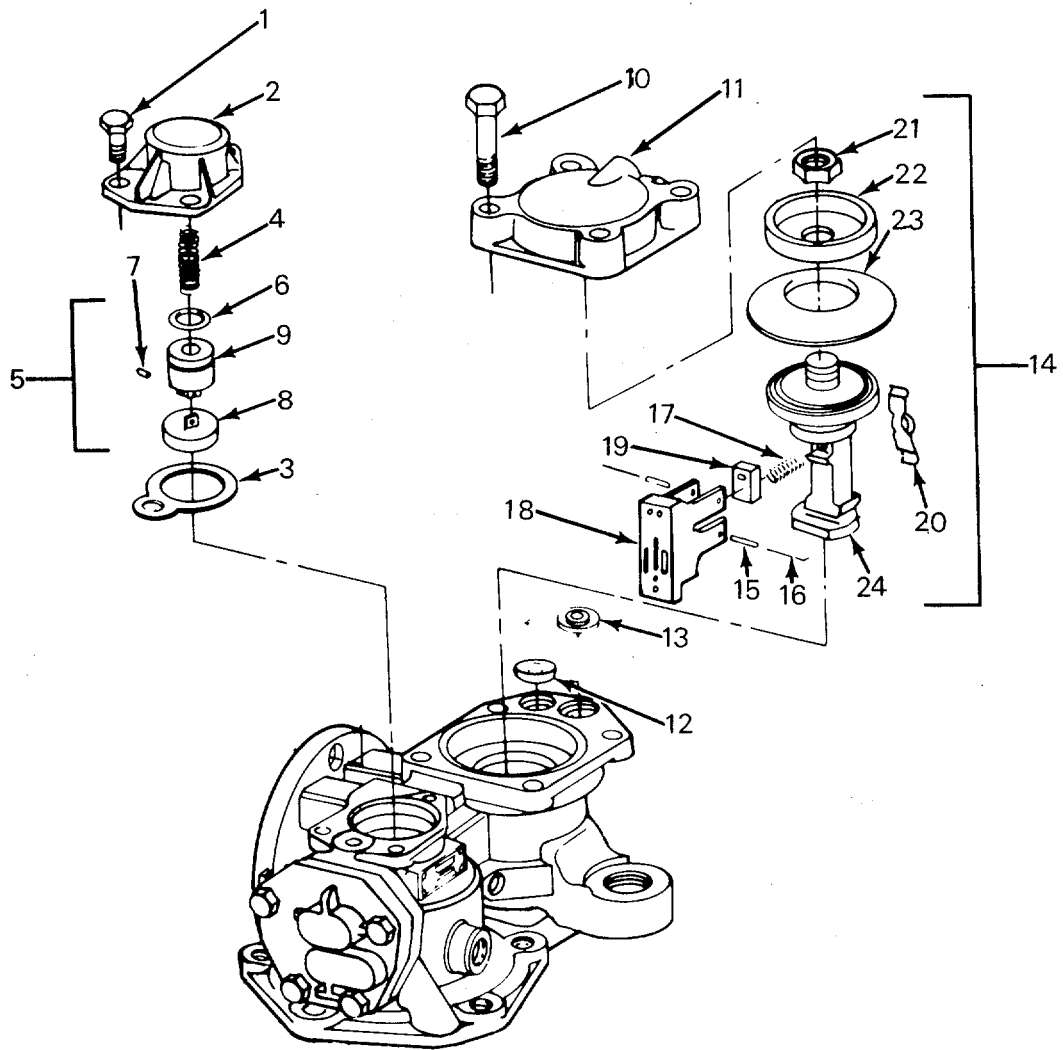
**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**DISASSEMBLY (cont)**

2. Remove spring (4).
3. Remove check valve and carrier assembly (5).
4. Disassemble check valve and carrier assembly (5) by removing O-ring (6), pin (7), and check valve (8) from carrier (9).
5. Remove four bolts (10) and remove equalizing piston cover (11) and gaskets (12) and (13).
6. Remove equalizing piston assembly (14).
7. Disassemble equalizing piston assembly (14) by the following:
  - a. Remove two lock pins (15), two spring pins (16), spring (17), slide valve (18), graduating valve (19), ~~p~~ridgs (20).
  - b. Remove nut (21), follower (22), and diaphragm (23) from piston (24).

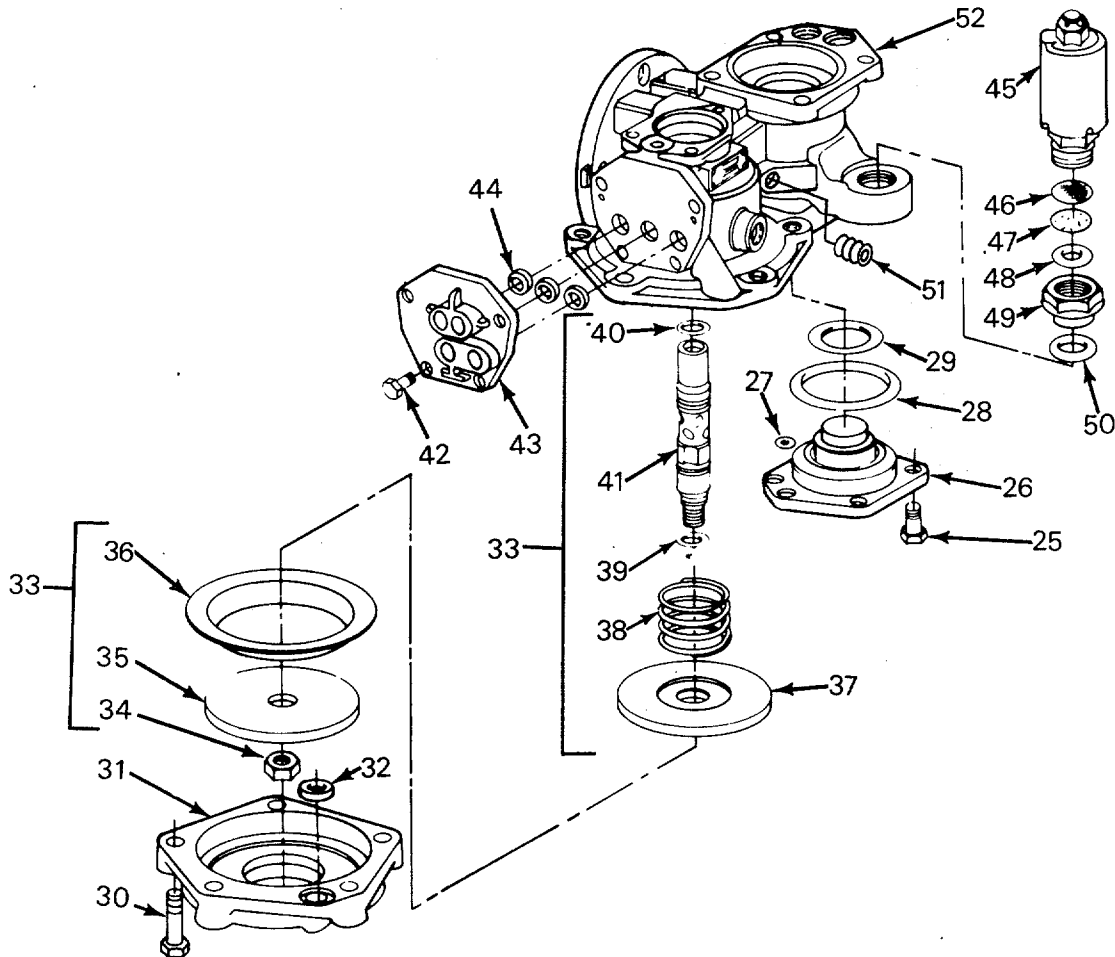




4-13. 6-NFR DISTRIBUTING VALVE (cont)

DISASSEMBLY (cont)

8. Remove four bolts (25), slide valve stop (26), gasket (27), O-ring (28), and gasket (29).
9. Remove five bolts (30), bottom cover (31), and gasket (32).
10. Remove large diaphragm piston assembly (33).
11. Disassemble large diaphragm piston assembly (33) by the following:
  - a. Remove nut (34), follower (35), diaphragm (36), piston head (37), and piston spring (38).
  - b. Remove O-rings (39) and (40) from piston stem (41).
12. Remove four bolts (42), cover (43), and three gaskets (44).
13. Remove safety valve (45), screen (46), strainer (47), gasket (48), adapter (49), and O-ring (50). Remove pipe plug (51) from body (52).



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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- **Dry-cleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

14. Use a cloth dampened with dry-cleaning solvent and remove grease and oil from exterior and interior of body (52).
15. Use dry-cleaning solvent and clean metal parts. Dry with compressed air.
16. Inspect metal parts for cracks, breaks, cuts, or other damage. Replace damaged parts.
17. Check that springs have not rusted, became distorted, or have taken on permanent set. Replace damaged springs.
18. Refinish faces of rubber check valves by lapping on a piece of medium-weight emery paper.

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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**


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**CLEANING, INSPECTION, AND REPAIR (cont)****CAUTION**

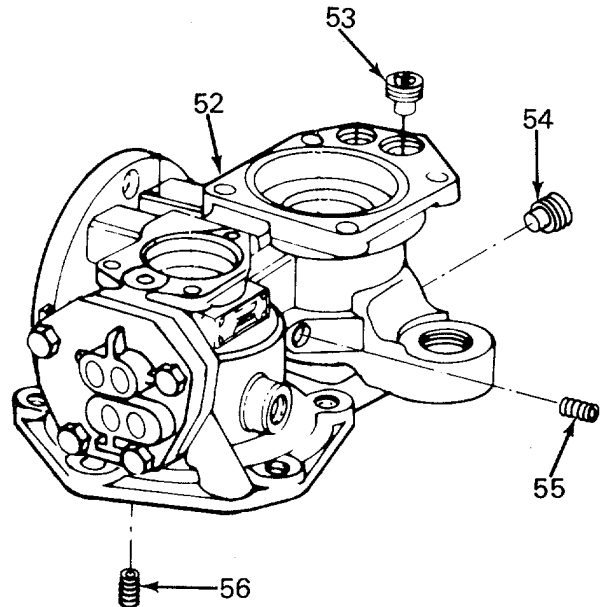
**Do not use metallic tools to clean chokes. The use of metallic tools will change size of chokes, resulting in failure of brake valve system.**

**NOTE**

**To avoid misplacement of chokes, remove and replace one choke plug at a time.**

19. Clean, inspect, and repair choke plugs (53), (54), (55) and (56) by the following:

- a. Remove choke plug and place in dry-cleaning solvent.
- b. Inspect choke plug passage for cleanliness. Use compressed air and remove foreign matter.
- c. Remove choke plug from dry-cleaning solvent and dry with compressed air. Check that choke plug is clean and unrestricted.
- d. Lightly coat threads of choke plug with compound consisting of one part graphite and two parts oil and install.



20. Clean, inspect, and repair slide valve bushing by the following:

- a. Check that slide valve bushing is not scratched or scored.
- b. Use plug gage and check depth of seat.
- c. If slide valve seat is scratched or scored, use a lapping compound and recondition.
- d. Use marking pigment and gage blocks and inspect for low spots on bearing surface.
- e. Remove burrs from slide valve seat and regage.
- f. Use a depth gage and measure clearance groove. If it is less than 0.005 inch (0.13 mm) deep, use a hacksaw blade and recut. Do not cut deeper than 0.020 inch (0.51 mm).

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#### 4-13. 6-NFR DISTRIBUTING VALVE (cont)

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#### CLEANING, INSPECTION, AND REPAIR (cont)

21. Clean, inspect, and repair slide valve (18) and graduating valve (19) by the following:
  - a. Check that valves are not scratched, scored, or damaged. Replace damaged valves.
  - b. Use a micrometer and measure slide valve (18) thickness from the bottom of the graduating valve seat. Replace slide valve if thickness is less than 0.549 inch (13.944 mm).
  - c. Use a depth gage and measure depth of 1/8-inch (3.2 mm) slots in slide valve (18). Replace slide valve if depth of slots is greater than 0.093 inch (2.362 mm).
  - d. Use flat gage and gage thickness of graduating valve (19).
  - e. If graduating valve (19) is within gage limits, use lapping compound and lap slide valve to slide valve seat by the following:
    - (1) Condition the valve by rubbing slide valve against seat several times with lapping compound. Remove burrs and rough surface marks.

#### **WARNING**

**Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

- (2) Use compressed air and remove foreign particles from cavities.
  - (3) Regage graduating valve (19).
22. Check that piston is not bent. Use a micrometer and measure diameter of two guides on piston. Replace piston if diameter is greater than 1.733 inches (44.02 mm).
23. Use triple valve oil and lubricate slide valve bushing.
24. Use pneumatic grease and lubricate O-rings, O-ring grooves in spool valves, and bushings into which spool valves enter. Use a clean wiping rag and remove excess lubricant.
25. Lubricate rubber check valves by placing them in a box with dry graphite and -- shaking the box. Remove check valves. Wipe excess graphite off on a piece of wiping rag.

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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

26. Check that choke plugs (53), (54), (55) and (56) are installed in their proper locations. Install pipe plug (51) in body (52). Install O-ring (50) on adapter (49).
27. Install adapter (49), gasket (48), strainer (47), screen (46), and safety valve (45) in body (52).
28. Install three gaskets (44) and cover (43) and secure with four bolts (42).
29. Assemble large diaphragm piston assembly (33) by the following:
  - a. Install O-rings (40) and (39) on piston stem (41).
  - b. Install piston spring (38) and piston head (37) on piston stem (41).
  - c. Install diaphragm (36) and follower (35) on piston head (37) and secure with nut (34).
30. Install large diaphragm piston assembly (33) in body (52).
31. Install gasket (32) and bottom cover (31) and secure with five bolts (30).
32. Install gasket (29), O-ring (28), and gasket (27) on slide valve stop (26).
33. Position slide valve stop (26) on body (52) and install four bolts (25).
34. Assemble equalizing piston assembly (14) by the following:
  - a. Install diaphragm (23) and follower (22) on piston (24) and secure with nut (21). Tighten nut to 30 lb-ft (40 N.m).
  - b. Install graduating valve (19) on slide valve (18) and install spring (20) in recess of graduating valve.
  - c. Install piston (24) on slide valve (18). Check that spring (20) enters recess of piston stem.
  - d. While holding slide valve (18) in position on piston (24), install spring (17) on stem of piston. Secure with two spring pins (16) and two lock pins (15).

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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**ASSEMBLY (cont)**

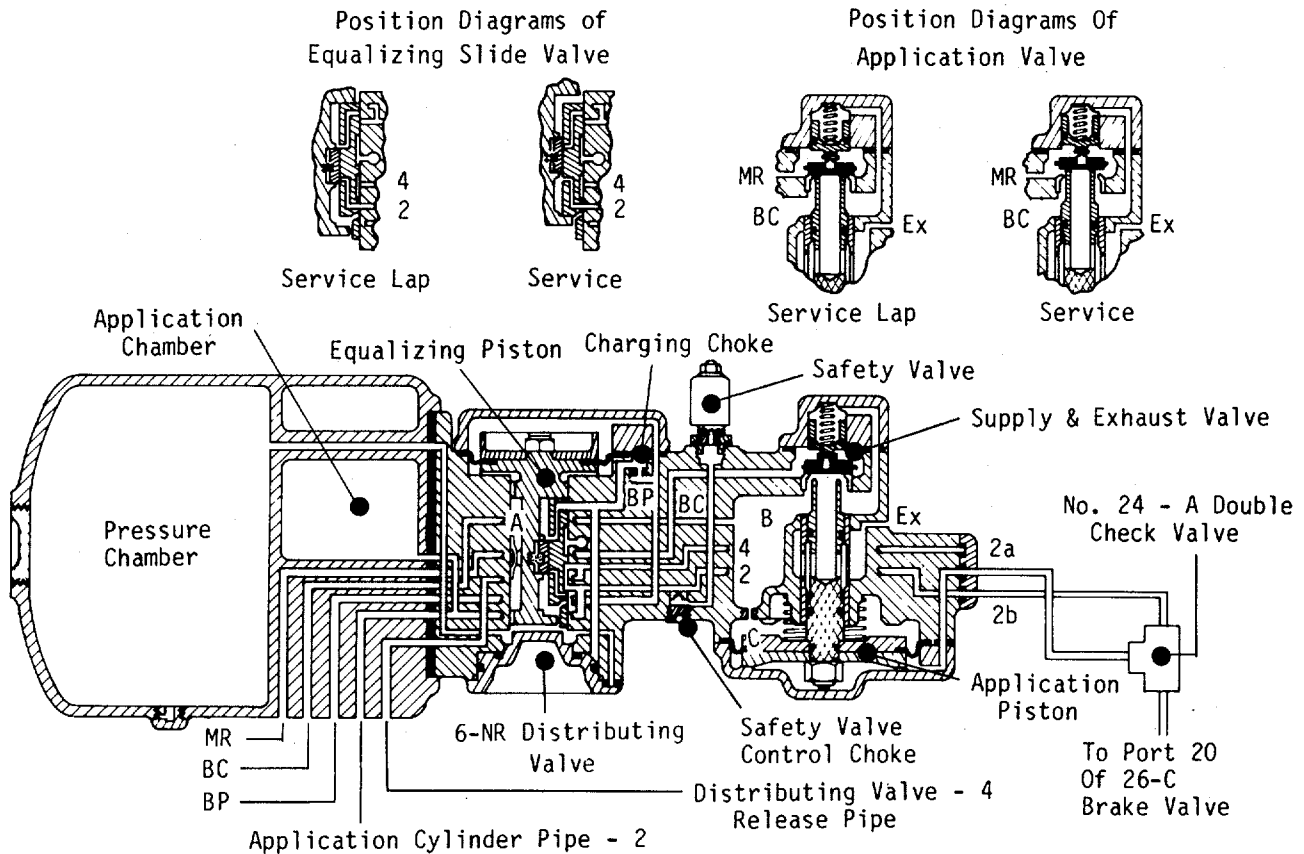
35. Apply one drop triple valve oil to slide valve seat in bushing and one drop to face of slide valve (18). Distribute over entire surface.
36. Install equalizing piston assembly (14) in body (52). Check that bead of diaphragm (23) is ~~top~~ seated in recess of body.
37. Install gaskets (13) and (12) and equalizing piston cover (11) and secure with four bolts (10).
38. Assemble check valve and carrier assembly (5) by the following:
  - a. Install check valve (8) on carrier (9) and secure with pin (7).
  - b. Install O-ring (6) on carrier (9).
39. Install check valve and carrier assembly (5) in body (52). Install spring (4) in carrier (9).
40. Install gasket (3) and top cover (2) and secure with three bolts (1).

**TEST**

41. Test the 6-NFR distributing valve in accordance with New York Air Brake Company Test Specification NYT-460.
  - a. During charging and release, the 6-FNR distributing valve functions as follows:
    - (1) Brake pipe air flows first to the outer face of the equalizing piston diaphragm, forcing the piston and slide valve to release position.
    - (2) Air in brake pipe flows through charging choke and equalizing slide valve to the pressure chamber, charging it to brake pipe pressure.
    - (3) In this position, equalizing slide valve connects application chamber through release port No. 4 to exhaust.
    - (4) Application cylinder on the outer face of application piston is exhausted via passage 2a, through No. 24-A double check valve, passages 26, 2, then 4 in the distributing valve, to exhaust.
    - (5) The release spring holds application piston in release position against application cylinder cover.
    - (6) The inner end of application piston, which is machined to form the exhaust valve seat, is moved away from the rubber supply and exhaust valve to vent the brake cylinder passage.

4-13. 6-NFR DISTRIBUTING VALVE (cont)

TEST (cont)



(7) Main reservoir air is constantly present in the chamber and to application cylinder on the outer face of application piston via passage No. 2, 26, No. 24-A double check valve, and passage 2a.

b. During a service brake application, the 6-NFR distributing valve functions as follows:

- (1) Brake pipe pressure reduces, causing a difference in pressure between brake pipe and pressure chamber.
- (2) The higher pressure in the pressure chamber and equalizing slide valve chamber causes the equalizing piston and slide valve to move upward to service position where slide valve port connections are made.



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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**TEST (cont)**

- (3) Upon the first movement toward service position, the graduating valve severs communication between brake pipe and pressure chamber.
  - (4) Communication between pressure chamber and passage 2 is then made, allowing pressure chamber air to flow to application chamber and to application cylinder on outer face of application piston via passages 2 and 26, 24-A double check valve, and passage 2a.
  - (5) Flow of pressure chamber air is continued until pressure has been reduced to slightly below brake pipe pressure on the opposite side of the equalizing piston, at which time the piston and graduating valve are moved to service lap position, terminating further flow of pressure chamber air to passage 2. Maximum pressure in passage 2 is limited by the safety valve, which is connected to passage 2 by the safety valve control choke.
  - (6) Pressure that is developed in passage 2 and the application cylinder on the outer face of the application piston causes the piston to move upward against the force of the release spring, first to seal the exhaust seat against the underside of the supply and exhaust valve, and then to raise this valve from its supply seat to allow main reservoir air to flow to brake cylinder cavity B and passage BC.
  - (7) Brake cylinder air pressure also builds up in chamber C on the inner face of application piston and diaphragm via the stabilizing choke.
  - (8) As brake cylinder pressure in chamber C approaches application cylinder pressure on the opposite side of the diaphragm and piston, the application piston is moved downward to allow the supply and exhaust valve to be seated on its supply valve seat to terminate further flow of main reservoir air to the brake cylinder.
- c. During brake release the 6-NFR brake valve functions as follows:
- (1) An increase in brake pipe pressure moves the equalizing piston and slide valve to release position to connect passage 2 and the application chamber to exhaust at port 4.
  - (2) Reduction of pressure in passage 2 and the application cylinder permits the higher brake cylinder pressure in chamber C to move the piston out of contact with the exhaust valve seat, allowing brake cylinder air to flow through chamber B, past the exhaust valve seat, to atmosphere through the brake cylinder exhaust passage.

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**4-13. 6-NFR DISTRIBUTING VALVE (cont)**

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**TEST (cont)**

- d. During an emergency application, the 6-NFR distributing valve functions in the same manner as during a service application, with the addition of the following:
  - (1) Main reservoir is connected to port 12 via the brake valve emergency valve.
  - (2) From port 12, main reservoir air flows through check valve and choke fitting to passage 2, past equalizing piston, to the outer face of the application piston via passages 2 and 2b, 24-A double check valve, and passage 2a.
  - (3) Main reservoir pressure will increase to the value of the safety valve setting, where it is maintained by the safety valve control choke and blowdown of the safety valve.
  - (4) Should the brake valve handle be moved out of EMERGENCY position, control pressure in passage 2 is prevented from escaping from vent pipe No. 12 by a check valve. The pipe 12 choke ensures a positive brake release when an emergency brake application is bailed off.
- e. During the independent brake application, air pressure from passage 20 of the 26-C brake valve flows directly to the outer face of the application piston via 24-A double check valve and passage 2a.

**4-14. NO. 8 VENT VALVE**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Test Equipment

AB test rack  
 AB 178 test plate PC TA-2968-C  
 Ring gasket PC BC-8378

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Triple valve oil (Item 26, Appendix B)  
 Lapping compound (Item 8, Appendix B)

Equipment Condition Reference

Para 3-49

Condition Description

No. 8 vent valve removed

**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

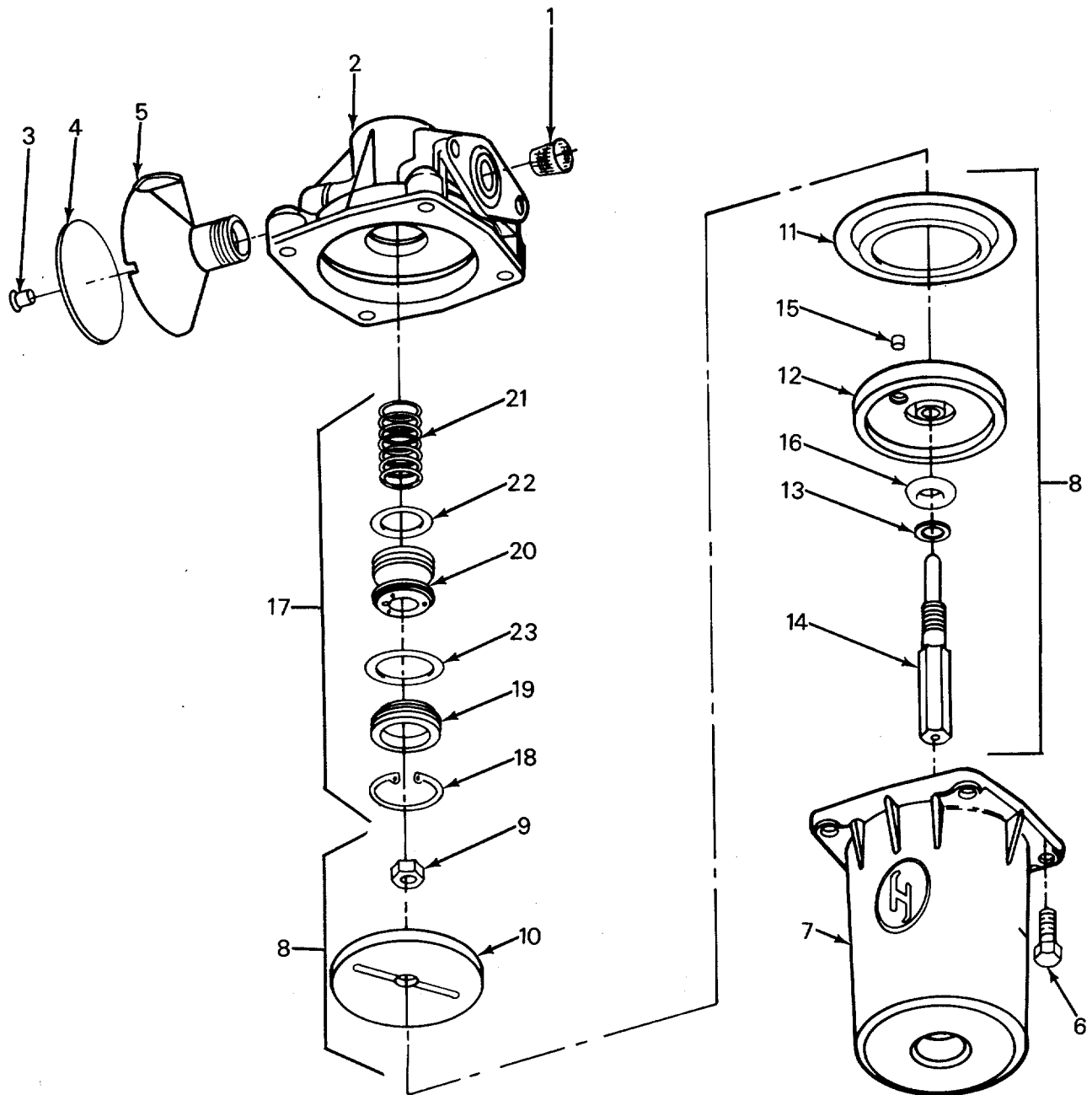
**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Remove strainer (1) from body (2).
2. Remove pop rivet (3), seal (4), and vent protector body (5).

4-14. NO. 8 VENT VALVE (cont)

DISASSEMBLY (cont)



3. Remove four bolts (6) and diaphragm housing (7).
4. Remove piston diaphragm assembly (8).

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**4-14. NO. 8 VENT VALVE (cont)**

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**DISASSEMBLY (cont)**

5. Disassemble piston diaphragm assembly (8) by the following:
  - a. Remove locknut (9), follower (10), diaphragm (11), piston (12), and flat washer (13) from piston stem (14).
  - b. Remove felt (15) and seal (16) from piston (12).
6. Remove exhaust valve assembly (17).
7. Disassemble exhaust valve assembly (17) by the following:
  - a. Compress exhaust valve assembly (17) and remove retaining ring (18).
  - b. Remove exhaust valve seat (19), exhaust valve (20), and spring (21).
  - c. Remove O-ring (22) from exhaust valve (20).
  - d. Remove O-ring (23) from exhaust valve seat (19).

**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  - ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**
8. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of body (2).
  9. Use drycleaning solvent and clean metal parts. Dry with compressed air.
  10. Inspect metal parts for cracks, breaks, cuts, or other damage.

---

**4-14. NO. 8 VENT VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

11. Check that spring (21) has not rusted, become distorted, or has taken a permanent set.
12. Replace damaged parts.
13. Check that exhaust valve seat (19) is not scratched or scored. If exhaust valve seat is damaged, recondition by the following:
  - a. Lap exhaust valve seat (19) with lapping compound using a front-to-back motion.
  - b. Use compressed air and remove foreign matter from exhaust valve seat (19).
  - c. Use a cloth dampened with drycleaning solvent and clean exhaust valve seat (19).
14. Check that exhaust valve seat (19) is not cracked or cut. Replace damaged exhaust valve seat.
15. Use pneumatic grease and lubricate O-rings, O-ring grooves in spool valves and bushings into which spool valves enter. Use a clean wiping rag and remove excess lubricant.
16. Use triple valve oil and lubricate piston stem guides.

**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

17. Assemble exhaust valve assembly (17) by the following:
  - a. Install O-ring (23) on exhaust valve seat (19).
  - b. Install O-ring (22) on exhaust valve (20).
  - c. Install spring (21), exhaust valve (20), and exhaust valve seat (19) in body (2) and install retaining ring (18).
18. Assemble piston diaphragm assembly (8) by the following:
  - a. Install seal (16) and felt (15) in piston (12).
  - b. Install flat washer (13) and piston (12) on piston stem (14). Check that felt (15) is toward threaded end of piston stem.

---

**4-14. NO. 8 VENT VALVE (cont)**

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**ASSEMBLY (cont)**

- c. Install diaphragm (11) on piston (12). Check that bead of diaphragm is in groove of piston.
  - d. Install follower (10) on diaphragm (11). Check that ribbed side of follower is toward threaded side of piston stem (14).
  - e. Install locknut (9).
19. Install piston diaphragm assembly (8) in diaphragm housing (7). Check that bead of diaphragm (11) is in groove of diaphragm housing.
20. Position body (2) on diaphragm housing (7) and install four bolts (6).
21. Install vent protector body (5) and seal (4) and secure with pop rivet (3).
22. Install strainer (1) in body (2).

**TEST**

23. Test No. 8 vent valve in accordance with New York Air Brake Company Test Specification T-2720-C.

**4-15. A-1 CHARGING CUTOFF PILOT VALVE**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Test Equipment

4-C test rack  
 4-CB adapter plate PC 526036  
 4-B-5 test plate PC 531019  
 Pipe bracket PC 564916  
 Gasket PC 563102

Reference

Para 3-50

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Emery cloth (Item 5, Appendix B)  
 Powder Graphite (Item 12, Appendix B)  
 Lubricating Oil (Item 21, Appendix B)

Equipment Condition  
Condition Description

A-1 charging cutoff pilot valve removed

**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

**NOTE**

- ⌚ **A-1 charging cutoff pilot valve provides train break-in-two protection.**
- ⌚ **When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

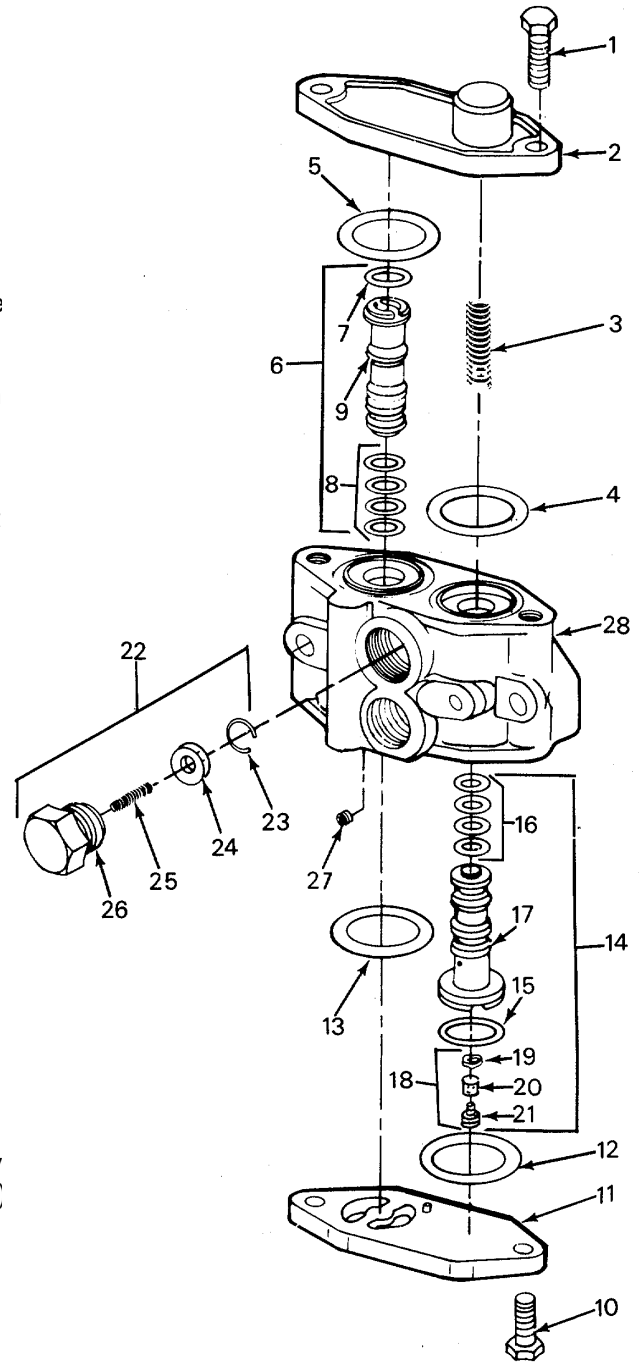
1. Remove two bolts (1), top cover (2), spring (3), gaskets (4) and (5), and cutoff piston assembly (6) from body (28).



**4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)**

**DISASSEMBLY (cont)**

2. Disassemble cutoff piston assembly (6) by removing O-ring (7) and four O-rings (8) from cutoff valve (9).
3. Remove two bolts (10) and bottom cover (11). Remove gaskets (12) and (13).
4. Remove actuating piston assembly (14).
5. Disassemble actuating piston assembly (14) by the following:
  - a. Remove O-ring (15) and four O-rings (16) from actuating piston (17).
  - b. Remove plug assembly (18) and disassemble by removing strainer retainer (19) and felt strainer (20) from plug (21).



6. Remove two check valve assemblies (22) from body (28).
7. Disassemble two check valve assemblies (22) by removing two retaining rings (23), check valves (24), and springs (25) from capnuts (26).
8. Remove choke plug (27) from body (28).

---

**4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⌚ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⌚ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

9. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of body (28).
10. Use drycleaning solvent and clean metal parts. Dry with compressed air.
11. Inspect metal parts for cracks, breaks, cuts, or other damage.
12. Check that springs (3) and (25) are not rusted or distorted or have taken a permanent set.
13. Replace damaged parts.
14. Refinish faces of check valves (24) by lapping on a piece of 600 grit emery paper.

**CAUTION**

**Do not use metallic tools to clean chokes. The use of metallic tools will change size of chokes, resulting in failure of brake valve system.**

**NOTE**

**To avoid misplacement of chokes, remove and replace one choke plug at a time.**

15. Clean, inspect, and repair chock plug (27) by the following:
  - a. Place chock plug (27) in drycleaning solvent.
  - b. Inspect chock plug (27) passage for cleanliness. Use compressed air and remove foreign matter.

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**4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR (cont)**

- c. Remove choke plug (27) from drycleaning solvent and dry with compressed air. Check that choke plug is clean and unrestricted.
  - d. Lightly coat threads of choke plug (27) with compound consisting of one part powder graphite and two parts lubricating oil.
16. Use pneumatic grease and lubricate O-rings, O-ring grooves in spool valves, and bushings into which spool valves enter. Use a clean wiping rag and remove excess lubricant.

**ASSEMBLY****WARNING**

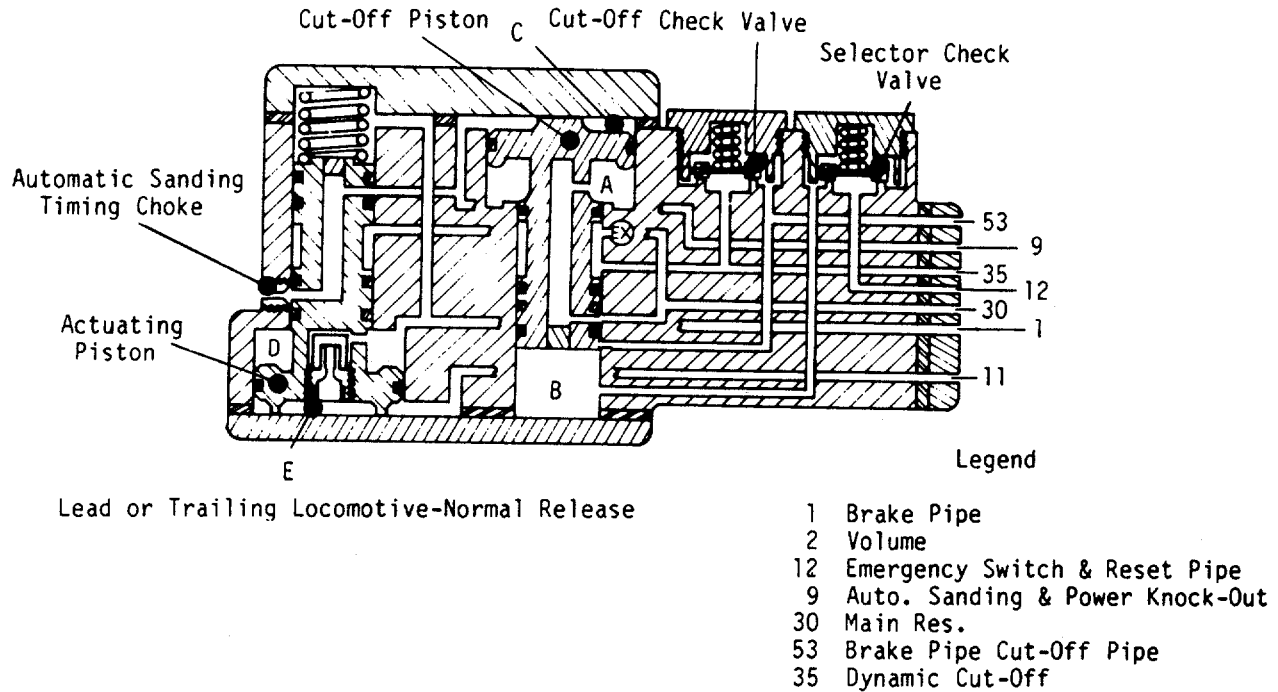
**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

17. Install choke plug (27) in body (28).
18. Assemble two check valve assemblies (22) by installing two springs (25), check valves (24), and retaining rings (23) in capnuts (26).
19. Install two check valve assemblies (22) in body (28).
20. Assemble actuating piston assembly (14) by the following:
  - a. Install four O-rings (16) and O-ring (15) on actuating piston (17).
  - b. Position felt strainer(20) on plug (21) and install strainer retainer (19).
  - c. Install plug assembly (18) in actuating piston (17) and tighten.
21. Install actuating piston assembly (14) in body (28). Install gaskets (13) and (12).
22. Position bottom cover (11) and install two bolts (10).
23. Assemble cutoff piston assembly (6) by installing four O-rings (8) and O-ring (7) on cutoff valve (9).
24. Install cutoff piston assembly (6) and gasket (5).
25. Position gasket (4), spring (3), and top cover (2) and install ~~two~~ bolts (1).

4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)

TEST

26. Test the A-1 charging cutoff valve in accordance with New York Air Brake Company Test Specification NYT-560-C. The A-1 charging cutoff pilot valve functions as follows:



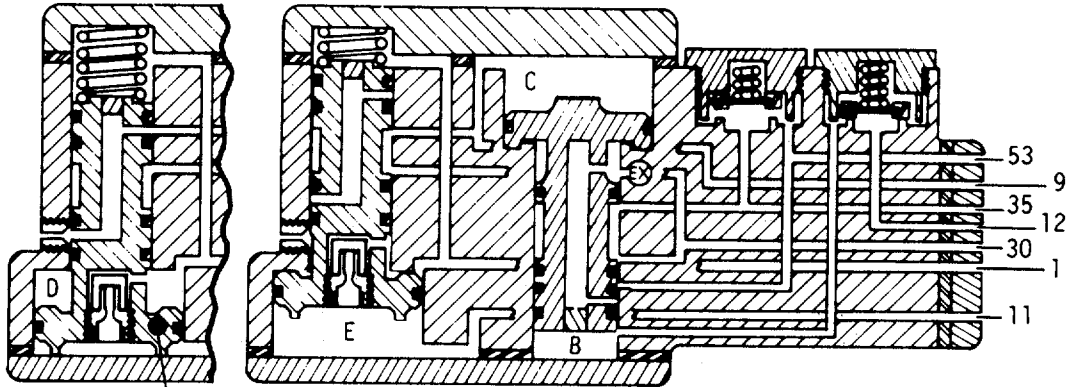
Lead or Trailing Locomotive-Normal Release

- a. During normal brake operation, the A-1 charging cutoff pilot valve will be in its normal position as follows:
- (1) Main reservoir air will be present in chamber A, beneath the cutoff piston head to hold it in its upper position. Chamber B beneath the cutoff piston spool valve will be connected to exhaust via port 30 and the cutoff pilot valve exhaust in the automatic brake valve on leading units.
  - (2) Chamber C, above the cutoff piston and port 9, is connected to exhaust via the actuating piston spool valve and automatic sanding timing choke.
  - (3) Brake pipe flows through port 1 to chamber D surrounding the back side of the actuating piston, through the choke in the piston to chamber E at the outer face of the piston, and through port 11 to the 90-cubic-inch (1475 cc) volume reservoir, charging the volume reservoir and both sides of the actuating piston to brake pipe pressure.
  - (4) Port 35 and the chamber beneath the dynamic cutout switch are exhausted through the cutoff piston spool valve.

## 4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)

## TEST (cont)

- b. When a break-in-two occurs, the A-i charging cutoff pilot valve functions as follows:



Actuating Piston Position After  
#11 Pipe Volume Reservoir Exhausts  
Though Timing Choke

## Lead Locomotive-Break-In-Two Emergency

- (1) Brake pipe pressure drops faster from chamber D than it can from chamber E via the choke. The resultant pressure differential across the actuating piston causes it and its spool valve to be moved upward against spring loading.
- (2) Main reservoir air is connected through the actuating piston spool valve to chamber C at the outer face of the cutoff piston and also to port 9 and the power cutoff (PCO) switch and sanding reservoir.
- (3) With chamber B beneath the cutoff spool valve normally exhausted, the presence of main reservoir pressure in chamber C at the outer face of the cutoff piston will cause the piston and its spool valve to be forced inward to its lowest position, where chamber A beneath the cutoff piston head is exhausted.
- (4) Main reservoir air is connected through the cutoff piston spool valve 35 and past the unseated cutoff check valve to port 53 and to the brake pipe cutoff valve in the 26-C brake valve.
- (5) Air pressure in the 90-cubic-inch (1475 cc) volume reservoir, port 11, and chamber E beneath the actuating chamber continue to reduce to zero through the piston choke and port 1 to brake pipe exhaust.

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**4-15. A-1 CHARGING CUTOFF PILOT VALVE (cont)**

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**TEST (cont)**

- (6) When the pressure has been reduced to a predetermined value, spring tension will move the actuating piston and its spool valve to the lowest position.
  - (7) Air pressure in the sanding reservoir will then exhaust through the automatic sanding timing choke via port 9 and the actuating piston spool valve. Air pressure likewise exhausts from chamber C at the outer face of the cutoff piston.
- c. When the 26-C brake valve handle is moved to EMERGENCY position to reset, the A-1 charging cutoff pilot valve functions as follows:
- (1) Main reservoir air is connected to port 12 from the brake valve and flows past the unseated selector check valve to chamber B beneath the cutoff piston to force the cutoff piston and its spool valve upward to their normal release position.
  - (2) Pipe 53 pressure, supplied with air flow from port 12, cannot be dissipated through the cutoff pilot valve at the brake valve.
  - (3) The brake valve handle must be moved to RELEASE position before the pipe 53 air pressure can be drained and the brakes release. A slight inherent delay in releasing the brakes has been introduced with the use of this arrangement of break-in-two protection.

**4-16. H-5 RELAY AIR VALVE**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Pneumatic grease (Item 18, Appendix B)  
 Wiping rags (Item 32, Appendix B)

Test Equipment

AB test rack  
 RA-47C pipe bracket  
 Diaphragm cock N-5523 (2)  
 Diaphragm cock 179-TA (3)  
 Diaphragm cock N-6911 (6)  
 Cutout cock N-2593  
 Single-pointer air gage N-1796 (4)

Equipment Condition  
Condition Description

Reference

Para 3-51

H-5 relay air valve removed

**DISASSEMBLY**

**WARNING**

Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.

**NOTE**

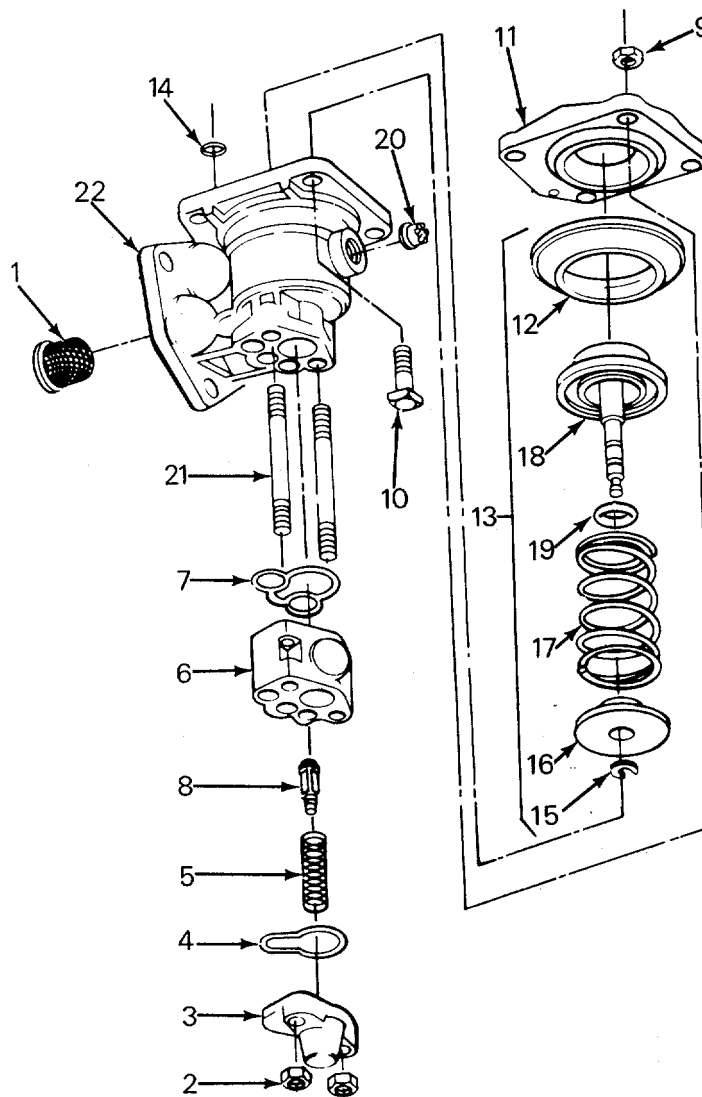
- ⌚ The H-5 relay air valve provides for automatic brake release on the locomotive, independent of the train brakes.
- ⌚ When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove three strainers (1) from body (22).
2. Remove two nuts (2) and remove cover (3), gasket (4), spring (5), check valve body (6), and gasket (7).

4-16. H-5 RELAY AIR VALVE (cont)

DISASSEMBLY (cont)

3. Remove supply valve (8) from check valve body (6).
4. Remove four nuts (9) and bolts (10) and remove cover (11), diaphragm (12), follower unit assembly (13), and gasket (14).
5. Disassemble follower unit assembly (13) by the following:
  - a. Use a vise and compress follower unit assembly (13).



- b. Remove retainer (15), seat (16), and spring (17) from follower (18).
  - c. Remove O-ring (19) from stem of follower (18).
6. Remove chock plug (20) from body (22). Remove two studs (21) from body.



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**4-16. H-5 RELAY AIR VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⓘ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
  - ⓘ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**
7. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of check valve body (6) and body (22).
  8. Use drycleaning solvent and cleaning metal parts. Dry with compressed air.
  9. Clean, inspect, and repair choke plug (20) by the following:
    - a. Place choke plug in drycleaning solvent.
    - b. Inspect chokeplug passage for cleanliness. Use compressed air and remove foreign matter.
    - c. Remove choke plug from drycleaning solvent and dry with compressed air. Check that choke plug is clean and unrestricted.
    - d. Lightly coat threads of choke plug with compound consisting of one part graphite and two parts oil and install.
  10. Inspect metal parts for cracks, breaks, cuts, or other damage.
  11. Check that springs (5) and (17) has not rusted, become distorted, or have taken a permanent set.
  12. Replace damaged parts.
  13. Use pneumatic grease and lubricate O-rings, O-ring grooves in spool valves, and bushings into which spool valves enter. Use a clean wiping rag and remove excess lubricant.

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**4-16. H-5 RELAY AIR VALVE (cont)**

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**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

14. Install two studs (21) and chock plug (20) in body (22).
15. Assemble follower unit assembly (13) by the following:
  - a. Install O-ring (19) on stem of follower (18).
  - b. Position spring (17) and seat (16) on follower (18). Use a vise, compress spring, and install retainer (15).
  - c. Position diaphragm (12) on follower (18) with the diaphragm heavy bead up.
16. Install follower unit assembly (13) with diaphragm (12) in body (22). Check that bead of diaphragm is in bead groove of body.
17. Install gasket (14).
18. Install cover (11) and secure with four bolts (10) and nuts (9).
19. Install supply valve (8) in check valve body (6).
20. Install gasket (7) on check valve body (6).
21. Install check valve body (6) on body (22).
22. Install spring (5) on supply valve (8).
23. Position gasket (4) on cover (3), position cover on body (22), and install two nuts (2).
24. Install three strainers (1) in body (22).

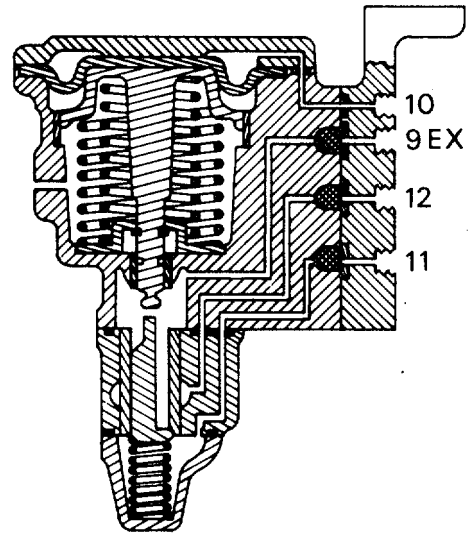
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**4-16. H-5 RELAY AIR VALVE (cont)**

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**TEST**

25. Test the H-5 relay air valve in accordance with New York Air Brake Company Test Specification NYT-408-C. The H-5 relay air valve functions as follows:
- a. When control port 10 is not pressurized, the diaphragm and spool valve are held in the upper position by a return spring. Non of the ports are in communication at this time.
  - b. When control port 10 is pressurized sufficiently to move the spool against the force of the return spring, port 11 is in communication with port 9, which is exhausted. Port 12 is still blocked off.



**4-17. EMERGENCY BRAKE VALVE**

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |

**INITIAL SETUP**

Tools

Tool kit SC4940-97-CL-E12

Equipment Condition Reference

Para 3-52

Material/Parts

Drycleaning solvent (Item 34, Appendix B)  
 Brake cylinder grease (Item 15, Appendix B)  
 Valve set 5330-00-366-2420; P/N 92273 (82772)

Condition Description

Emergency brake valve removed

**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

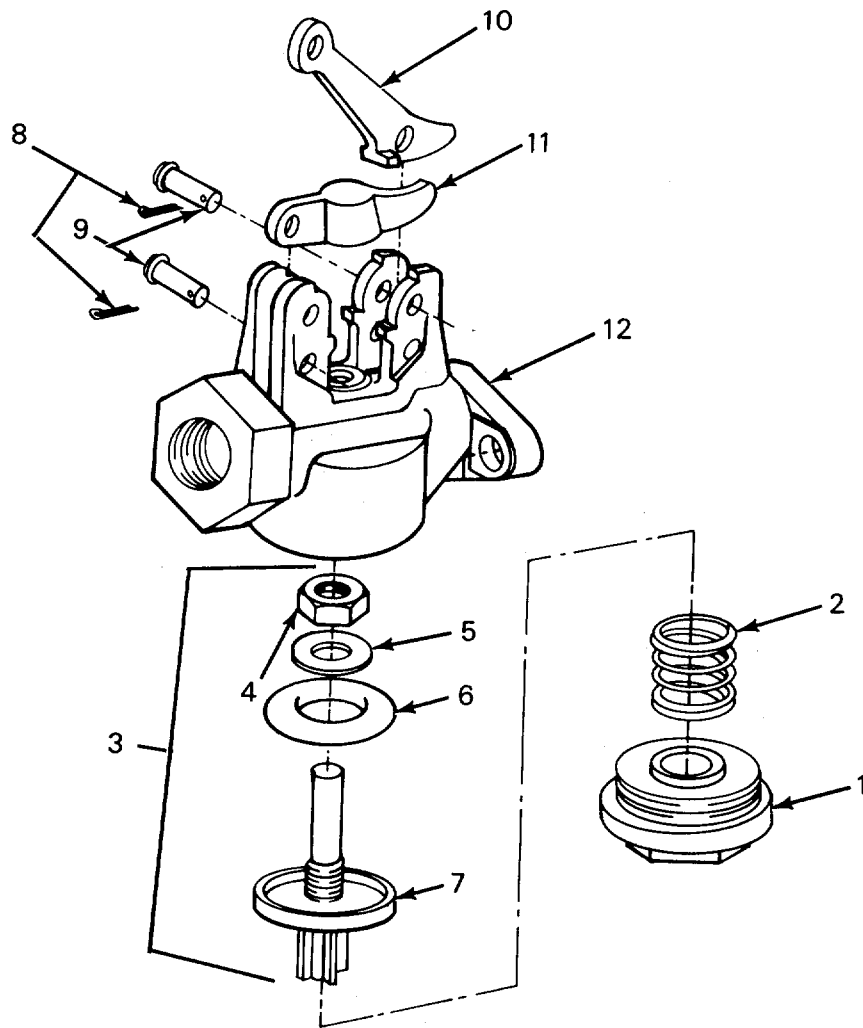
**NOTE**

**When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Remove capnut (1), spring (2), and vent valve assembly (3).
2. Remove nut (4), flat washer (5), and valve seat (6) from valve (7).
3. Remove two cotter pins (8) and pins (9).
4. Remove operating lever (10) and valve lever (11) from body (12).

4-17. EMERGENCY BRAKE VALVE (cont)

DISASSEMBLY (cont)



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**4-17. EMERGENCY BRAKE VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- ⚠ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- ⚠ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

5. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of body (12).
6. Use drycleaning solvent and clean metal parts. Dry with compressed air.
7. Inspect metal parts for cracks, breaks, cuts, or other damage.
8. Check that spring (2) has not rusted, become distorted, or has taken a permanent set.
9. Check that valve (7) and valve stem are not bent.
10. Replace damaged parts. Discard valve seat (6) and cotter pin (8) and replace with new valve seat and cotter pins.
11. Use brake cylinder lubricant and lubricate pins (9), upper and lower parts of valve stem, and spring (2).

**ASSEMBLY****WARNING**

**Valve assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

12. Position valve lever (11) and operating lever (10) on body (12). Install two pins (9) and cotter pins (8).

---

**4-17. EMERGENCY BRAKE VALVE (cont)**

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**ASSEMBLY (cont)**

13. Assemble vent valve assembly (3) by the following:
  - a. Install valve seat (6) on valve (7).
  - b. Install flat washer (5) and nut (4).
14. Install vent valve assembly (3) in body (12).
15. Position spring (2), and install capnut (1).

**TEST**

16. Test the emergency brake valve in accordance with New York Air Brake Company Test Specification T-1063.

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**4-18. STRAINER AND CHECK VALVE**

---

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |
- 

INITIAL SETUP

Tools

Tool kit SC4940-97-CL-E12  
Filter curled hair (734877)

Reference

Para 3-53

Material/Parts

Drycleaning solvent (Item 34, Appendix B)

Equipment Condition  
Condition Description

Strainer and check valve removed

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**DISASSEMBLY**

**WARNING**

**Valve assemblies are under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.**

**NOTE**

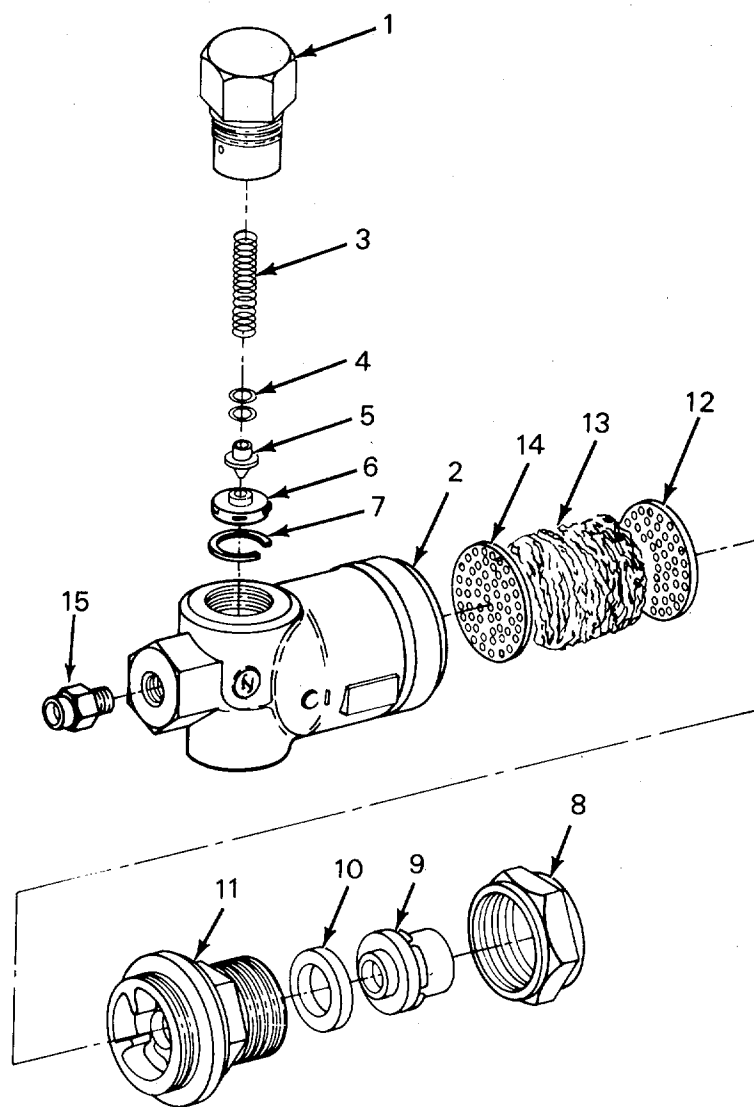
**When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.**

1. Remove capnut (1) from body (2).
2. Remove snapping (3), check valve (4), spring seat (5), two shims (6), and spring (7) from capnut (1).
3. Remove nut (8), swivel (9), and gasket (10) from capnut (11).



4-18. STRAINER AND CHECK VALVE(cont)

DISASSEMBLY (cont)



4. Remove capnut (11), strainer (12), air filter (13), and strainer (14) from body (2).
5. Remove choke fitting (15).

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**4-18. STRAINER AND CHECK VALVE (cont)**

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**CLEANING, INSPECTION, AND REPAIR****WARNING**

- Ⓢ **Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 - 138°F (38 - 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.**
- Ⓢ **Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.**

6. Use a cloth dampened with drycleaning solvent and remove grease and oil from exterior and interior of body (2).
7. Use drycleaning solvent and clean metal parts. Dry with compressed air.
8. Inspect metal parts for cracks, breaks, cuts, or other damage. Inspect for damaged threads.
9. Check that spring (7) has not rusted, become distorted, or has taken a permanent set.
10. Replace damaged parts. Replace air filter (13).

**ASSEMBLY****WARNING**

**Valves assemblies are under a spring load. Use caution during assembly procedures so that no parts fly out, causing injury to personnel.**

11. Install choke fitting (15).
12. Position strainer (14), air filter (13), and strainer (12) and install capnut (11).
13. Install gasket (10) on swivel (9) and install in capnut (11). Install nut (8).

---

**4-18. STRAINER AND CHECK VALVE (cont)**

---

**ASSEMBLY (cont)**

14. Install spring (7), two shims (6), spring seat (5), and check valve (4) in cap nut (11). Install snapping (3).
15. Install cap nut (1).

**TEST**

16. Test strainer and check valve in accordance with New York Air Brake Company Test Specification T-1660.

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**4-19. CUTOUT COCK AND STRAINER**


---

This task covers:

- |                |               |             |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Assembly |
| b. Cleaning    | d. Repair     | f. Test     |
- 

**INITIAL SETUP**
**Tools**

Tool kit SC4940-97-CL-E12

**Material/Parts**

Drycleaning solvent (Item 34, Appendix B)  
Filter 569146

**Equipment Condition  
Reference**

Para 3-55

**Condition Description**

Cutout cock and strainer removed

---

**DISASSEMBLY**
**WARNING**

Valve assemblies may be under a spring load. Use caution during disassembly procedures so that no parts fly out, causing injury to personnel.

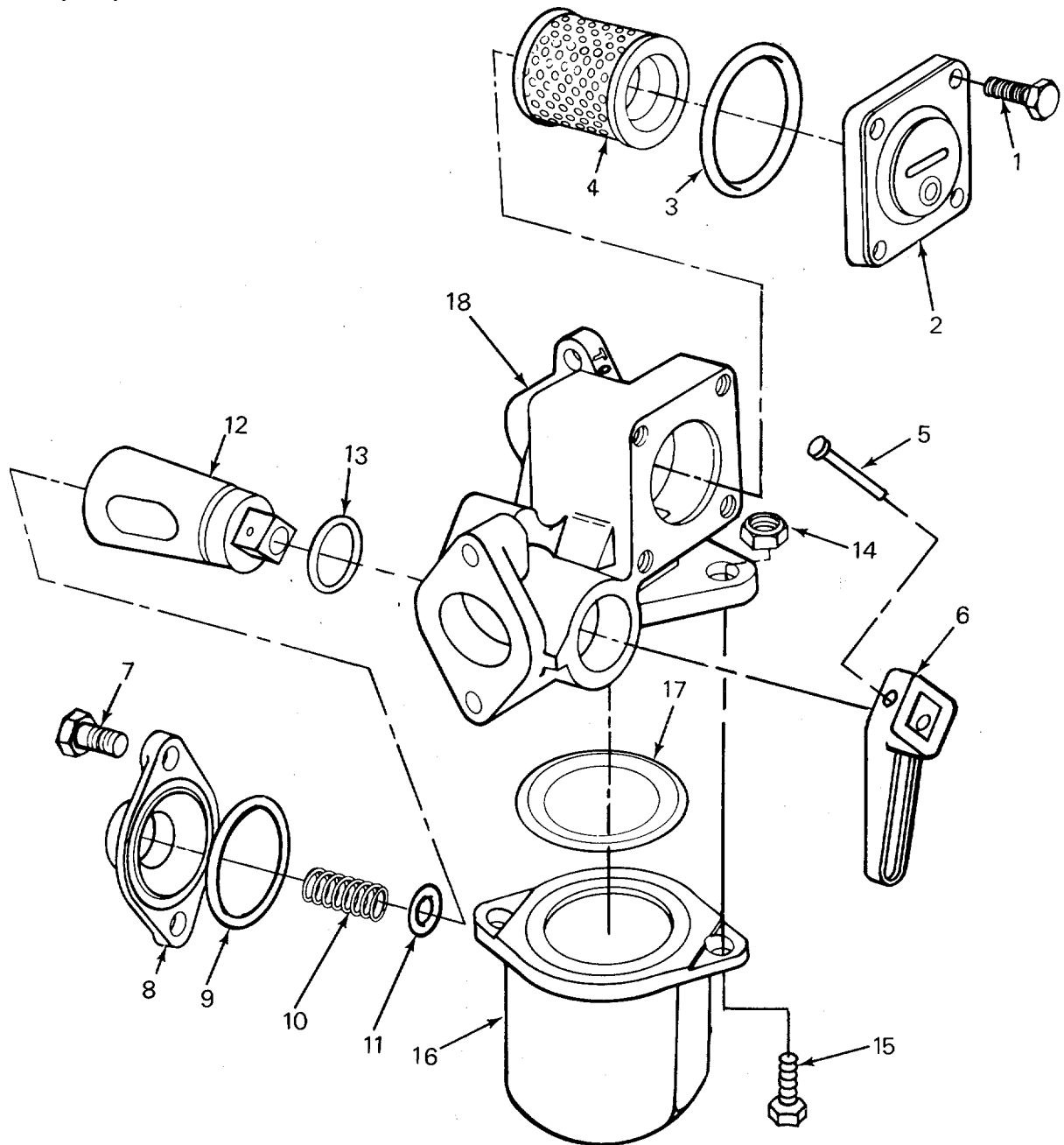
**NOTE**

When removing or repairing brake valves or components, check air lines and pipes for corrosion, brakes, splits, or loose connections. Repair of air lines and piping consists of replacing defective pipes, lines, and connections. Refer to TM 55-2210-224-24P for identification of piping.

1. Remove four bolts (1), strainer cover (2), gasket (3), and filter (4).
2. Remove pin (5) and handle (6).

## 4-19. CUTOUT COCK AND STRAINER

## DISASSEMBLY (cont)



3. Remove two bolts (7), cover (8), gasket (9), spring (10), flat washer (11), key (12), and O-ring (13).

4. Remove two nuts (14), bolts (15), sump cover (16), and gasket (17) from body (18).

---

## 4-19. CUTOUT COCK AND STRAINER

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### CLEANING, INSPECTION, AND REPAIR

#### WARNING

- Drycleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use only in a well-ventilated area. Avoid contact with skin, eyes, and clothes and don't breathe vapors. Do not use near open flame or excessive heat. The flash point is 100 138°F (38 59°C). If you become dizzy, get fresh air and medical aid immediately. If contact with eyes is made, wash your eyes and get medical aid immediately.
- Compressed air used for cleaning purposes will not exceed 30 psi (207 kPa). Do not direct compressed air against skin. Use goggles or full face shield.

5. Use a cloth dampened in drycleaning solvent and remove grease and oil from exterior and interior of body (18).
6. Use drycleaning solvent and clean metal parts. Dry with compressed air.
7. Inspect metal parts for cracks, breaks, cuts, or other damage.
8. Check that spring (10) has not rusted, become distorted, or has taken a permanent set.
9. Replace damaged parts. Replace filter (4).

#### ASSEMBLY

10. Position gasket (17) on sump cover (16). Position body (18) and install two bolts (15) and nuts (14).
11. Install O-ring (13) on key (12) and install key in body (18).
12. Install flat washer (11) and spring (10) on key (12).
13. Position gasket (9) on cover (8). Position cover on body (18) and install two bolts (7).
14. Position handle (6) and install pin (5).
15. Install filter (4) in body (18).
16. Position gasket (3) on strainer cover (2). Position cover on body (18) and install four bolts (1).

## APPENDIX A

### REFERENCES

#### A-1. SCOPE

This appendix lists all forms, field manuals, technical bulletins, technical manuals and miscellaneous publications referenced in this manual.

#### A-2. ADMINISTRATIVE PUBLICATIONS

- |                     |   |
|---------------------|---|
| a. <u>Pamphlet.</u> |   |
| DA PAM 738-750      | The Army Maintenance Management System (TAMMS)          |
| b. <u>Forms.</u>    |   |
| DA Form 2028        | Recommended Changes to Publications and Blank Forms     |
| DA Form 2028-2      | Recommended Changes to Equipment Technical Publications |
| DA Form 2404        | Equipment Inspection and Maintenance Work Sheet         |
| DA Form 2407        | Maintenance Request                                     |
| DA Form 2408        | Equipment Log Assembly                                  |
| DA Form 2410        | Component Removal and Repair/Overhaul Record            |
| FRA Form 6180-49A   | Locomotive Inspection and Repair Record                 |
| SF 364              | Report of Discrepancy (ROD)                             |
| SF 368              | Quality Deficiency Report                               |

#### A-3. SPECIFICATIONS AND STANDARDS

- |                                    |  |
|------------------------------------|--|
| a. <u>Military Specifications.</u> |  |
| MIL-I-45607<br>Equipment           | Acquisition, Maintenance, and Disposition of Inspecti  |
| MIL-P-53044                        | Painting and Marking: Freight and Maintenance Cars; Railway Motive<br>Power and Work Equipment |
| b. <u>Military Standards.</u>      |  |
| MIL-STD-120                        | Gage Inspection  |
| MIL-STD-45662                      | Calibration Systems Requirements   |

**A-4. TECHNICAL PUBLICATIONS**

a. Bulletins.

TB 55-2200-207-15/1

Inspection and Maintenance Checklist for Diesel-Electric Locomotives

b. Manuals.

CFR-49

Code of Federal Regulations

FM 21-11

First Aid for Soldiers

TM 5-2815-233-14

Unit, Intermediate Direct Support, and Intermediate General Support Maintenance Manual, Diesel Engine, 670 HP, Model NT-8554-L4, Cummins Engine Company

TM 5-2815-233-24P

Unit, Intermediate Direct Support, and Intermediate General Support Maintenance Manual and Repair Parts and Special Tools List, Diesel Engine, 670 HP, Cummins Model NTA 855-L4.

TM 9-237

Welding Theory and Application

TM 9-6140-200-14

Operator, Organizational, Direct Support, and General Support Maintenance Manual for Lead-Acid Storage Batteries

TM 43-0139

Painting Instructions for Field Use

TM 55-2210-224-12

Operator and Unit Maintenance Manual, Locomotive, Diesel-Electric, 56-1/2-inch gage, 80 Ton, 670 HP, 0-4-4-0 Wheel, Model B-B-160/160-4GE747-A1, NSN 2210-01-158-2980

TM 55-2210-224-24P

Unit, Intermediate Direct Support, and Intermediate General Support Maintenance Repair Parts and Special Tools Lists, Locomotive, Diesel-Electric, 56-1/2-inch gage, 80-Ton, 670 HP, 0-4-4-0 Wheel, Model B-B-160/160-4GE747-A1 NSN 2210-01-159-2980

c. Lubricating Order.

LO 55-2210-224-12

Locomotive, Diesel-Electric, 56-1/2-inch gage, 80 Ton, 670 HP, 0-4-4-0 Wheel, Model B-B-160/160-4GE747-A1, NSN 2210-01-158-2980



**APPENDIX B****EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST****Section I. INTRODUCTION****B-1. SCOPE**

This listing is for information purposes only and is not authority to requisition the listed items. These items are authorized to you by CTA 50-970 or CTA 8-100, Expendable/Durable Items (Except Medical, Class V, Repair Parts, and Heraldic Items).

**B-2. EXPLANATION OF COLUMNS**

a. Column 1 - Item Number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material, e.g., Use drycleaning solvent (item 34, app B).

b. Column 2 - Category. This column identifies the lowest category of maintenance that requires the listed item.

F - Intermediate Direct Support Maintenance  
H - Intermediate General Support Maintenance

c. Column 3 - National Stock Number. This is the National Stock Number assigned to the item; use it to request or requisition the item.

d. Column 4 - Description. Indicates the Federal item name and, if required, a description to identify the item. The last line of each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses, followed by the part number.

e. Column 5 - Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two character alphabetical abbreviation (e.g., ea, in., pr). A V in this column indicates that the amount used will vary. If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

## Section II. EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) Item No.	(2) Category	(3) National Stock Number	(4) Description	(5) U/M
1	F	8040-00-144-9774	Adhesive, Silicone, Rubber (81349) MIL-A-46146	oz
2	F	6850-00-181-7940	Antifreeze, Ethylene Glycol, Inhibited (81349) MIL-A-46153	gl
3	F	5306-00-804-6063	Bolt, Eye 1 X 5 X 1 inch (81348) 73715-05XIPCII	ea
4	F	7930-00-664-6910	Cleaner, Glass (81349) A-A-40	bx
5	H	5350-00-174-0992	Cloth, Abrasive, Emery (58536) A-A-1200	ea
6	H	8030-00-753-4953	Compound, Antiseize, Mica Base (81349) MIL-A-13881	lb
7	F	6850-00-664-7530	Compound, Cleaning, Alkali (81349) P-C-436	dr
8	F	5350-00-197-9461	Compound, Lapping, 1000 Grit (87742) 1000	cn
9	F	8030-01-025-1692	Compound, Sealing (81349) MIL-S-46163	cc
10	F	6830-00-682-6839	Dioxide, Carbon (dry ice) (81348) BB-C-IO11B	lb
11	F	8010-00-852-9034	Enamel, Alkyd, Gloss Gray (81348) TT-E-489	pt
12	H		Graphite, Powder	
13	F	9150-00-190-0904	Grease, Automotive and Artillery GAA (81349) MIL-G-10924	lb
14	F		Grease, Ball and Roller Bearing, BB (93508) RA-71005	
15	F		Grease, Brake Cylinder, CC (59595) AAR-M-914-70	
16	F	9150-00-272-7652	Grease, Graphite, GG-1 (81348) VV-G-671	lb

Section II. EXPENDABLE SUPPLIES AND MATERIALS LIST (continued)

(1) Item No.	(2) Category	(3) National Stock Number	(4) Description	(5) U/M
17	H		Grease, Lime Base	
18	F	9150-00-269-8255	Grease, Pneumatic System GPS 1.75-lb (0.79 kg) pail (81349) MIL-G-4343	lb
19	F	8010-00-873-9315	Lacquer, Clear Acrylic (87187) TT-L-50	oz
20	F		Lubricant, Graphite, DD (93508) 72777	ea
21	H		Lubricating Oil, Engine OE/HDO (81349) MIL-L-2104	
			Grade 10	
		9150-00-189-6727	1-qt (0.95 L) can	qt
			Grade 30	
		9150-00-189-6729	55-gal (208.2 L) drum	gl
22	F		Lubricating Oil, Gear, Multi- Purpose, GO (81349) MIL-L-2105	
			Grade 90	
		9150-01-035-5393	5-gal (18.93 L) can	gl
			Grade 140	
		9150-01-035-5395	5-gal (18.93 L) can	gl
23	F	5510-00-220-6226	Lumber, 4 X 4, 16 ft (81348) MM-L-751	ft
24	F	9150-00-252-6174	Oil, Lubricating, General-Purpose (81348) VV-L-820	qt
25	F		Oil, Lubricating, Railway Car and Locomotive AA (59595) 57-40W	gl
26	F		Oil, Triple Valve	qt

## Section II. EXPENDABLE SUPPLIES AND MATERIALS LIST (continued)

(1) Item No.	(2) Category	(3) National Stock Number	(4) Description	(5) U/M
27	F		Paint	
		8010-00-297-0591	Black, Polyurethane (09869) 48A-27038-66	gl
		8010-00-664-4761	White, Enamel (81348) TT-E-489	gl
		8010-00-286-7758	Yellow, Enamel (81348) TT-E-489	gl
28	F	8010-00-297-0591	Paint, Rubberized Insulating Epoxy (09861)	gl
29	F		Paper, Insulating	
30	F	8110-00-551-0128	Pigment, Iron Blue Marking (81348) TT-P-381	oz
31	F	4710-00-003-0093	Pipe, 3-inch ID, 15 ft (81346) ASTM A120	ft
32	F	7920-00-205-3570	Rags, Wiping, Cotton, General- Purpose, class 2, grade 2	be
33	F	3439-01-026-1084	Solder, Tin Alloy (81348) QQ-S-571	lb
34	F	6850-00-281-1985	Solvent, Drycleaning, SD-II (81348) P-D-680	gl
35	H	8030-00-889-3534	Tape, Antiseize, Polytetra- fluoroethylene, Class 1 (81349) MIL-T-27730	yd
36	F	5970-00-955-9976	Tape, Electrical, Pressure Sensitive (07099) MS70T09-S	
37	F	5970-00-785-4098	Varnish, Insulating, Electrical (red) (81349) MIL-I-204092	oz
38	F	9505-00-221-2650	Wire, Nonelectrical, Safety (96906) MS20995C20	lb

**APPENDIX C**

**ILLUSTRATED LIST OF MANUFACTURED ITEMS**

There are no intermediate direct support or intermediate general support manufactured items on the 80-ton Diesel-electric locomotive

**C-1/(C-2 blank)**

## APPENDIX D

### TORQUE LIMITS

#### D-1. GENERAL

This section provides general torque limits for screws used on the locomotive. Special torque limits are indicated in the maintenance procedures for applicable components. The general torque limits given in this appendix shall be used when specific torque limits are not indicated in the maintenance procedure. These general torque limits cannot be applied to screws that retain rubber components. The rubber components will be damaged before the correct torque limit is reached. If a special torque limit is not given in the maintenance instructions, tighten screw or nut until it touches the metal bracket then tighten it one more turn.

#### D-2. TORQUE LIMITS

Table D-1 lists dry torque limits. Dry torque limits are used on screws that do not have lubricants applied to the threads. Table D-2 lists wet torque limits. Wet torque limits are used on screws that have high-pressure lubricants applied to the threads.

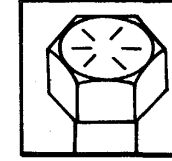
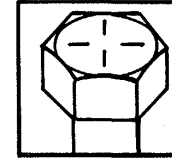
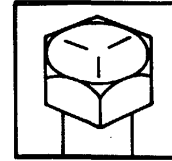
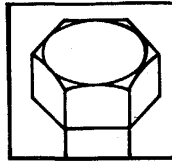
#### D-3. HOW TO USE TORQUE TABLE

- a. Measure the diameter of the screw you are installing.
- b. Count the number of threads per inch.
- c. Under the heading SIZE, look down the left-hand column until you find the diameter of the screw you are installing (there will usually be two lines beginning with the same size).
- d. In the second column under SIZE, find the number of threads per inch that matches the number of threads you counted in step b.
- e. To find the grade screw you are installing, match the markings on the head to the correct picture of CAPSCREW HEAD MARKINGS on the torque table.
- f. Look down the column under the picture you found in step e. until you find the torque limit (in lb-ft or N.m) for the diameter and threads per inch of the screw you are installing.

Table D-1. Torque Limits for Dry Fasteners

CAPSCREW HEAD MARKINGS

Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).



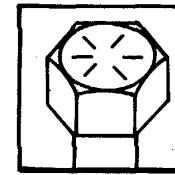
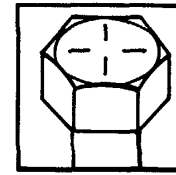
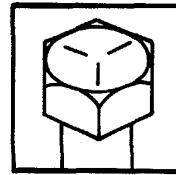
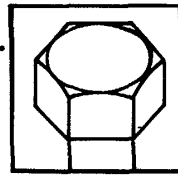
TORQUE

SIZE			TORQUE							
DIA INCHES	THREADS PER INCH	MILLIMETERS	SAE GRADE NO. 1 or 2		SAE GRADE NO. 5		SAE GRADE NO. 6 or 7		SAE GRADE NO. 8	
			POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS
1/4	20	6.35	5	6.78	8	10.85	10	13.56	12	16.27
1/4	28	6.35	6	8.14	10	13.56	-	-	14	18.98
5/16	18	7.94	11	14.92	17	23.05	19	25.76	24	32.52
5/16	24	7.94	13	17.63	19	25.76	-	-	27	36.61
3/8	16	9.53	18	24.41	31	42.04	34	46.10	44	59.66
3/8	24	9.53	20	27.12	35	47.46	-	-	49	66.44
7/16	14	11.11	28	37.97	49	66.44	55	74.58	70	94.92
7/16	20		30	40.68	55	74.58	-	-	78	105.77
1/2	13	12.70	39	52.88	75	101.70	85	115.26	105	142.38
1/2	20		41	55.60	85	115.26	-	-	120	162.78
9/16	12	14.29	51	69.16	110	149.16	120	162.72	155	210.18
9/16	18		55	74.58	120	162.72	-	-	170	230.52
5/8	11	15.88	63	85.43	150	203.40	167	226.45	210	284.76

Table D-2. Torque Limits for Wet Fasteners

CAPSCREW HEAD MARKINGS

Manufacturer's marks may vary.  
These are all SAE Grade 5  
(3-line).



TORQUE

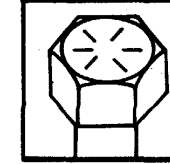
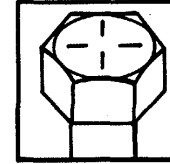
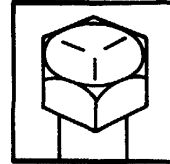
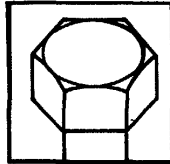
SIZE			SAE GRADE NO. 1 or 2		SAE GRADE NO. 5		SAE GRADE NO. 6 or 7		SAE GRADE NO. 8	
DIA INCHES	THREADS PER INCH	MILLIMETERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS
1/4	20	6.35	4.9	6.10	7.2	9.76	9.0	12.20	10.8	14.64
1/4	28	6.35	5.4	7.33	9.0	12.20	-	-	12.6	17.08
5/16	18	7.94	9.9	13.34	15.3	22.54	17.1	23.18	21.6	29.27
5/16	24	7.94	11.7	15.87	17.1	23.18	-	-	24.3	32.95
3/8	16	9.53	16.2	21.97	27.9	37.84	30.6	41.49	39.6	53.69
3/8	24	9.53	18.0	24.41	31.5	42.71	-	-	44.1	59.80
7/16	14	11.11	25.2	34.17	44.1	59.80	49.5	67.12	63.0	85.42
7/16	20		27.0	36.61	49.5	67.12	-	-	70.2	95.19
1/2	13	12.70	35.1	47.59	67.5	91.53	76.5	103.73	94.5	128.14
1/2	20		36.9	50.04	76.5	103.73	-	-	108.0	146.50
9/16	12	14.29	45.9	62.24	99.0	134.24	108.0	146.45	139.5	189.16
9/16	18		49.5	67.12	108.0	146.45	-	-	153.0	207.47
5/8	11	15.88	56.7	76.89	135.0	183.06	150.3	203.80	189.0	256.28



Table D-1. Torque Limits for Dry Fasteners (continued)

CAPSCREW HEAD MARKINGS

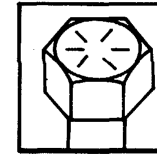
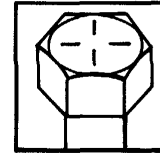
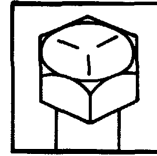
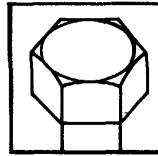
Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).



SIZE			TORQUE							
			SAE GRADE NO. 1 or 2		SAE GRADE NO. 5		SAE GRADE NO. 6 or 7		SAE GRADE NO. 8	
DIA INCHES	THREADS PER INCH	MILLIMETERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS
5/8	18		95	128.82	170	230.52	-	-	240	325.44
3/4	10	19.05	105	142.38	270	366.12	280	379.68	375	508.50
3/4	16		115	155.94	295	400.02	-	-	420	596.52
7/8	9	22.23	160	216.96	395	535.62	440	596.64	605	820.38
7/8	14		175	237.30	435	589.86	-	-	675	915.30
1	8	25.40	235	318.66	590	800.04	660	894.96	910	1233.96
1	14		250	339.00	660	894.96	-	-	990	1342.44
1-1/8	-	25.58	-	-	800-874	1092.0-1193.3	-	-	1280-1440	1735.7-1952.8
1-1/4	-	31.75	-	-			-	-	1820-2000	2467.9-2712.0
1-3/8	-	34.93	-	-	1460-1680	1979.8-2278.1	-	-	2380-2720	3227.3-3688.3
1-1/2	-	38.10	-	-	1940-2200	2630.6-2983.2	-	-	3160-3560	4285.0-4827.4

CAPSCREW HEAD MARKINGS

Manufacturer's marks may vary.  
These are all SAE Grade 5  
(3-line).



TORQUE

SIZE			TORQUE							
DIA INCHES	THREADS PER INCH	MILLIMETERS	SAE GRADE NO. 1 or 2		SAE GRADE NO. 5		SAE GRADE NO. 6 or 7		SAE GRADE NO. 8	
			POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS	POUNDS FEET	NEWTON METERS
5/8	18		85.5	115.94	153.0	207.47	-	-	216.0	296.90
3/4	10	19.05	94.5	128.14	243.0	329.51	252.0	341.71	337.5	457.65
3/4	16		103.5	140.35	265.5	360.02	-	-	378.0	536.87
7/8	9	22.23	144.0	195.26	355.5	482.06	396.0	536.98	544.5	738.34
7/8	14		157.5	213.57	391.5	530.87	-	-	607.5	823.77
1	8	25.40	211.5	286.79	531.0	720.04	594.0	805.46	819.0	1110.56
1	14		225.0	305.10	594.0	805.46	-	-	891.0	1208.20
1-1/8	-	25.58	-	-	720.0- 792.0	976.32- 1073.97	-	-	1152- 1296	1562.13- 1757.52
1-1/4	-	31.75	-	-	-	-	-	-	-	2221.11- 2440.80
1-3/8	-	34.93	-	-	1314.0- 1512.0	1781.82- 2050.29	-	-	2142- 2448	2904.57- 3319.47
1-1/2	-	38.10	-	-	1746.0- 1980.0	2367.54- 2684.88	-	-	2844- 3204	3856.5- 4344.66

D-5/(D-6 blank)

## INDEX

## Subject, Paragraph

## A

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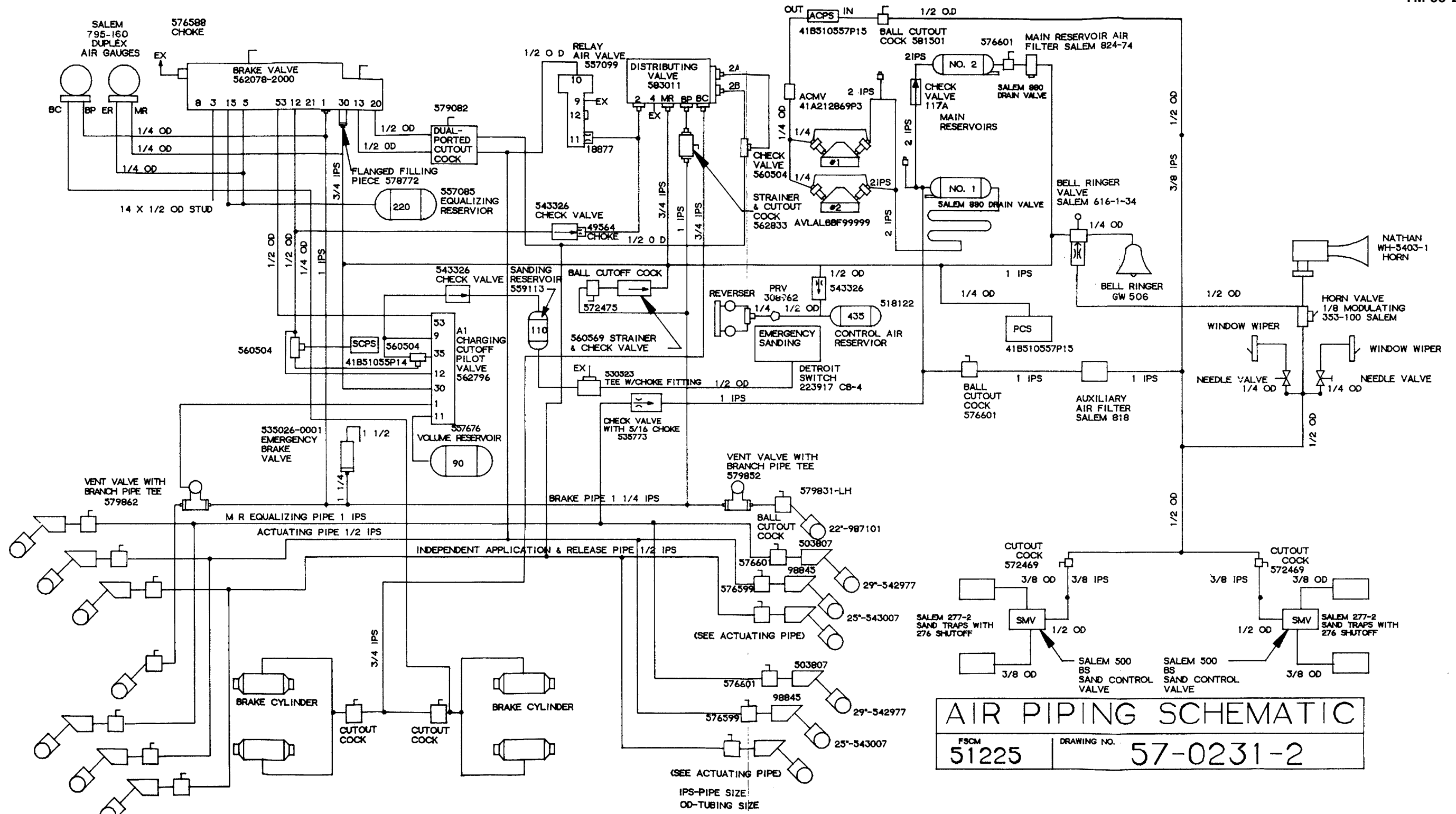
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     Repair, 4-11  
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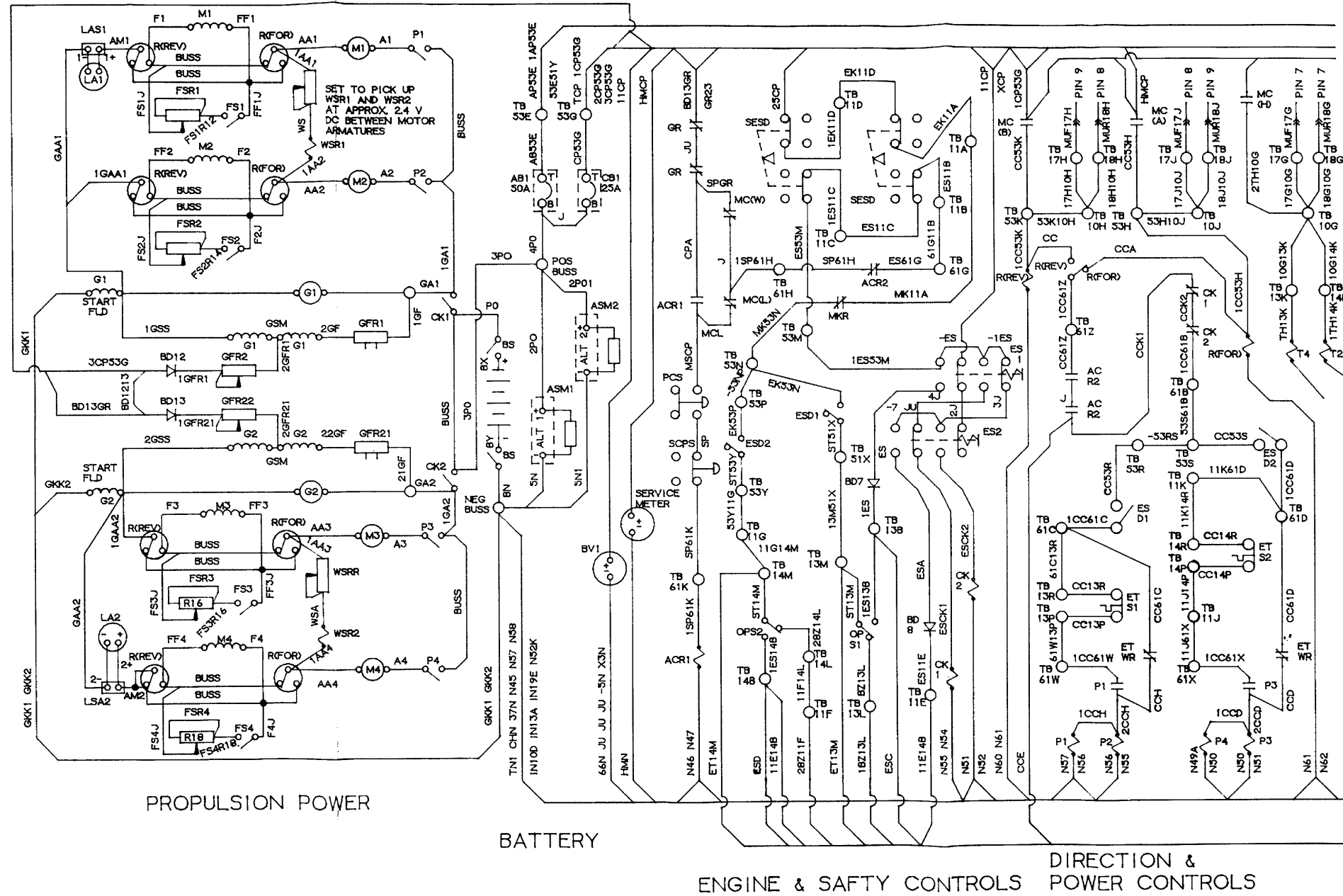
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FO-1 Air Piping Schematic

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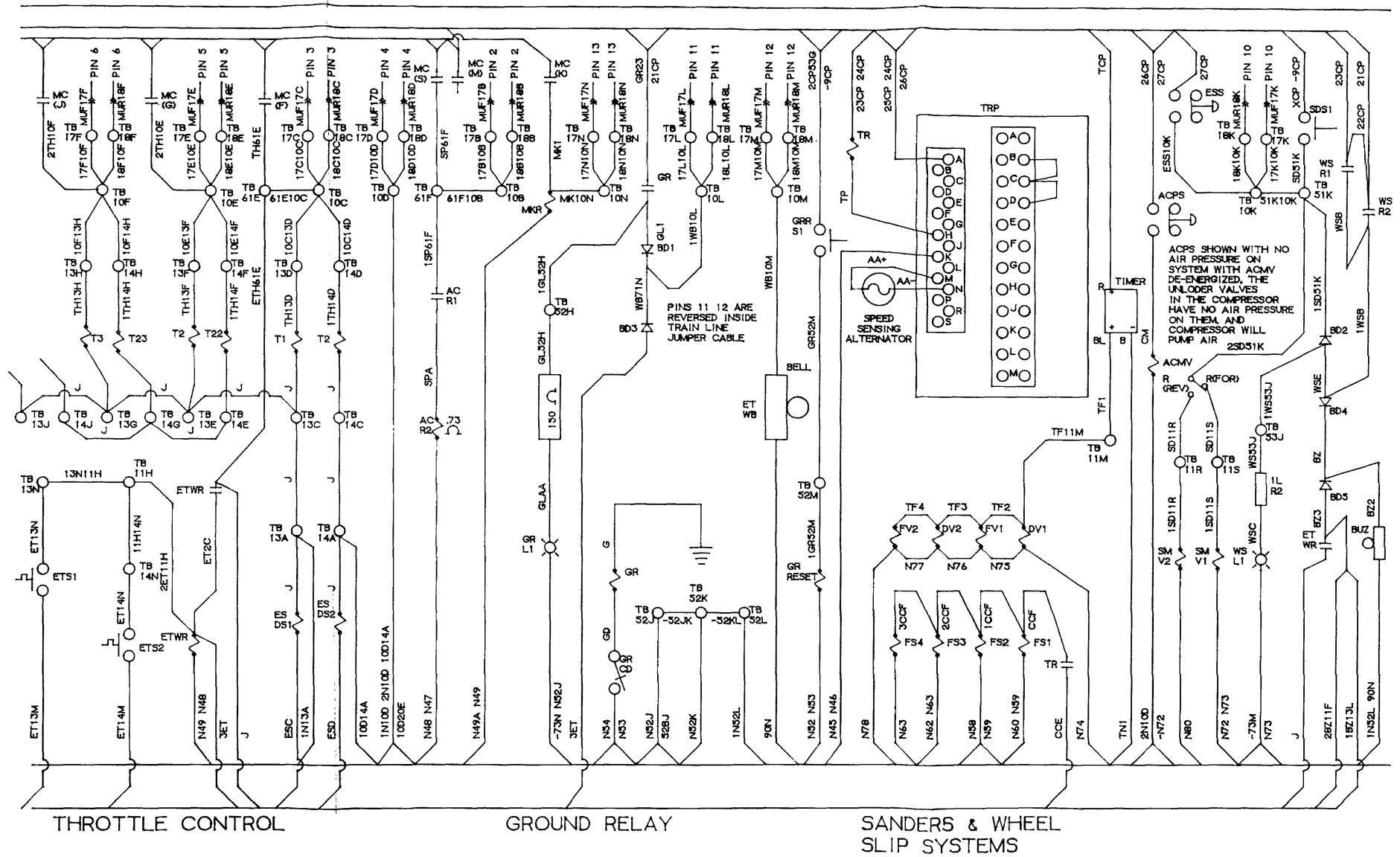
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|--------------------------|----------------------------------|--------------|------------------------------------|
| AB1                      | AUX. CIRCUIT BREAKER             | GLS1,        | GAGE LIGHT SWITCH                  |
| ACMV                     | AIR COMP. MAGNET VALVE           | GRRV 1       | GROUND RELAY RESET SWITCH          |
| ACPS                     | AIR COMP. PRESSURE SWITCH        | GR           | GROUND RELAY                       |
| ARC 1,2                  | SAFETY RELAY                     |              | GROUND RELAY RESET COIL            |
| ALT 1,2                  | ALTERNATOR W/INTERNAL REGULATOR  |              |                                    |
| ASM 1,2                  | ALTERNATOR SUPPR. MODULE         | GRCO         | GROUND RELAY CUTOUT SWITCH         |
| BATT                     | BATTERY, 16 CELL LEAD ACID       | GRL 1        | GROUND RELAY INDICATING LIGHT      |
| BD1,2,3,4,5,7,8,10,12,13 | BLOCKING DIODES                  | HLR 1,2      | HEADLIGHT RESISTOR                 |
| BELS 1                   | BELL VALVE                       | HS1          | HORN VALVE                         |
| BS                       | BATTERY SWITCH                   | ILR1         | INDICATING AND GAGE LIGHT RESISTOR |
| BUZ                      | WARNING BUZZER                   | ILR2         | INDICATING LIGHT RESISTOR          |
| BV1                      | BATTERY VOLTMETER                | J1           | JUMPER FOR MU                      |
| CB1                      | CONTROL CIRCUIT BREAKER          | LA, 1,2      | LOAD METER                         |
| CBL 1,2,3                | CAB LIGHT                        | LAS 1,2      | LOAD AMMETER SHUNT                 |
| CBLs 1,2                 | CAB LIGHT SWITCH                 | M1,2,3,4     | TRACTION MOTOR                     |
| CH 1                     | CAB HEATER                       | MC           | MASTER CONTROLLER                  |
| CK 1,2                   | CRANKING CONTACTOR               | MKR          | MOTOR KILL RELAY                   |
| DV 1,2                   | DUMP VALVE                       | MUHL         | MULTIPLE UNIT HEADLIGHT SWITCH     |
| EH 1,2                   | ENGINE HEATER                    | OPS 1,2      | ENGINE OIL PRESSURE SWITCH         |
| EHR 1,2                  | ENGINE HEATER RECP.              | P1,2,3,4     | MOTOR LINE CONTACTOR               |
| EPG 1,2                  | ENGINE OIL PRESSURE GAGE         | PCS          | PRESSURE CONTROL SWITCH            |
| ES 1,2                   | ENGINE START SWITCH              | R            | REVERSER                           |
| ESD T,2                  | ENGINE STOP SWITCH               | RECP1,2      | RECEPTACLES FOR MU                 |
| ESDS 1,2                 | ENGINE STOP SOLENOID             | RH 1,2       | REAR HEADLIGHT                     |
| ESS                      | EMERGENCY SANDING SWITCH         | RHS1,2       | REAR HEADLIGHT SWITCH              |
| ETG 1,2                  | ENGINE TEMPERATURE GAGE          | SCPS         | SAFETY CONTROL PRESSURE SWITCH     |
| ETS 1,2                  | ENGINE TEMPERATURE SWITCH        | SDS1         | SANDING SWITCH                     |
| ETWD                     | ENGINE TEMPERATURE WARNING RELAY | SESD         | EMERGENCY SHUTDOWN SWITCHATOR      |
| ETWR                     | ENGINE TEMPERATURE WARNING RELAY | SLS1         | STEP LIGHT SWITCH                  |
| FH 1,2                   | FRONT HEADLIGHT                  | SMV1,2       | SANDING MAGNET VALVE               |
| FHS 1                    | FRONT HEADLIGHT SWITCH           | STL1,2,3,4   | STEP LIGHTS                        |
| FS 1,2,3,4               | FIELD SHUNT CONTACTOR            | T1,2,3,4     | FUEL COILS                         |
| FSR 1,2,3,4              | FIELD SHUNT RESISTOR             |              |                                    |
| FV1, 2                   | FILTER VALVE                     | T21,22,23,24 |                                    |
| G1, G2                   | TRACTION GENERATOR               | TR           | FIELD SHUNT TRANSITION RELAY       |
| GFR 1, 21                | GENERATOR FIELD RESISTOR         | TRP          | TRANSITION PANEL                   |
| GFR 2, 22                | GENERATOR FIELD RESISTOR         | WLS1         | WARNING LIGHT SWITCH               |
| GL                       | GAGE LIGHT                       | WSL1         | WHEELSLIP INDICATING LIGHT         |
|                          |                                  | WSR1,2       | WHEELSLIP RELAY                    |
|                          |                                  | WSRR         | WHEELSLIP RESISTOR PANEL           |



FO-2 Electrical Schematic (1 of 3)  
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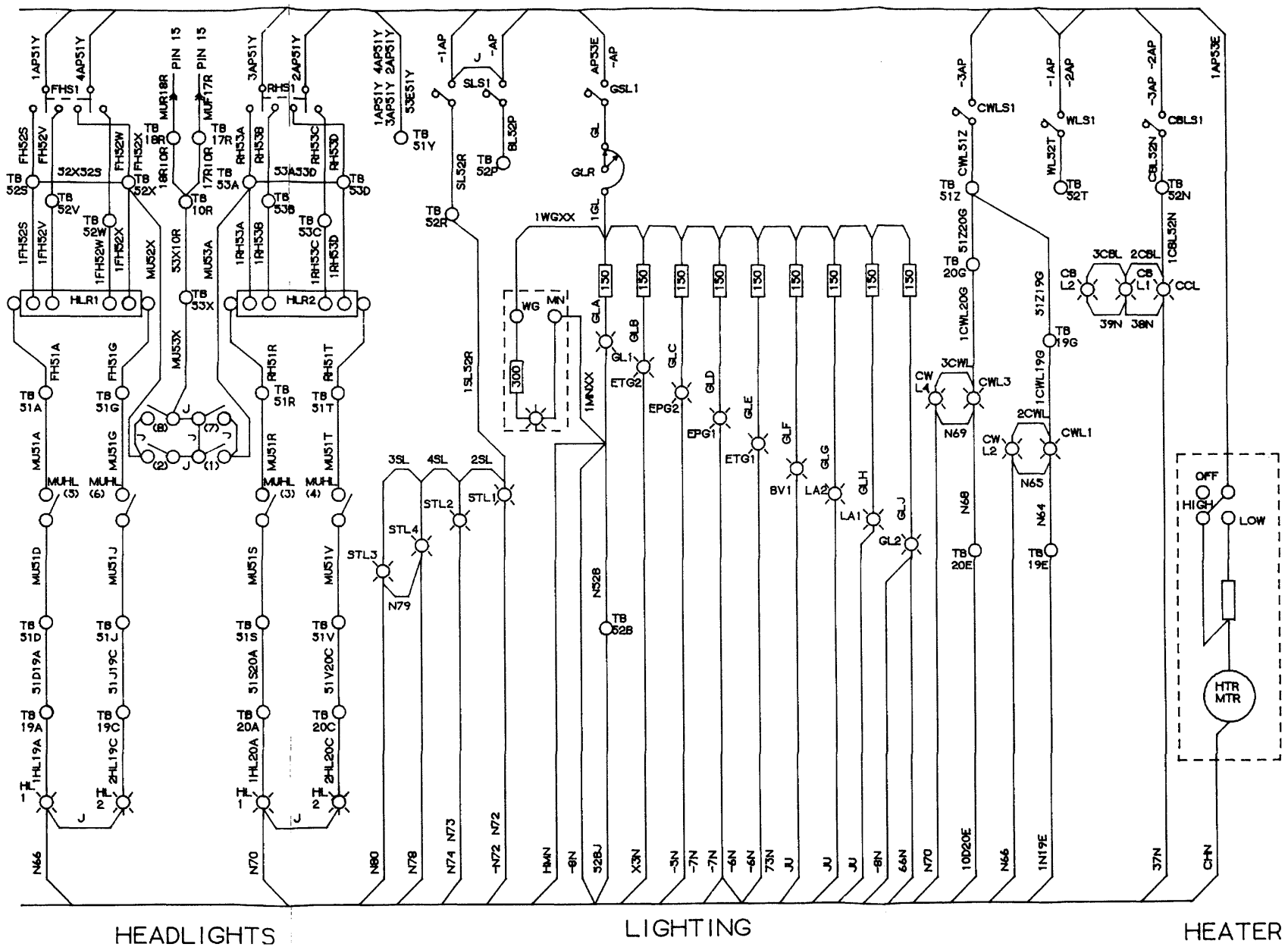
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|--------------------------|----------------------------------|--------------|------------------------------------|
| AB1                      | AUX. CIRCUIT BREAKER             | GLS1,        | GAGE LIGHT SWITCH                  |
| ACMV                     | AIR COMP. MAGNET VALVE           | GRRS 1       | GROUND RELAY RESET SWITCH          |
| ACPS                     | AIR COMP. PRESSURE SWITCH        | GR           | GROUND RELAY                       |
| ARC 1,2                  | SAFETY RELAY                     |              | GROUND RELAY RESET COIL            |
| ALT 1,2                  | ALTERNATOR W/INTERNAL REGULATOR  |              |                                    |
| ASM 1,2                  | ALTERNATOR SUPPR. MODULE         | GRCO         | GROUND RELAY CUTOUT SWITCH         |
| BATT                     | BATTERY, 16 CELL LEAD ACID       | GRL 1        | GROUND RELAY INDICATING LIGHT      |
| BD1,2,3,4,5,7,8,10,12,13 | BLOCKING DIODES                  | HLR 1,2      | HEADLIGHT RESISTOR                 |
| BELS 1                   | BELL VALVE                       | HS1          | HORN VALVE                         |
| BS                       | BATTERY SWITCH                   | ILR1         | INDICATING AND GAGE LIGHT RESISTOR |
| BUZ                      | WARNING BUZZER                   | ILR2         | INDICATING LIGHT RESISTOR          |
| BV1                      | BATTERY VOLTMETER                | J1           | JUMPER FOR MU                      |
| CB1                      | CONTROL CIRCUIT BREAKER          | LA, 1,2      | LOAD METER                         |
| CBL 1,2,3                | CAB LIGHT                        | LAS 1,2      | LOAD AMMETER SHUNT                 |
| CBLS 1,2                 | CAB LIGHT SWITCH                 | M1,2,3,4     | TRACTION MOTOR                     |
| CH 1                     | CAB HEATER                       | MC           | MASTER CONTROLLER                  |
| CK 1,2                   | CRANKING CONTACTOR               | MKR          | MOTOR KILL RELAY                   |
| DV 1,2                   | DUMP VALVE                       | MUHL         | MULTIPLE UNIT HEADLIGHT SWITCH     |
| EH 1,2                   | ENGINE HEATER                    | OPS 1,2      | ENGINE OIL PRESSURE SWITCH         |
| EHR 1,2                  | ENGINE HEATER RECP.              | P1,2,3,4     | MOTOR LINE CONTACTOR               |
| EPG 1,2                  | ENGINE OIL PRESSURE GAGE         | PCS          | PRESSURE CONTROL SWITCH            |
| ES 1,2                   | ENGINE START SWITCH              | R            | REVERSER                           |
| ESD T,2                  | ENGINE STOP SWITCH               | RECP1,2      | RECEPTACLES FOR MU                 |
| ESDS 1,2                 | ENGINE STOP SOLENOID             | RH 1,2       | REAR HEADLIGHT                     |
| ESS                      | EMERGENCY SANDING SWITCH         | RHS1,2       | REAR HEADLIGHT SWITCH              |
| ETG 1,2                  | ENGINE TEMPERATURE GAGE          | SCPS         | SAFETY CONTROL PRESSURE SWITCH     |
| ETS 1,2                  | ENGINE TEMPERATURE SWITCH        | SDS1         | SANDING SWITCH                     |
| ETWD                     | ENGINE TEMPERATURE WARNING RELAY | SESD         | EMERGENCY SHUTDOWN SWITCHATOR      |
| ETWR                     | ENGINE TEMPERATURE WARNING RELAY | SLS1         | STEP LIGHT SWITCH                  |
| FH 1,2                   | FRONT HEADLIGHT                  | SMV1,2       | SANDING MAGNET VALVE               |
| FHS 1                    | FRONT HEADLIGHT SWITCH           | STL1,2,3,4   | STEP LIGHTS                        |
| FS 1,2,3,4               | FIELD SHUNT CONTACTOR            | T1,2,3,4     | FUEL COILS                         |
| FSR 1,2,3,4              | FIELD SHUNT RESISTOR             | T21,22,23,24 |                                    |
| FV1, 2                   | FILTER VALVE                     | TR           | FIELD SHUNT TRANSITION RELAY       |
| G1, G2                   | TRACTION GENERATOR               | TRP          | TRANSITION PANEL                   |
| GFR 1, 21                | GENERATOR FIELD RESISTOR         | WLS1         | WARNING LIGHT SWITCH               |
| GFR 2, 22                | GENERATOR FIELD RESISTOR         | WSL1         | WHEELSLIP INDICATING LIGHT         |
| GL                       | GAGE LIGHT                       | WSR1,2       | WHEELSLIP RELAY                    |
|                          |                                  | WSRR         | WHEELSLIP RESISTOR PANEL           |



FO-3 Electrical Schematic (2 of 3)

FP5/(FP6 Blank)

- |                          |                                  |              |                                    |
|--------------------------|----------------------------------|--------------|------------------------------------|
| AB1                      | AUX, CIRCUIT BREAKER             | GLS1,        | GAGE LIGHT SWITCH                  |
| ACMV                     | AIR COMP. MAGNET VALVE           | GRRS 1       | GROUND RELAY RESET SWITCH          |
| ACPS                     | AIR COMP. PRESSURE SWITCH        | GR           | GROUND RELAY                       |
| ARC 1,2                  | SAFETY RELAY                     |              | GROUND RELAY RESET COIL            |
| ALT 1,2                  | ALTERNATOR W/INTERNAL REGULATOR  |              |                                    |
| ASM 1,2                  | ALTERNATOR SUPPR. MODULE         | GRCO         | GROUND RELAY CUTOUT SWITCH         |
| BATT                     | BATTERY, 16 CELL LEAD ACID       | GRL 1        | GROUND RELAY INDICATING LIGHT      |
| BD1,2,3,4,5,7,8,10,12,13 | BLOCKING DIODES                  | HLR 1,2      | HEADLIGHT RESISTOR                 |
| BELS 1                   |                                  | HS1          | HORN VALVE                         |
| BS                       | BATTERY SWITCH                   | ILR1         | INDICATING AND GAGE LIGHT RESISTOR |
| BUZ                      | WARNING BUZZER                   | ILR2         | INDICATING LIGHT RESISTOR          |
| BV1                      | BATTERY VOLTMETER                | J1           | JUMPER FOR MU                      |
| CB1                      | CONTROL CIRCUIT BREAKER          | LA, 1,2      | LOAD METER                         |
| CBL 1,2,3                | CAB LIGHT                        | LAS 1,2      | LOAD AMMETER SHUNT                 |
| CBLS 1,2                 | CAB LIGHT SWITCH                 | M1,2,3,4     | TRACTION MOTOR                     |
| CH 1                     | CAB HEATER                       | MC           | MASTER CONTROLLER                  |
| CK 1,2                   | CRANKING CONTACTOR               | MKR          | MOTOR KILL RELAY                   |
| DV 1,2                   | DUMP VALVE                       | MUHL         | MULTIPLE UNIT HEADLIGHT SWITCH     |
| EH 1,2                   | ENGINE HEATER                    | OPS 1,2      | ENGINE OIL PRESSURE SWITCH         |
| EHR 1,2                  | ENGINE HEATER RECEPTOR           | P1,2,3,4     | MOTOR LINE CONTACTOR               |
| EPG 1,2                  | ENGINE OIL PRESSURE GAGE         | PCS          | PRESSURE CONTROL SWITCH            |
| ES 1,2                   | ENGINE START SWITCH              | R            | REVERSER                           |
| ESD 1,2                  | ENGINE STOP SWITCH               | RECP1,2      | RECEPTACLES FOR MU                 |
| ESDS 1,2                 | ENGINE STOP SOLENOID             | RH 1,2       | REAR HEADLIGHT                     |
| ESS                      | EMERGENCY SANDING SWITCH         | RHS1,2       | REAR HEADLIGHT SWITCH              |
| ETG 1,2                  | ENGINE TEMPERATURE GAGE          | SCPS         | SAFETY CONTROL PRESSURE SWITCH     |
| ETS 1,2                  | ENGINE TEMPERATURE SWITCH        | SDS1         | SANDING SWITCH                     |
| ETWD                     | ENGINE TEMPERATURE WARNING RELAY | SESD         | EMERGENCY SHUTDOWN SWITCH          |
| ETWR                     | ENGINE TEMPERATURE WARNING RELAY | SLS1         | STEP LIGHT SWITCH                  |
| FH 1,2                   | FRONT HEADLIGHT                  | SMV1,2       | SANDING MAGNET VALVE               |
| FHS 1                    | FRONT HEADLIGHT SWITCH           | STL1,2,3,4   | STEP LIGHTS                        |
| FS 1,2,3,4               | FIELD SHUNT CONTACTOR            | T1,2,3,4     | FUEL COILS                         |
| FSR 1,2,3,4              | FIELD SHUNT RESISTOR             | T21,22,23,24 |                                    |
| FV1, 2                   | FILTER VALVE                     | TR           | FIELD SHUNT TRANSITION RELAY       |
| G1, G2                   | TRACTION GENERATOR               | TRP          | TRANSITION PANEL                   |
| GFR 1, 21                | GENERATOR FIELD RESISTOR         | WLS1         | WARNING LIGHT SWITCH               |
| GFR 2, 22                | GENERATOR FIELD RESISTOR         | WSL1         | WHEELSLIP INDICATING LIGHT         |
| GL                       | GAGE LIGHT                       | WSR1,2       | WHEELSLIP RELAY                    |
|                          |                                  | WSRR         | WHEELSLIP RESISTOR PANEL           |



FO-2 Electrical Schematic (3 of 3)

FP7/(FP8 Blank)

From	Wire ID	To	From	Wire ID	To	From	Wire ID	To	From	Wire ID	To
1LR2	WSC	WSL1	BD8	ESA	ES2	CK2	3P0	POSS BUSS	ES2	4J	ES1
1LR2	WS53J	TB53J	BD8	ES11E	TB11E	CK2	N51	P3	ES2	3J	ES1
AB1-B	4P0	POSS BUSS	BD12	3CP53G	TB53G	CK2	ESCK2	ES2	ES2	2J	ES1
AB1-B	J	CB1-B	BD12	BD1213	BD13	CK2	N52	GR RESET	ES2	ESCK2	CK2
AB1-T	AB53E	TB53E	BD12	1GFR1	GFR2	CK2	CCK2	CK1	ES2	-7JU	ES2
ACMV	2N10D	TB10D	BD13	BD13GR	GFR2	CK2	1CC61B	TB61B	ESD1	ST51X	TB51X
ACMV	CM	ACPS	BD13	1GFR21	GFR22	CK2	GA2	G2	ESD1	CC53R	TB53R
ACMV	-N72	STL1	BD13	BD1213	BD12	CWL1	1CWL19G	TB19G	ESD1	1CC61C	TB61C
ACPS	26CP	TRPA	BS	BX	BATTERY POS	CWL1	2CWL	CWL2	ESD1	EK53N	TB53N
ACPS	27CP	ESS	BS	BY	BATTERY NEG	CWL1	N65	CWL2	ESD2	EK53P	TB53P
ACPS	CM	ACMV	BS	PO	CK1	CWL1	N64	TB19E	ESD2	ST53Y	TB53Y
ACR-COIL	N46	TRP-K	BS	BN	NEG BUSS	CWL2	2CWL	CWL1	ESD2	CC53S	TB35S
ACR1	CPA	GR	BUZZER	1N52L	TB52L	CWL2	N65	CWL1	ESD2	1CC61D	TB61D
ACR1	MSCP	PCS	BUZZER	90N	ETWB	CWL2	N66	HL1	ESDS1	ESC	TB13B
ACR1	MCL	MC-L	BUZZER	BZ2	BD5	CWL3	N68	TB20E	ESDS1	J	TB13A
ACR1	1SP61F	TB61F	BV1	GLF	RESISTOR BLOCK	CWL3	N69	CWL4	ESDS2	ESD	TB14B
ACR1	SPA	ACR2	BV1+	11CP	ES1	CWL3	3CWL	CWL4	ESDS2	J	TB14A
ACR1-COIL	1SP61K	TB61K	BV1-	X3N	ETG2	CWL3	1CWL20G	TB20G	ESS	27CP	ACPS
ACR1-COIL	N47	ACR2-COIL	BV1-	-5N	EPG2	CWL4	N69	CWL3	ESS	ESS10K	TB10K
ACR2	ES61G	TB61G	BV1-	JU	BV1-Lt	CWL4	3CWL	CWL3	ETG1	-6N	EPG1
ACR2	SP61H	TB61H	BV1-	JU	LA2-Lt	CWL4	N70	HL1	ETG1	GLE	RESISTOR BLOCK
ACR2	CCE	TR	BV1-	JU	LA1-Lt	CWLS1	CWL51Z	TB51Z	ETG2	GLB	RESISTOR BLOCK
ACR2	CC61Z	TB61Z	BV1-	66N	GL2-Lt	CWLS1	-3AP	CBLS1	ETG2	X3N	BV1-
ACR2	CCK1	CK1	BV1-Lt	JU	BV1-	DV1	TF2	FV1	ETS1	ET13M	TB13M
ACR2	SPA	ACR1	CB1-B	J	AB1-B	DV1	N75	FV1	ETS1	CC13R	TB13R
ACR2	J	ACR2-	CB1-T	CP53G	TB53G	DV1	TF11M	TB11M	ETS1	CC13P	TB13P
ACR2 (COIL)	N48	ETWR (COIL)	CBL1	38N	CCL	DV1	N74	STL2	ETS1	ET13N	TB13N
ACR2-	J	ACR2	CBL1	2CBL	CCL	DV2	TF4	FV2	ETS2	ET14M	TB14M
ACR2-COIL	N47	ACR1-COIL	CBL1	39N	CBL2	DV2	N77	FV2	ETS2	CC14R	TB14R
ALT1	5N	NEG BUSS	CBL1	3CBL	CBL2	DV2	TF3	FV1	ETS2	CC14P	TB14P
ALT1	2P0	POS BUSS	CBL2	39N	CBL1	DV2	N76	FV1	ETS2	ET14N	TB14N
ALT2	5N1	NEG BUSS	CBL2	3CBL	CBL1	EPG1	GLD	RESISTOR BLOCK	ETWB	90N	BUZZER
ALT2	2P01	POS BUSS	CBLS1	-3AP	CWLS1	EPG1	-7N	EPG2	ETWB	WB10M	TB10M
BATTERY NEG	BY	BS	CBLS1	-2AP	WLS1	EPG1	-6N	ETG1	ETWR	CC61C	TB61C
BATTERY POS	BX	BS	CBLS1	CBL52N	TB52N	EPG2	-7N	EPG1	ETWR	CCD	P3
BD1	WB71N	BD3	CCL	37N	NEG BUSS	EPG2	GLC	RESISTOR BLOCK	ETWR	2ET11H	TB11H
BD1	1WB10L	TB10L	CCL	38N	CBL1	EPG2	-5N	BV1-	ETWR	3ET	BD3
BD1	GL1	GR	CCL	2CBL	CBL1	ES1	XCP	SDS1	ETWR	J	ETWR
BD2	1SDS1K	TB51K	CCL	1CBL52N	TB52N	ES1	ES	BD7	ETWR	ETH61E	TB61E
BD2	1WS53J	TB53J	CH	CHN	NEG BUSS	ES1	4J	ES2	ETWR	2BZ11F	TB11F
BD2	WSE	BD4	CK1	1GA1	P2	ES1	3J	ES2	ETWR	1BZ13L	TB13L
BD3	3ET	ETWR	CK1	GA1	G1	ES1	2J	ES2	ETWR	CCH	P1
BD3	WB71N	BD1	CK1	PO	BS	ES1	-ES	ES1	ETWR	CC61D	TB61D
BD4	WSE	BD2	CK1	ESCK1	ES2	ES1	-1ES	ES1	ETWR	ET2C	ETWR (COIL)
BD4	BZ	BD5	CK1	N54	GRCO	ES1	11CP	BV1+	ETWR	J	ETWR
BD4	1WSB	WSR2	CK1	N55	P2	ES1	1ES53M	TB53M	ETWR	BZ3	BD5
BD5	BZ	BD4	CK1	CCK1	ACR2	ES1	-ES	ES1	ETWR (COIL)	ET2C	ETWR
BD5	BZ2	BUZZER	CK1	CCK2	CK2	ES1	-1ES	ES1	ETWR (COIL)	N49	MKR
BD5	BZ3	ETWR	CK1	GA1	G1	ES2	ESA	BD8	ETWR (COIL)	N48	ACR2 (COIL)
BD7	1ES	TB13B	CK2	GA2	G2	ES2	ESCK1	CK1	FHS1	FH52S	TB52S
BD7	ES	ES1	CK2	1GA2	P3	ES2	-7JU	ES2	FHS1	1AP51Y	TB51Y

FO-5 Wire Run List (1 of 5)

FP9/(FP10 Blank)

From	Wire ID	To	From	Wire ID	To	From	Wire ID	To	From	Wire ID	To
FHS1	4AP51Y	TB51Y	G2	GA2	CK2	GRRS1	2CP53G	TB53G	M2 (COIL)	FF2	R (REV)
FHS1	FH52V	TB52V	G2	21GF	GFR21	GSL1	-AP	SLS1	M2 (COIL)	F2	R (BUSS)
FHS1	FH52W	TB52W	G2	22GF	GFR21	GSL1	GL	GLR	M3	AA3	R (FOR)
FS1	FF1J	R (BUSS)	G2	21GF	GFR21	GSL1	AP53E	TB53E	M3	A3	P3
FS1	FS1R12	FSR1	G2	GA2	CK2	HL1	N66	CWL2	M3	1AA3	WSRR
FS1	N60	R (REV)	G2 (COIL)	2GSS	G2 (START FLD)	HL1	1HL19A	TB19A	M3 (COIL)	F3	R (REV)
FS1	1CCF	FS2	G2 (COIL)	2GFR21	GFR22	HL1	J1	HL2	M3 (COIL)	FF3	R (BUSS)
FS1	CCF	TR	G2 (START FLD)	1GAA2	R (REV)	HL1	N70	CWL4	M4	A4	P4
FS1	N59	FS2	G2 (START FLD)	2GSS	G2 (COIL)	HL1	1HL20A	TB20A	M4	AA4	R (FOR)
FS2	F2J	R (Rev)	G2 (START FLD)	GKK2	NEG BUSS	HL1	J2	HL2	M4 (COIL)	FF4	R (REV)
FS2	2CCF	FS3	G2 (START FLD)	GAA2	LSA2	HL2	2HL19C	TB19C	M4 (COIL)	F4	R (BUSS)
FS2	1CCF	FS1	GFR1	1GF	G1	HL2	2HL20C	TB20C	MC (A)	J	MC (B)
FS2	N59	FS1	GFR1	2GF	G1	HL2	J2	HL1	MC (B)	CC53K	TB53K
FS2	FS2R14	FSR2	GFR1	1GF	G1	HL2	J1	HL1	MC (B)	J	MC (A)
FS2	N58	NEG BUSS	GFR2	2GFR1	G1 (COIL)	HLR1	FH51A	TB51A	MC (B)	J	MC (M)
FS3	FF3J	R (BUSS)	GFR2	1GFR1	BD12	HLR1	1FH52S	TB52S	MC (F)	TH61E	TB61E
FS3	FS3R16	FSR3	GFR21	22GF	G2	HLR1	1FH52V	TB52V	MC (F)	J	MC (M)
FS3	N62	R (FOR)	GFR21	21GF	G2	HLR1	1FH52W	TB52W	MC (F)	J	MC (K)
FS3	N63	GFR21	GFR21	21GF	G2	HLR1	1FH52X	TB52X	MC (G)	2TH10E	TB10E
FS3	3CCF	FS4	GFR22	2GFR21	G2 (COIL)	HLR1	FH51G	TB51G	MC (G)	J	MC (K)
FS3	2CCF	FS2	GFR22	1GFR21	BD13	HLR2	RH51R	TB51R	MC (G)	J	MC (J)
FS4	F4J	R (BUSS)	GL1	GLA	RESISTOR BLOCK	HLR2	1RH53A	TB53A	MC (H)	J	MC (J)
FS4	N63	FS3	GL1	1MNXX	MC-MN	HLR2	1RH53B	TB53B	MC (H)	2TH10G	TB10G
FS4	3CCF	FS3	GL1-Lt	HMN	SERVICE METER-	HLR2	1RH53C	TB53C	MC (J)	2TH10F	TB10F
FS4	FS4R18	FSR4	GL2	GLJ	RESISTOR BLOCK	HLR2	1RH53D	TB53D	MC (J)	J	MC (G)
FSR1	FS1J	R (BUSS)	GL2-Lt	66N	BV1-	HLR2	RH51T	TB51T	MC (J)	J	MC (H)
FSR1	FS1R12	FS1	GLR	1GL	RESISTOR BLOCK	HTR SW	1AP53E	TB53E	MC (K)	MK1	MKR
FSR2	FS2J	R (BUSS)	GLR	1GR	RESISTOR BLOCK	ILR1	GL52H	TB52H	MC (K)	J	MC (F)
FSR2	FS2R14	FS2	GLR	GL	GSL1	ILR1	GLAA	GRL1	MC (K)	J	MC (G)
FSR3	FS3J	R (BUSS)	GR	CPA	ACR1	LA1	GLH	RESISTOR BLOCK	MC (L)	J	MC (W)
FSR3	FS3R16	FS3	GR	SPGR	MC-W	LA1+	1+	LAS1	MC (M)	J	MC (B)
FSR4	FS4J	R (BUSS)	GR	GR23	GR	LA1-	1-	LAS1	MC (M)	J	MC (S)
FSR4	FS4R18	FS4	GR	21CP	WSR2	LA1-Lt	JU	BV1-	MC (M)	J	MC (F)
FV1	TF3	DV2	GR	GL1	BD1	LA2	GLG	RESISTOR BLOCK	MC (S)	SP61F	TB61F
FV1	N76	DV2	GR	1GL52H	TB52H	LA2	2-	LSA2	MC (S)	J	MC (M)
FV1	TF2	DV1	GR	G	GROUND	LA2	2+	LSA2	MC (W)	J	MC (L)
FV1	N75	DV1	GR	BD13GR	BD13	LA2-Lt	JU	BV1-	MC (A)	CC53H	TB53H
FV2	N78	STL4	GR	GR23	GR	LAS1	GAA1	G1 (START FLD)	MC-A	HMCP	SERVICE METER
FV2	TF4	DV2	GR (COIL)	GD	GRCO	LAS1	1-	LA1-	MC-B	1CP53G	TB53G
FV2	N77	DV2	GR (RESET)	N53	GRCO	LAS1	1+	LA1+	MC-L	MCL	ACR1
G1	GA1	CK1	GR RESET	1GR52M	TB52M	LAS1	AM1	R (REV)	MC-L	1SP61H	TB61H
G1	1GF	GFR1	GR RESET	N52	CK2	LSA2	GAA2	G2 (START FLD)	MC-L	J	MC-W
G1	GA1	CK1	GRCO	N54	CK1	LSA2	2-	LA2	MC-LIGHT	J	MC-RESISTOR
G1	1GF	GFR1	GRCO	N53	GR (RESET)	LSA2	2+	LA2	MC-LIGHT	J	MC-MN
G1	2GF	GFR1	GRCO	GD	GR (COIL)	LSA2	AM2	R (REV)	MC-MN	1MNXX	GL1
G1 (COIL)	1GSS	G1 (START FLD)	GRL1	GLAA	ILR1	M1	AA1	R (FOR)	MC-MN	J	MC-LIGHT
G1 (COIL)	2GFR1	GFR2	GRL1	-73N	WSL1	M1	A1	P1	MC-RESISTOR	J	MC-LIGHT
G1 (START FLD)	1GAA1	R (REV)	GRL1	N52J	TB52J	M1 (COIL)	F1	R (REV)	MC-RESISTOR	J	MC-WG
G1 (START FLD)	1GSS	G1 (COIL)	GROUND	G	GR	M1 (COIL)	FF1	R (REV)	MC-W	J	MC-L
G1 (START FLD)	GKK1	NEG BUSS	GRRS1	GR52M	TB52M	M2	AA2	R (FOR)	MC-W	SPGR	GR
G1 (START FLD)	GAA1	LAS1	GRRS1	-9CP	SDS1	M2	A2	P2	MC-WG	1WGXX	RESISTOR BLOCK

From	Wire ID	To	From	Wire ID	To	From	Wire ID	To	From	Wire ID	To
MC-WG	J	MC-RESISTOR	MUHL-8	MU53X	TB53X	PCS	SP	SCPS	RESISTOR BLOCK	GLD	EPG1
MKR	MK10N	TB10N	MUHL-8	J	MUHL SW(7)	POS BUSS	2P0	ALT1	RESISTOR BLOCK	GLE	ETG1
MKR	MK1	MC (K)	MUR REAR PIN 3	MUR18C	TB18C	POS BUSS	2P01	ALT2	RESISTOR BLOCK	GLF	BV1
MKR	MK53N	TB53N	NEG BUSS	GKK1	G1 (START FLD)	POSS BUSS	3P0	CK2	RESISTOR BLOCK	GLG	LA2
MKR	MK11A	TB11A	NEG BUSS	GKK2	G2 (START FLD)	POSS BUSS	4P0	AB1-B	RESISTOR BLOCK	GLH	LA1
MKR	N49A	P4	NEG BUSS	BN	BS	R	2SD51K	TB51K	RESISTOR BLOCK	GLJ	GL2
MKR	N49	ETWR (COIL)	NEG BUSS	5N	ALT1	R (BUSS)	FS1J	FSR1	RESISTOR BLOCK	1GL	GLR
MU FRONT PIN 2	MUF17B	TB17B	NEG BUSS	5N1	ALT2	R (BUSS)	FF1J	FS1	RHS1	RH53A	TB53A
MU FRONT PIN 3	MUF17C	TB17C	NEG BUSS	TN1	TIMER	R (BUSS)	F2	M2 (COIL)	RHS1	RH53B	TB53B
MU FRONT PIN 4	MUF17D	TB17D	NEG BUSS	CHN	CH	R (BUSS)	FS2J	FSR2	RHS1	RH53C	TB53C
MU FRONT PIN 5	MUF17E	TB17E	NEG BUSS	37N	CCL	R (BUSS)	FF3	M3 (COIL)	RHS1	RH53D	TB53D
MU FRONT PIN 6	MUF17F	TB17F	NEG BUSS	N45	TRP	R (BUSS)	FS3J	FSR3	RHS1	3AP51Y	TB51Y
MU FRONT PIN 7	MUF17G	TB17G	NEG BUSS	N57	P1	R (BUSS)	FF3J	FS3	RHS1	2AP51Y	TB51Y
MU FRONT PIN 8	MUF17J	TB17J	NEG BUSS	N58	FS2	R (BUSS)	F4	M4 (COIL)	SCPS	SP	PCS
MU FRONT PIN 9	MUF17H	TB17H	NEG BUSS	1N10D	TB10D	R (BUSS)	FS4J	FSR4	SCPS	SP6TK	TB6TK
MU FRONT PIN 10	MUF17K	TB17K	NEG BUSS	1N13A	TB13A	R (BUSS)	F4J	FS4	SDS1	SD51K	TB51K
MU FRONT PIN 11	MUF17L	TB17L	NEG BUSS	1N19E	TB19E	R (FOR)	1AA1	WSRR	SDS1	XCP	ES1
MU FRONT PIN 12	MUF17M	TB17M	NEG BUSS	N52K	TB52K	R (FOR)	AA1	M1	SDS1	-9CP	GRRS1
MU FRONT PIN 13	MUF17N	TB17N	OPS1	ST13M	TB13M	R (FOR)	1AA4	WSR2	SERVICE METER	HMCP	MC-A
MU FRONT PIN 15	MUF17R	TB17R	OPS1	BZ13L	TB13L	R (FOR)	AA4	M4	SERVICE METER-	HMN	GL1-Lt
MU REAR PIN 2	MUF18B	TB18B	OPS1	1ES13B	TB13B	R (FOR)	1CC53H	TB53H	SESD	25CP	TRP-A
MU REAR PIN 4	MUR18D	TB18D	OPS2	ST14M	TB14M	R (FOR)	1CC61Z	TB61Z	SESD	ES53M	TB53-M
MU REAR PIN 5	MUR18E	TB18E	OPS2	1ES14B	TB14B	R (FOR)	N62	FS3	SESD-1	1EK11D	TB11D
MU REAR PIN 6	MUR18F	TB18F	OPS2	2BZ14L	TB14L	R (FOR)	SD11S	TB11S	SESD-1	1ES11C	TB11C
MU REAR PIN 7	MUR18G	TB18G	P1	A1	M1	R (FOR)	1AA2	WSR1	SESD-2	EK11D	TB11D
MU REAR PIN 8	MUR18H	TB18H	P1	1CC61W	TB61W	R (FOR)	AA2	M2	SESD-2	ES11C	TB11C
MU REAR PIN 9	MUR18J	TB18J	P1	2CCH	P2	R (FOR)	AA3	M3	SESD-2	EK11A	TB11A
MU REAR PIN 10	MUR18K	TB18K	P1	1CCH	P2	R (FOR)	N61	R (REV)	SESD-2	ES11B	TB11B
MU REAR PIN 11	MUR18L	TB18L	P1	CCH	ETWR	R (FOR)	CCA	R (FOR) COIL+	SLS1	SL52R	TB52R
MU REAR PIN 12	MUR18M	TB18M	P1	N56	P2	R (FOR)	CCA	R (FOR)	SLS1	-1AP	WLS1
MU REAR PIN 13	MUR18N	TB18N	P1	N57	NEG BUSS	R (REV)	N60	FS1	SLS1	-AP	GSL1
MU REAR PIN 15	MUR18R	TB18R	P2	N55	CK1	R (REV)	N61	R (FOR)	SLS1	BL52P	TB52P
MUHL	MU51S	TB51S	P2	A2	M2	R (REV)	1CC53K	TB53K	SMV1	1SD11S	TB11S
MUHL (3)	MU51R	TB51R	P2	1GA1	CK1	R (REV)	SD11R	TB11R	SMV1	N72	STL1
MUHL (6)	MU51G	TB51G	P2	2CCH	P1	R (REV)	AM2	LSA2	SMV1	N73	WSL1
MUHL (6)	MU51J	TB51J	P2	1CCH	P1	R (REV)	1GAA2	G2 (START FLD)	SMV2	1SD11R	TB11R
MUHL SW(1)	J	MUHL-2	P2	N56	P1	R (REV)	AM1	LAS1	SMV2	N80	STL3
MUHL SW(1)	J	MUHL SW(7)	P3	A3	M3	R (REV)	F1	M1 (COIL)	SS ALT	AA+	TRPM
MUHL SW(2)	MU52X	TB52X	P3	1GA2	CK2	R (REV)	FF1	M1 (COIL)	SS ALT	AA-	TRPN
MUHL SW(4)	MU51T	TB52T	P3	N51	CK2	R (REV)	1GAA1	G1 (START FLD)	STL 3	3SL	STL4
MUHL SW(4)	MU51V	TB51V	P3	1CC61X	TB61X	R (REV)	FF2	M2 (COIL)	STL1	-N72	ACMV
MUHL SW(5)	MU51D	TB51D	P3	CCD	ETWR	R (REV)	F3	M3 (COIL)	STL1	N72	SMV1
MUHL SW(5)	MU51A	TB51A	P3	1CCD	P4	R (REV)	FF4	M4 (COIL)	STL1	2SL	STL2
MUHL SW(7)	J	MUHL SW(1)	P3	N50	P4	R (REV)	CC	R (REV) COIL+	STL2	N74	DV1
MUHL SW(7)	J	MUHL-8	P3	2CCD	P3- COIL+	R (REV) COIL+	CC	R (REV)	STL2	4SL	STL4
MUHL SW(8)	MU53X	TB53X	P3- COIL+	2CCD	P3	R (REV)	F2J	FS2	STL2	2SL	STL1
MUHL SW(8)	J	MUHL-2	P4	1CCD	P3	RESISTOR BLOCK	1WGXX	MC-WG	STL3	N79	STL4
MUHL-1	MU53A	TB53A	P4	N49A	MKR	RESISTOR BLOCK	1GR	GLR	STL3	N80	SMV2
MUHL-2	MU52X	TB52X	P4	N50	P3	RESISTOR BLOCK	GLA	GL1	STL4	N78	FV2
MUHL-2	J	MUHL SW(8)	P4	A4	M4	RESISTOR BLOCK	GLB	ETG2	STL4	N79	STL3
MUHL-2	J	MUHL SW(1)	PCS	MSCP	ACR1	RESISTOR BLOCK	GLC	EPG2	STL4	3SL	STL 3

FO-7 Wire Run List (3 of 5)

FP13/(FP14 Blank)

From	Wire ID	To	From	Wire ID	To	From	Wire ID	To	From	Wire ID	To
STL4	4SL	STL2	TB10J	17J10J	TB17J	TB13D	TH13D	T1	TB14K	1TH14K	T24
T1	J	TB13C	TB10J	18J10J	TB18J	TB13D	10C13D	TB10C	TB14L	2BZ14L	OPS2
T1	TH13D	TB13D	TB10K	ESS10K	ESS	TB13E	J	T2	TB14L	11F14L	TB11F
T2	TH13F	TB13F	TB10K	51K10K	TB51K	TB13E	J	TB13G	TB14M	11G14M	TB11G
T2	J	TB13E	TB10K	18K10K	TB18K	TB13E	J	TB13C	TB14M	ET14M	ETS2
T21	J	TB14C	TB10K	17K10K	TB17K	TB13F	10E13F	TB10E	TB14M	ST14M	OPS2
T21	TH14D	TB14D	TB10L	1WB10L	BD1	TB13F	TH13F	T2	TB14N	11H14N	TB11H
T22	1TH14F	TB14F	TB10L	17L10L	TB17L	TB13G	J	T3	TB14N	ET14N	ETS2
T22	J	TB14E	TB10L	18L10L	TB18L	TB13G	J	TB13J	TB14P	CC14P	ETS2
T23	1TH14H	TB14H	TB10M	WB10M	ETWB	TB13G	J	TB13E	TB14P	11J14P	TB11J
T23	J	TB14G	TB10M	17M10M	TB17M	TB13H	10F13H	TB10F	TB14R	11K14R	TB11K
T24	1TH14K	TB14K	TB10M	18M10M	TB18M	TB13H	TH13H	T3	TB14R	CC14R	ETS2
T24	J	TB14J	TB10R	53X10R	TB53X	TB13J	J	T4	TB17B	17B10B	TB10B
T3	TH13H	TB13H	TB10R	18R10R	TB18R	TB13J	J	TB13G	TB17B	MUF17B	MU FRONT PIN 2
T3	J	TB13G	TB10R	17R10R	TB17R	TB13K	10G13K	TB10G	TB17C	MUF17C	MU FRONT PIN 3
T4	TH13K	TB13K	TB11A	EK11A	SESD-2	TB13K	TH13K	T4	TB17C	17C10C	TB10C
T4	J	TB13J	TB11A	MK11A	MKR	TB13L	BZ13L	OPS1	TB17D	17D10D	TB10D
T851J	51J19C	TB19C	TB11B	ES11B	SESD-2	TB13L	1BZ13L	ETWR	TB17D	MUF17D	MU FRONT PIN 4
TB10	18B10B	TB18B	TB11B	61G11B	TB61G	TB13M	13M51X	TB51X	TB17E	17E10E	TB10E
TB10B	61F10B	TB61F	TB11C	1ES11C	SESD-1	TB13M	ET13M	ETS1	TB17E	MUF17E	MU FRONT PIN 5
TB10B	17B10B	TB17B	TB11C	ES11C	SESD-2	TB13M	ST13M	OPS1	TB17F	17F10F	TB10F
TB10C	61E10C	TB61E	TB11D	1EK11D	SESD-1	TB13N	ET13N	ETS1	TB17F	MUF17F	MU FRONT PIN 6
TB10C	17C10C	TB17C	TB11D	EK11D	SESD-2	TB13N	13N11H	TB11H	TB17G	MUF17G	MU FRONT PIN 7
TB10C	18C10C	TB18C	TB11E	11E14B	TB14B	TB13P	CC13P	ETS1	TB17G	17G10G	TB10G
TB10C	10C13D	TB13D	TB11E	ES11E	BD8	TB13P	61W13P	TB61W	TB17H	MUF17H	MU FRONT PIN 9
TB10C	10C14D	TB14D	TB11F	11F14L	TB14L	TB13R	61C13R	TB61C	TB17H	17H10H	TB10H
TB10D	1N10D	NEG BUSS	TB11F	2BZ11F	ETWR	TB13R	CC13R	ETS1	TB17J	MUF17J	MU FRONT PIN 8
TB10D	10D14A	TB14A	TB11G	53Y11G	TB53Y	TB14A	J	TB14C	TB17J	17J10J	TB10J
TB10D	2N10D	ACMV	TB11G	11G14M	TB14M	TB14A	J	ESDS2	TB17K	17K10K	TB10K
TB10D	10D20E	TB20E	TB11H	13N11H	TB13N	TB14A	10D14A	TB10D	TB17K	MUF17K	MU FRONT PIN 10
TB10D	17D10D	TB17D	TB11H	11H14N	TB14N	TB14B	1ES14B	OPS2	TB17L	17L10L	TB10L
TB10D	18D10D	TB18D	TB11H	2ET11H	ETWR	TB14B	ESD	ESDS2	TB17L	MUF17L	MU FRONT PIN 11
TB10E	2TH10E	MC (G)	TB11J	11J14P	TB14P	TB14B	11E14B	TB11E	TB17M	17M10M	TB10M
TB10E	17E10E	TB17E	TB11J	11J61X	TB61X	TB14C	J	TB14E	TB17M	MUF17M	MU FRONT PIN 12
TB10E	18E10E	TB18E	TB11K	11K61D	TB61D	TB14C	J	T21	TB17N	17N10N	TB10N
TB10E	10E13F	TB13F	TB11K	11K14R	TB14R	TB14C	J	TB14A	TB17N	MUF17N	MU FRONT PIN 13
TB10E	10E14F	TB14F	TB11M	TF11M	DV1	TB14D	TH14D	T21	TB17N	MUF17N	MU FRONT PIN 13
TB10E	10E14F	TB14F	TB11M	TF1	TIMER+	TB14D	10C14D	TB10C	TB17R	17R10R	TB10R
TB10F	2TH10F	MC (J)	TB11M	TF1	R (REV)	TB14D	J	T22	TB17R	MUF17R	MU FRONT PIN 15
TB10F	17F10F	TB17F	TB11R	SD11R	SMV2	TB14E	J	TB14G	TB18B	18B10B	TB10B
TB10F	18F10F	TB18F	TB11R	1SD11R	R (FOR)	TB14E	J	TB14C	TB18B	MUF18B	MU REAR PIN 2
TB10F	10F13H	TB13H	TB11S	SD11S	SMV1	TB14E	J	TB14C	TB18C	MUR18C	MUR REAR PIN 3
TB10F	10F14H	TB14H	TB11S	1SD11S	J	TB14F	10E14F	TB10E	TB18C	18C10C	TB10C
TB10G	2TH10G	MC (H)	TB13A	J	TB13C	TB14F	1TH14F	T22	TB18D	18D10D	TB10D
TB10G	17G10G	TB17G	TB13A	J	ESDS1	TB14G	J	T23	TB18D	MUR18D	MU REAR PIN 4
TB10G	18G10G	TB18G	TB13A	1N13A	NEG BUSS	TB14G	J	TB14J	TB18E	18E10E	TB10E
TB10G	10G13K	TB13K	TB13B	1ES13B	OPS1	TB14G	J	TB14E	TB18E	MUR18E	MU REAR PIN 5
TB10G	10G14K	TB14K	TB13B	1ES	BD7	TB14H	10F14H	TB10F	TB18E	18F10F	TB10F
TB10H	53K10H	TB53K	TB13B	ESC	ESDS1	TB14H	1TH14H	T23	TB18F	MUR18F	MU REAR PIN 6
TB10H	17H10H	TB17H	TB13C	J	TB13E	TB14H	J	T24	TB18F	MUR18F	MU REAR PIN 6
TB10H	18H10H	TB18H	TB13C	J	T1	TB14J	J	TB14G	TB18G	MUR18G	MU REAR PIN 7
TB10H	18H10H	TB18H	TB13C	J	TB13A	TB14J	J	TB14G	TB18G	18G10G	TB10G
TB10J	53H10J	TB53H	TB13C	J		TB14K	10G14K	TB10G	TB18H	MUR18H	MU REAR PIN 8

From	Wire ID	To	From	Wire ID	To	From	Wire ID	To	From	Wire ID	To
TB18H	18H10H	TB10H	TB51V	MU51V	MUHL SW(4)	TB53C	1RH53C	HLR2	TB61H	1SP61H	MC-L
TB18J	MUR18J	MU REAR PIN 9	TB51V	51V20C	TB20C	TB53C	RH53C	RHS1	TB61H	SP61H	ACR2
TB18J	18J10J	TB10J	TB51X	ST51X	ESD1	TB53D	1RH53D	HLR2	TB61K	SP61K	SCPS
TB18K	18K10K	TB10K	TB51X	13M51X	TB13M	TB53D	RH53D	RHS1	TB61K	1SP61K	ACR1-COIL
TB18K	MUR18K	MU REAR PIN 10	TB51Y	1AP51Y	FHS1	TB53D	53A53D	TB53A	TB61W	61W13P	TB13P
TB18L	18L10L	TB10L	TB51Y	4AP51Y	FHS1	TB53E	AB53E	AB1-T	TB61W	1CC61W	P1
TB18L	MUR18L	MU REAR PIN 11	TB51Y	3AP51Y	RHS1	TB53E	AP53E	GSL1	TB61X	11J61X	TB11J
TB18M	18M10M	TB10M	TB51Y	2AP51Y	RHS1	TB53E	1AP53E	HTR SW	TB61X	1CC61X	P3
TB18M	MUR18M	MU REAR PIN 12	TB51Y	53E514	TB53E	TB53E	53E514	TB51Y	TB61Z	1CC61Z	R (FOR)
TB18N	18N10N	TB10N	TB51Z	51Z20G	TB20G	TB53G	1CP53G	MC-B	TB61Z	CC61Z	ACR2
TB18N	MUR18M	MU REAR PIN 13	TB51Z	CWL51Z	CWLS1	TB53G	TCP	TIMER	TIMER	TN1	NEG BUSS
TB18R	18R10R	TB10R	TB51Z	51Z19G	TB19G	TB53G	2CP53G	GRRS1	TIMER	TCP	TB53G
TB18R	MUR18R	MU REAR PIN 15	TB52B	52BJ	TB52J	TB53G	CP53G	CB1-T	TIMER+	TF1	TB11M
TB19A	1HL19A	HL1	TB52H	GL52H	ILR1	TB53G	3CP53G	BD12	TR	23CP	WSR1
TB19A	51D19A	TB51D	TB52H	1GL52H	GR	TB53H	CC53H	MC(A)	TR	TP	TRP-H
TB19C	51J19C	TB51J	TB52J	52BJ	TB52B	TB53H	53H10J	TB10J	TR	24CP	TRP-A
TB19C	2HL19C	HL2	TB52J	-52JK	TB52K	TB53H	1CC53H	R (FOR)	TR	CCF	FS1
TB19E	N64	CWL1	TB52J	N52J	GRL1	TB53J	WS53J	1LR2	TR	CCE	ACR2
TB19E	1N19E	NEG BUSS	TB52K	N52K	NEG BUSS	TB53J	1WS53J	BD2	TRP	N45	NEG BUSS
TB19G	51Z19G	TB51Z	TB52K	-52JK	TB52J	TB53K	CC53K	MC (B)	TRP-A	25CP	SESD
TB19G	1CWL19G	CWL1	TB52K	-52KL	TB52L	TB53K	1CC53K	R (REV)	TRP-A	24CP	TR
TB10N	MK10N	MKR	TB52L	-52KL	TB52K	TB53K	53K10H	TB10H	TRP-H	TP	TR
TB10N	17N10N	TB17N	TB52L	1N52L	BUZZER	TB53M	1ES53M	ES1	TRP-K	N46	ACR-COIL
TB10N	18N10N	TB18N	TB52M	1GR52M	GR RESET	TB53N	MK53N	MKR	TRPA	26CP	ACPS
TB20A	1HL20A	HL1	TB52M	GR52M	GRRS1	TB53N	EK53N	ESD1	TRPM	AA+	SS ALT
TB20A	51S20A	TB51S	TB52N	1CBL52N	CCL	TB53N	-53NP	TB53P	TRPN	AA-	SS ALT
TB20C	51V20C	TB51V	TB52N	CBL52N	CBLS1	TB53P	-53NP	TB53N	WLS1	-1AP	SLS1
TB20C	2HL20C	HL2	TB52P	BL52P	SLS1	TB53P	EK53P	ESD2	WLS1	-2AP	CBLS1
TB20E	10D20E	TB10D	TB52R	1SL52R	TB52R	TB53R	-53RS	TB35S	WLS1	WL52T	TB52T
TB20E	N68	CWL3	TB52R	SL52R	SLS1	TB53R	CC53R	ESD1	WLS1	-73N	GRL1
TB20G	1CWL20G	CWL3	TB52R	1SL52R	TB52R	TB53X	53X10R	TB10R	WLS1	N73	SMV1
TB20G	51Z20G	TB51Z	TB52S	1FH52S	HLR1	TB53X	MU53X	MUHL SW(8)	WLS1	WSC	1LR2
TB35S	53S61B	TB61B	TB52S	FH52S	FHS1	TB53X	MU53X	MUHL-8	WSR1	WS	WSRR
TB35S	-53RS	TB53R	TB52S	52X52S	TB52X	TB53Y	ST53Y	ESD2	WSR1	1AA2	R (FOR)
TB35S	CC53S	ESD2	TB52T	MU51T	MUHL SW(4)	TB53Y	53Y11G	TB11G	WSR1	23CP	TR
TB51A	MU51A	MUHL SW(5)	TB52T	WL52T	WLS1	TB61B	1CC61B	CK2	WSR1	WSB	WSR2
TB51A	FH51A	HLR1	TB52V	1FH52V	HLR1	TB61B	53S61B	TB35S	WSR1	22CP	WSR2
TB51D	51D19A	TB19A	TB52V	FH52V	FHS1	TB61C	1CC61C	ESD1	WSR2	1WSB	BD4
TB51D	MU51D	MUHL SW(5)	TB52W	1FH52W	HLR1	TB61C	61C13R	TB13R	WSR2	WSB	WSR1
TB51G	FH51G	HLR1	TB52W	FH52W	FHS1	TB61C	CC61C	ETWR	WSR2	22CP	WSR1
TB51G	MU51G	MUHL (6)	TB52X	1FH52X	HLR1	TB61D	1CC61D	ESD2	WSR2	WSA	WSRR
TB51J	MU51J	MUHL (6)	TB52X	MU52X	MUHL SW(2)	TB61D	11K61D	TB11K	WSR2	1AA4	R (FOR)
TB51K	51K10K	TB10K	TB52X	52X52S	TB52S	TB61D	CC61D	ETWR	WSR2	21CP	GR
TB51K	SD51K	SDS1	TB52X	MU52X	MUHL-2	TB61E	ETH61E	ETWR	WSRR	1AA3	M3
TB51K	1SD51K	BD2	TB53-M	ES53M	SESD	TB61E	TH61E	MC (F)	WSRR	WSA	WSR2
TB51K	2SD51K	R	TB53A	1RH53A	HLR2	TB61E	61E10C	TB10C	WSRR	1AA1	R (FOR)
TB51R	MU51R	MUHL (3)	TB53A	RH53A	RHS1	TB61F	SP61F	MC (S)	WSRR	WS	WSR1
TB51R	RH51R	HLR2	TB53A	53A53D	TB53D	TB61F	61F10B	TB10B			
TB51S	51S20A	TB20A	TB53A	MU53A	MUHL-1	TB61F	1SP61F	ACR1			
TB51S	MU51S	MUHL	TB53B	1RH53B	HLR2	TB61G	61G11B	TB11B			
TB51T	RH51T	HLR2	TB53B	RH53B	RHS1	TB61G	ES61G	ACR2			

FO-9 Wire Run List (5 of 5)

FP17/(FP18 Blank)

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## The Metric System and Equivalents

### Linear Measure

1 centimeter = 10 millimeters = .39 inches  
 1 decimeter = 10 centimeters = 3.94 inches  
 1 meter = 10 decimeters = 39.37 inches  
 1 dekameter = 10 meters = 32.8 feet  
 1 hectometer = 10 dekameters = 328.08 feet  
 1 kilometer = 10 hectometers = 3,280.8 feet

### Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce  
 1 deciliter = 10 centiliters = 3.38 fl. ounces  
 1 liter = 10 deciliters = 33.81 fl. ounces  
 1 dekaliter = 10 liters = 2.64 gallons  
 1 hectoliter = 10 dekaliters = 26.42 gallons  
 1 kiloliter = 10 hectoliters = 264.18 gallons

### Weights

1 centigram = 10 milligrams = .15 grain  
 1 decigram = 10 centigrams = 1.54 grains  
 1 gram = 10 decigrams = .035 ounce  
 1 dekagram = 10 grams = .35 ounce  
 1 hectogram = 10 dekagrams = 3.52 ounces  
 1 kilogram = 10 hectograms = 2.2 pounds  
 1 quintal = 100 kilograms = 220.46 pounds  
 1 metric ton = 10 quintals = 1.1 short tons

### Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch  
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches  
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. ft.  
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet  
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres  
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

### Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. Inch  
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches  
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

## Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pounds-feet	newton-meters	1.356	metric tons	short tons	1.102
pound-inches	newton-meters	.11296			

## Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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**PIN: 062285-000**