

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

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LOCOMOTIVE

DIESEL ELECTRIC

56½" GAGE, 44 TON

0-4-4-0, 400 HP

DAVENPORT BESLER



DEPARTMENT OF THE ARMY NOVEMBER 1955

**LOCOMOTIVE, DIESEL ELECTRIC, 56½" GAGE, 44 TON,  
0-4-4-0, 400 HP, DAVENPORT BESLER**

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## CHAPTER 1

### INTRODUCTION

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#### Section 1. GENERAL

##### 1. Scope

This manual is published for the information and guidance of the personnel concerned with the operation and maintenance of Davenport Besler Company 44 Ton, 400 HP, Diesel Electric Locomotive, providing information and instructions for carrying out their duties and discharging their responsibilities. This manual outlines procedures for necessary inspection and proper maintenance by trained personnel familiar with locomotive construction and repair.

##### 2. References

a. TC 7 & 8 L-78 Locomotive, Diesel Electric, 56½" Gage, 44 Ton 0-4-4-0, 400 HP, Davenport Besler (TC Stock No. 58-4991-05-518).

b. TM 55-270-Operation Of Railroads, General Instructions For The Inspection And Maintenance Of Locomotives And Locomotive Cranes.

c. TM 55-271-Operation Of Railroads, Diesel Electric locomotives.

d. TM 55-405-Preventive Maintenance Of Electric Motors and Generators.

e. TM 55-1046-Operator's Instructions for Caterpillar Diesel D17000 Power Unit.

f. TM 55-1046-1-Engines, Caterpillar D17000, Locomotive, Electrical Set, Industrial, Marine.

g. TM 55-2029-Brake Equipment 6-SL For Diesel Electric Yard Switching Locomotives (Westinghouse Air Brake Pamphlet 5046-15).

h. TM 55-2034-Air Compressors 4-YC and Z For Diesel Electric Locomotives (Westinghouse Air Brake Instruction Pamphlet 5002-5, Sup. 1).

i. LO 55-1279-Locomotive, Diesel Electric (561/2" Gage, 44 Ton, 04-4-0, 400 HP, Davenport Besler).

##### 3. Standard Forms and Records

a. DD Form 862-Daily Inspection Work Sheet For Diesel Electric Locomotives (Cut Sheet).

b. DD Form 863-Monthly And Semi-Annual Inspection Work Sheet For Diesel Electric Locomotives.

c. DD Form 864-Annual Inspection Work Sheet For Diesel Electric Locomotives.

d. DD Form 438-1-Railway Equipment Report, Motive Power Other Than Steam-Part 1-Registry Assignment And Service Record (Cut Sheet).

e. DD Form 438-5-Railway Equipment Maintenance (Exclusive of Rolling Stock) (Cut Sheet).

f. DD Form 865-Daily Assignment Work Sheet For Locomotives And Locomotive Cranes (Cut Sheet).

g. DA Form 55-154-Record Of Special Tests Made On Air Brake Equipment (Cut Sheet).

h. DA Form 55-226-Daily Inspection Report Locomotives and Locomotive Cranes (Cut Sheet).

i. DA Form 55-230-Monthly Inspection And Repair Report Of Locomotives And Locomotive Cranes Other Than Steam (Cut Sheet).

#### Section II. DESCRIPTION AND DATA

##### 4. General Description

This locomotive has two Caterpillar Model D17000 diesel engines, each nominally rated 190 hp at 1,000 rpm. Each engine is directly connected to a Westinghouse type 195A, direct current, shunt wound generator. The generators which supply electrical energy to the traction motors are equipped with windings

for use in starting the engines by storage battery power. When the engines are shut down, auxiliary power is supplied by two 16 cell, lead acid type batteries which are recharged by the auxiliary generators. The auxiliary power is furnished at a constant potential over the full operating range of engine speed. The

locomotive has four Westinghouse type 928GK, direct current, series wound, totally inclosed traction motors. The motors deliver power to four axles individually, through single reduction spur gearing with a ratio of 13:72. The air brake equipment is combined straight and automatic, Schedule 6-SL. A handbrake is provided for holding the locomotive at a standstill. There are two air cooled, two cylinder air compressors used, having a net delivery of 114 cubic feet per minute at 700 rpm. The locomotive is equipped with Westinghouse single station, multiple unit controls, with the operator's station placed on the right hand side of the cab. Grouped at this station are the throttle lever, reversing lever, brake valve, sander valve, bell and horn controls, engine start switches, gage panel and tumbler switches for controlling lights. All meters and gages may be readily viewed by the operator when seated at his control station. Accessories applied to the locomotive include four air operated sanders, bell horn, two headlights, cab heater and four window wipers.

## 5. Component Data

### a. Locomotive.

Manufacturer.....	Davenport Besler Corporation
Model .....	DE44
Total nominal weight.....	91,270 pounds
Traction effort at 30%.....	26,400 pounds
Adhesion .....	
Minimum curve radius.....	75'
Gage .....	56 1/2"
Maximum permissible speed. ....	42 mph
Fuel oil capacity .....	250 gallons
Lubrication oil capacity .....	70 gallons
Cooling water capacity .....	70 gallons
Height (maximum) .....	13'2 3/4"
Length (over couplers) .....	33' 9 1/2"
Width (maximum).....	9'4"

### b. Engine.

Manufacturer .....	Caterpillar Tractor Company
Model .....	D17000
Cylinders .....	8
Bore.....	5"
Stroke .....	8"
Displacement .....	1,662 cubic inches

Fuel .....	Diesel oil
Horsepower .....	190
Fuel system .....	Solid injection
Cooling system .....	Radiator
Starting system .....	Electric, generator starting
Lubrication system .....	Pressure feed

### c. Main Generator.

Manufacturer.....	Westinghouse	Electric
	Company	
Type.....	195A	
Voltage.....	200, dc	
Speed	1,000 rpm	
Weight (approx.) .....	3,125 pounds	

### d. Auxiliary Generator.

Manufacturer .....	Westinghouse Electric Co.
Type .....	YB41B
Voltage.....	37.5, dc
Speed .....	750 to 2,250 rpm

### e. Traction Motor.

Manufacturer.....	Westinghouse Electric Co.
Type.....	928GK
Voltage .....	200, dc
Amperes .....	325
Gear ratio.....	13:72
Weight .....	3,210 pounds

### f. Brake Equipment.

Manufacturer.....	Westinghouse	Air	Brake
	Company		
Schedule.....	SL		

### g. Truck.

Manufacturer.....	Davenport Corporation	Besler
Wheel arrangement .....	0-4-4-0	
Wheel diameter.....	33"	

### h. Air Compressor.

Manufacturer.....	Westinghouse	Air	Brake
	Company		
Model .....	4-YC		
Bore (1st stage) .....	6 1/2"		
Bore (2d stage) .....	3 1/2"		
Stroke .....	4 1/4"		
Displacement .....	57 cfm at 700 rpm		

## CHAPTER 2

### OPERATING INSTRUCTIONS

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#### Section I. SERVICE UPON RECEIPT OF LOCOMOTIVE

##### 6. Electrical Equipment

a. Lubricate all bearings, gears and other parts of the motors, generators and control equipment (fig. 5). Inspect all bolts and nuts and tighten if necessary. Give the control fingers and contacts on the controller and reverser drums a light lubrication with a cloth moistened with oil. See that all fuses are in place and in good condition. Check supply of replacement fuses.

b. Check the height of solution in the battery, and the specific gravity, using a tested hydrometer. See that all connections to the generator unit and battery are complete, tight and clean.

##### 7. Mechanical Parts

Examine the mechanical parts to see that everything is in working order. Check lubrication of brake rigging and journal boxes.

##### 8. Diesel Engine

a. Give the diesel engine a detailed inspection and lubricate all parts as directed under LO 551279 (fig. 5).

b. Fill the main fuel tank, taking care that no dirt, water, or other foreign substances are admitted with the fuel.

c. Fill the cooling system with clean soft water, or with the correct antifreeze solution if temperatures below freezing are likely to be encountered. Water used in the cooling system should be soft, or as free as possible from scale forming minerals. If it is impossible to obtain soft water, treat the available water with some commercial water softener.

d. After the first few hours of operation, tighten all nuts, bolts and cap screws holding together parts having asbestos-lined gaskets between them. This applies especially to stud nuts for the engine cylinder heads, the engine inlet and exhaust manifolds. When the engine cylinder head nuts are tightened, the cylinder head gaskets are squeezed together and the valve clearances are changed. Adjust the valve and compression release rod clearances as described in TM 55-1046.

##### 9. Air Compressor

a. Fill the crankcase with lubricating oil. It requires approximately three quarts of oil.

b. Adjust belts tight enough to prevent slippage.

##### 10. Air System

a. Close all drain cocks on the air reservoirs, air lines, etc. See that the main reservoir cutout cock, brake cylinder cutout cocks and distributing valve cutout cock are open.

b. Refer to TM 55-2029 for information covering operation of the various units in the air brake system.

##### 11. Handbrake

Check the handbrake to see that its functions properly.

##### 12. Sand Supply

Fill the sandboxes with clean, dry sand.

#### Section II. CONTROLS

##### 13. Master Controller

a. The master controller is operated by means of two levers; these levers, designated as THROTTLE and REVERSE levers, control the speed and direction of

motion of the locomotive by operating two drums which are mounted on the same shaft.

b. The throttle drum, operated by the THROTTLE lever, is mounted below the reverse drum and is keyed to the main shaft. The reverse

drum is free to revolve on the main shaft and is operated by the REVERSE lever which is located below the THROTTLE lever.

c. The drums are so interlocked that the THROTTLE lever cannot be operated unless the REVERSE lever is in the ENGINE ONLY, FORWARD or REVERSE positions and the REVERSE lever cannot be operated unless the THROTTLE lever is in the OFF position.

d. Motion of the THROTTLE lever changes the engine throttle setting to increase or decrease the engine speed by means of a throttle operating device which is mounted on the engine and energized through the controller, and establishes the control circuits to actuate various switches which are employed for operating the traction motors. The reverse drum controls the operation of the reverser and the energizing of the control circuits from the battery.

e. The bearings and other working surfaces should be lubricated occasionally with a few drops of light machine oil.

f. The REVERSE handle is removable in the OFF position only and serves as a means of locking the controller when not in use. Refer to paragraphs 86 through 96 for maintenance instructions.

#### 14. Reverser

a. The reverser functions to reverse the connections between the fields and armatures of the traction motors and prescribe movement of the locomotive either FORWARD or BACKWARD.

b. The reverser consists of a drum (with insulated copper segments) capable of rotation through a small angle, two air cylinders with pistons for drum rotation,

control magnet valves power and control fingers and an insulating base.

c. To operate the reverser it is only necessary to complete the circuit from the battery through one of the magnet coils. The current in the coil magnetizes the core to pull down the armature and open the valve, thus admitting air to one of the cylinders to turn the drum.

d. The reverser drum is divided into two parts. The larger section, which handles the main motor current, is provided with heavy copper segments which make contact with stationary fingers mounted on each side of the drum. The smaller section, which handles only the low voltage control circuits, is provided with light copper segments which make contact with small fingers on each side. The object of these interlock fingers.

as they are called, is to provide an interlock between the reverser drum and the circuit for operating the power switches.

e. A handle is provided on the end of the reverser shaft so that it can be operated by hand in cases of emergency or during inspection.

f. The interlocking of the control circuits with the reverser is such that the drum contacts do not break the motor current. Any sign of arcing on the drum indicates either weak finger pressure or faulty operation. The drum contacts should be kept clean and smooth with the aid of fine sandpaper. The contacts should be wiped perfectly clean after they are smoothed, and particular care should be exercised to see that no grit is lodged under the fingers.

### Section III. DETAILED FUNCTION OF EQUIPMENT

#### 15. Generating Equipment and Control Devices

a. *Main Generators.* The main generator is driven by the engine and supplies current for the operation of the traction motors during running periods; it is also used as a motor operating from battery current to start the engine.

b. *Auxiliary Generator.* The auxiliary generator furnishes power for battery charging and for all electrical auxiliaries. It is under the control of the voltage regulator.

c. *Engine Starting Contactors.* Magnetic contactors G, G1 (and G2) establish engine starting circuits from the battery to the main generator and its series starting field.

d. *Voltage Regulator Panel.*

- (1) The regulator is a sensitive voltage relay which controls the auxiliary generator voltage for charging the battery by varying the field current in its shunt field circuit. It maintains approximately constant voltage over the auxiliary generator speed and load range.
- (2) The reverse current relay is located on the right side of the panel and controls the auxiliary generator battery charging

circuit. It is provided with voltage coils and a current coil for reverse-current protection. It closes the circuit when the auxiliary generator voltage reaches a predetermined value above battery voltage.

e. *Voltage Relay.* Relays T1 (and T2) measure main generator voltage and automatically control the shunt field motor connections. Relays ES1 (and ES2) measure main generator voltage and commutate a step of resistance in the self-excited field of the main generator. In this manner, proper engine loading is obtained over the current range of the generator.

## 16. Traction Motors and Switching Devices

a. *Traction Motors.* The traction motors are geared to the driving axles. They are self-ventilated.

b. *Traction Motor Contactors.* Magnetic contactors P1, P2, etc., connect the motors in the parallel combination.

c. *Field Shunt Contactors.* Magnetic contactors M1, M2, etc., connect the field shunt resistors in parallel with the motor fields. This results in better performance at higher locomotive speeds.

d. *Reverser.* The electro-pneumatic reversers change the connection between the motor fields and the armatures for forward or reverse motion of the locomotives.

## 17. Miscellaneous Devices

a. *Controller.* The controller has two handles with which the direction and speed of the locomotive are controlled. The controller is interlocked to prevent movement of the reverser handle while the throttle handle is in running notch.

b. *Pushbuttons.* These are provided for starting the diesel engines.

c. *Control Circuit Breaker.* This circuit breaker supplies power from the battery for all control circuits except the auxiliary generator field circuits.

d. *Auxiliary Generator Circuit Breaker.* This circuit breaker controls the auxiliary generator field circuits. It must be closed during all operating periods.

e. *Main Circuit Shunts and Ammeters.* These provide meter indication of the main generator load current. The ammeter has a colored band dial showing various load time limits and also an ampere scale.

f. *Auxiliary Generator Ammeter.* These are connected to measure the output of each auxiliary generator.

g. *Battery Circuit Shunt and Ammeter.* These are connected to measure the battery charge and discharge current.

h. *Engine Shutdown Valve.* Energizing the coil of the engine shutdown valve will stop the diesel engine.

i. *BS Contactor.* This contactor places the batteries in series for engine starting.

j. *BP Two Pole Contactor.* This contactor places the batteries in parallel for charging.

k. *Battery Signal Lamp.* This light is lit whenever the battery switch and the two pole contactor are closed. It, therefore, burns whenever the batteries are in the parallel connection.

### l. *Battery Relay Panel.*

(1) This relay panel eliminates the need for fuses in the series-parallel battery circuit. If the BS contactor and the BP two pole contactor were closed at the same time, the batteries would be short-circuited. However, the short circuit current would flow through the operating coils of the battery relay and pick the relay up, thus dropping out the BP two pole contactor and opening the short circuit. The holding coil of the relay then holds the relay in until the battery switch is opened. When the battery switch is opened, the relay will drop out, allowing the BP two pole contactor to reclose. However, if the cause of the short circuit is not removed, the relay will again pick up as soon as the battery switch is closed.

(2) The battery signal lamp is extinguished whenever the battery-relay picks up and remains extinguished until the relay is dropped out.

### m. *Ground Relay.*

(1) The ground relay GR has four contacts and two coils, a trip coil and a holding coil. When the ground relay picks up, it performs the following functions: energizes the ground relay holding coil; lights the ground warning light; opens the P contactors, removes the main generator excitation and reduces the diesel engine speed to idle.

- (2) The ground relay resistor is connected across the high voltage line, and since the midpoint of the resistor is grounded by the ground relay coil, the maximum voltage to ground that can exist under normal conditions is but one-half of the line voltage. If a ground occurs, a voltage will appear across the ground relay coil. If this voltage is 12 volts or greater, the relay will pick up and function as mentioned earlier. The magnitude of the voltage that appears across the ground relay coil is proportional to the distance of the ground from center potential and inversely proportional to the resistance of the ground.

*n. Ground Relay Cutout Breaker.*

- (1) This is a three-pole breaker with two poles that close in the ON position and one pole that closes in the OFF position. The breaker is thrown to the OFF position to cut out the ground relay. This disconnects the ground relay coil and lights the ground indicating light to show that the ground relay is cut out.
- (2) If only one ground exists, opening the ground relay cutout breaker will open the ground circuit, and no damage will occur if the locomotive is operated. If, however, two grounds exist or a second ground occurs after the ground relay is cut out, current will flow between the two grounds, serious damage may be done to the electrical equipment, and the ground relay is unable to function and protect the locomotive because it has been cut out of the circuit. Therefore, the ground relay should be cut out in case of emergency only, and all grounds should be removed immediately.

*o. Ground Relay Reset.*

- (1) When the ground relay reset button is pushed, the ground relay holding coil will be de-energized, and the ground relay will drop out, thus allowing normal operation of the locomotive after the ground has been removed.
- (2) If the ground relay is reset and an attempt is made to operate the locomotive without removing the ground, the ground relay will again pick up as soon as excitation is applied to the main generator.

*p. Wheel Slip Relays.*

- (1) This locomotive is equipped with wheel slip relays. The relays are shown on the locomotive wiring diagram (fig. 44) as WS1 and WS2, and are connected in a bridge circuit. One relay is used for each pair of motors. It is connected so as to compare the IR drop across the series fields of the two motors. If a pair of wheels slip, the motor whose wheels are slipping will draw less current. The IR drop across its series field will be less than across the other; the bridge will thus become unbalanced, and the relay will pick up when the unbalanced voltage equals the pickup voltage of the relay. Refer to figure 44 for the relay pickup voltage.
- (2) When a wheel slip relay picks up, it energizes a wheel slip indicating light. When the wheels stop slipping, the wheel slip relay will drop out, and the indicating lamp will be de-energized.

**Caution**

**Due caution should be exercised not to come in contact with the generator terminals or any part of the main circuit while the engine is in operation. The voltage employed on the generator and traction motor circuits is sufficiently high to give a very severe shock.**

**18. Safety Precautions**

*a.* Observance of the following simple precautions may prevent serious shock or burns:

- (1) Do not attempt to make adjustments on the generator while it is in operation.
- (2) Do not operate the TRACTION MOTOR SWITCHES or REVERSER by hand while the engine is running.
- (3) In general, the switch cabinet doors should not be opened when the engine is in operation.

*b.* The electrical circuits which lead to the devices whereby the operator controls the locomotive carry low-voltage battery current.

*c.* In testing equipment having pneumatic apparatus, use compressed air from some external source or pump up the reservoirs by running engine, but be certain to shut (down engine before testing circuits.

## Section IV. STARTING THE POWER PLANT

### 19. Preparatory to Starting Engines

- a. Before starting the engines, see that no tools, bolts, nuts, or other materials are lying around the engine or generator where they could possibly get caught or fall into any of the working mechanism.
- b. Close the battery switch and the control and fuel pump circuit breaker. Close the auxiliary generator cutout circuit breaker and all engine alarm cutout switches.
- c. Properly set all engine alarm apparatus.
- d. See that lubricating oil valves and system are set properly.
- e. See that fuel oil valves and system are set properly.
- f. Check lubricating oil of engines and compressors.
- g. Check fuel oil, cooling water and sand supplies.

### 20. Starting the Engines

- a. Place the reverse handle of the controller in the ENGINE ONLY position. The throttle handle may be advanced a few notches for starting.
- b. Start each engine separately by pushing the start button for the respective engine and observe that

each engine operates properly and that the lubricating oil pressure builds up.

- c. See that the battery is being charged as indicated by the battery meter.
- d. The diesel engine has no ignition and depends upon the heat developed by compression to make it fire. Therefore, after periods of shutdown during cold weather where the engine has cooled down to air temperature, there is danger of completely discharging the battery by continued cranking before the cylinders get warm enough to start. To guard against this condition a kerosene heater is provided for the purpose of warming up the cooling water in the engine jacket. Refer to paragraphs 23 through 27 for operating instructions for this heater.
- e. Do not attempt to start the engines until engine temperature shows at least 60° or 70° on the engine temperature indicator. After the engine starts, shut down the heater and close the valve to the engine cooling system.
- f. Refer to paragraphs 21 and 22 for starting the engines if locomotives are to operate in multiple.

## Section V. OPERATING THE LOCOMOTIVE

### 21. Single Unit Operation

- a. *Diesel Engines.*
  - (1) While operating the engines, make regular check of lubricating oil pressures and cooling water temperatures.
  - (2) If the engines become overheated for any reason, never add water to the cooling system until the engines have cooled off.
  - (3) After pulling heavy loads, allow the engines to idle for a few minutes before stopping them to prevent the danger of boiling the cooling water.
- b. *Brakes.*
  - (1) Do not attempt to move the locomotive until the brake pipe gauge hand indicates full brake pipe pressure.
  - (2) Never depend upon the airbrakes to hold the locomotive on a grade when the compressors are shut down.
  - (3) In emergencies apply the brakes at once and shut off the power afterwards.

#### c. *To Start Locomotive and Regulate Speed.*

- (1) After the engines are running, place the reverse handle for the desired locomotive direction and notch out on the throttle handle. Opening the throttle handle increases the speed of the engine to increase the voltage across traction motors and accelerates the locomotive.
- (2) Motor field shunting is automatically obtained at a predetermined main generator voltage. A voltage relay controls this transition to close and open the field shunting contactors.

#### **Caution**

**Great care must be exercised to avoid overspeeding the traction motors. Maximum permissible speed is 42 mph.**

d. *Load Indicator.* This locomotive is equipped with load ammeters which have both a colored band scale and an ampere scale. The ammeter is

connected to measure the output of the main generator. Each segment of the band shows the allowable load-time limits which may be carried by the generator and the motors connected in parallel with it. After the time limit in any one portion of the overload range is reached, the generators and motors have reached their maximum allowable temperature, and their load must be reduced to the continuous range or severe overheating of the motors will result. Operation in any one of the overload ranges, as shown on the dial, for the maximum time specified, is permitted again after a cooling period, at idle position, of 30 minutes duration.

e. *To Stop Locomotive.* Move the throttle to the "OFF" position and apply the airbrakes in the usual manner.

f. *To Reverse Locomotive.* In order to change the direction of motion of the locomotive, place the throttle in "OFF" position and bring the locomotive to a stop; then throw the reverse handle to the position required.

### **Caution**

**With the locomotive in motion, power must never be applied with reverse handle in the position opposite to the direction of the locomotive motion. If recourse to such action is necessary to stop the locomotive abruptly, serious damage to the motors is likely to result.**

g. *Wheel Slipping.*

- (1) If wheel slipping occurs, move the throttle handle toward the idle position until the slipping stops.
- (2) Never apply sand while the wheels are slipping as this could cause a broken traction motor gear. Always use sand sparingly as excess sand can be injurious to the traction motors.

h. *Leaving the Locomotive.*

- (1) Stop engines by operating engine shutdown pushbuttons.
- (2) Place reverse handle in OFF (remove to lock controller).
- (3) Open control circuit breaker.
- (4) Open battery switch.
- (5) Set handbrake.
- (6) Properly protect water system in cold weather.

## **22. Multiple Unit Operation**

a. *Application.* Two to four locomotives may be coupled together and operated as a single unit after connections are properly made. In addition to the conventional coupling of locomotive drawgear and air lines, the electrical control circuits of the locomotives must be connected. A jumper for this purpose must be firmly plugged into the receptacles at the end of the locomotives. The controls are then set so that the power and the brakes on all locomotives are controlled from only one cab. The locomotive from which operation is controlled is called the leading unit and any coupled locomotives are called trailing units. Certain alarm and protective devices and certain auxiliary controls such as sanding are connected through the jumper, but the power plants and heavy duty circuits of the coupled units remain entirely independent of each other.

b. *Operation.*

- (1) If the locomotives are not already coupled together and it is desired to operate two or more locomotives as a single unit, start the engines by going to each locomotive and starting the engines as described in paragraphs 19 and 20.
- (2) Couple the locomotives mechanically in the usual manner. Return all throttle and reverse handles to OFF. Couple the locomotives electrically by means of the train line jumpers. Open the control and fuel pump circuit breaker on the trailing locomotive or locomotives. This prevents currents from circulating between the batteries of the locomotives and automatically causes the engines to stop on any locomotive behind a BREAK in case a coupler breaks and the train parts in operation. Couple all auxiliary train line connections.
- (3) If the locomotives have already been fully connected but are shutdown, the engines must be started by going to each locomotive and starting the engines in the usual manner. On all locomotives, close the battery switch, auxiliary generator cutout and engine alarm cutout switches. See that the lubricating oil and fuel oil systems are set properly. On the trailing locomotive or locomotives, set the controller handle in the OFF position.
- (4) On the lead locomotive, close the control

and fuel pump circuit breaker. Set the controller handle in the OFF position.

- (5) After the engines are all firing, the operation from that point on is the same as for a single locomotive. However, the operator should note whether all locomotives are operating as they should. A dragging locomotive is worse than useless.

- (6) The sanders of all locomotives in the train are wired so that sand is always supplied to the leading side of the driving wheels even though one locomotive is in FORWARD and the other locomotive is in REVERSE.

- (7) All engines on the remote locomotives are stopped when the REM. ENG. STOP pushbutton is pushed on the controlling locomotive.

## Section VI. OPERATION OF AUXILIARY EQUIPMENT

### 23. Kerosene-Burning Heaters

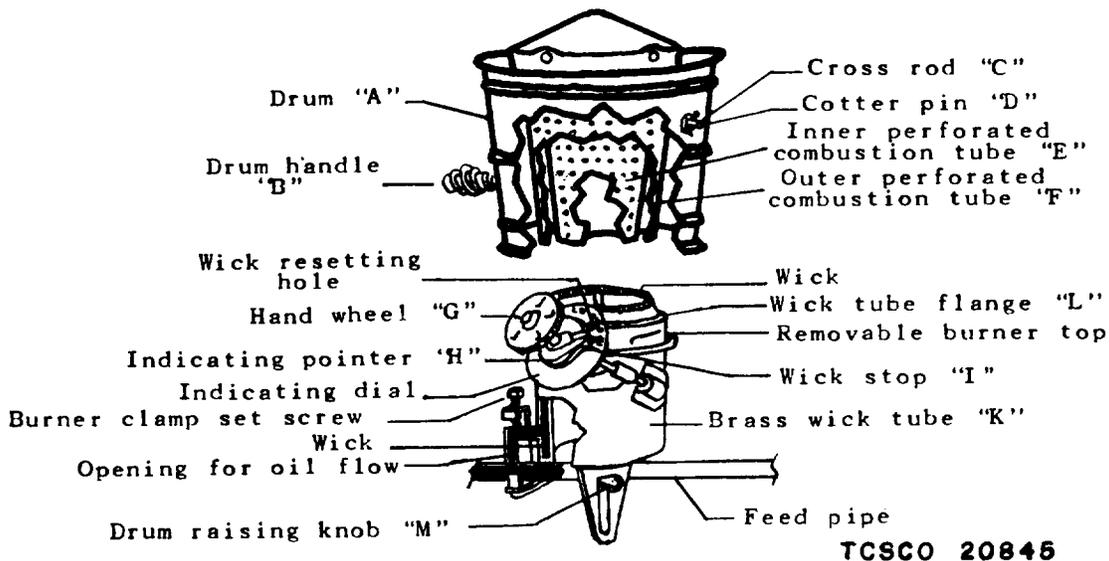
a. *How to Set Wick.* Before operating your heater see that the wick is properly set in the following manner (fig. 1):

- (1) Remove the drum A so that you can see the wick clearly.
- (2) Turn hand wheel G until the indicating pointer H is at the hole in the dial.
- (3) With the thumb of the right hand press the pointer through the hole as shown in figure 2. Hold it there.
- (4) With the left hand turn the handwheel raising or lowering the wick until the wick top is 1/16 above the top of the wick tubes; then release pointer. The wick is now properly adjusted.
- (5) It is occasionally necessary to reset the wick as it burns down in order to restore

high flame and get the fullest possible use out of each wick.

b. *Fuel.* Use only a good grade of kerosene. Never use gasoline or mixtures containing gasoline.

c. *How to Light.* Fill the oil reservoir and see that all parts of the burner are in place as shown in figure 1, with the drum A in raised position. Drum is raised by means of a small handle M in the slot below the feed pipe. Turn the handwheel to the right until indicator pointer rests against wick stop. Light the wick in several places, then lower drum gently in place by lowering handle M in the slot. Turn drum to the right and left by means of handle B to make sure that it rests evenly on the wick tube flange L. Three to five minutes are required for the flame to reach its fullest height. The high flame should be clear blue in color but when burner has been operating at LOW and is turned to HIGH it will burn yellow for a short time.



TCSCO 20846

Figure 1. Cross section of kerosene burner.

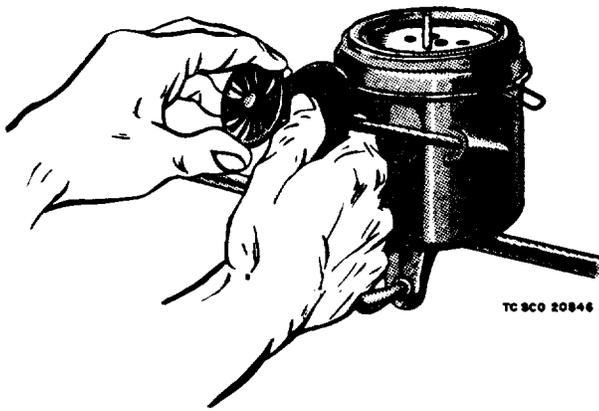


Figure 2. Wick setting

d. *How to Extinguish.*

- (1) Turn handwheel to left as far as it will go.
- (2) When the flame has gone out raise the drum by means of lifter handle M leaving it in the raised position as shown in figure 1. Leaving the drum in a raised position prevents oil from creeping up on the combustion tube which would cause an odor when the burner is again lighted.

e. *Care of Wicks and Burners.* When the burners are in long continuous use it is necessary, after ten or twelve hours of steady burning, to turn the wick up and down in order to loosen and break away any carbon at the top of the wick tubes. Otherwise, this carbon will seal the wick tightly at the top of the tubes and some of the wick may be broken away, resulting in an unsatisfactory flame. At least twice a week thoroughly clean the brass wick tube. Refer to paragraphs 100 through 104 for maintenance instructions.

**24. Viloco Internal Bell Ringer**

a. Air from control valve enters through hole in stud (8) and 1/16" orifice in body (1). Pressure moves piston (2) swinging clapper (4) until exhaust port in piston is uncovered. Since exhaust port has larger area than inlet port, pressure in cylinder is instantly exhausted and clapper rebounds moving piston in reverse direction. Exhaust port is covered and air pressure again builds up in cylinder for the next cycle (fig. 3).

b. Should ringer fail to operate, it is generally caused by dirt and gum adhering to piston or in cold weather by moisture in air line freezing up inlet port. Use a grade of light oil that will not gum up, and in

winter use alcohol fed into air line by means of a cup. Refer to paragraphs 105 through 107 for maintenance instructions.

**25. Viloco Bell Ringer Operating Valve**

a. The valve is designed to control bell ringer valve through inlet and is metered to bell ringer through control port. Area through port is governed

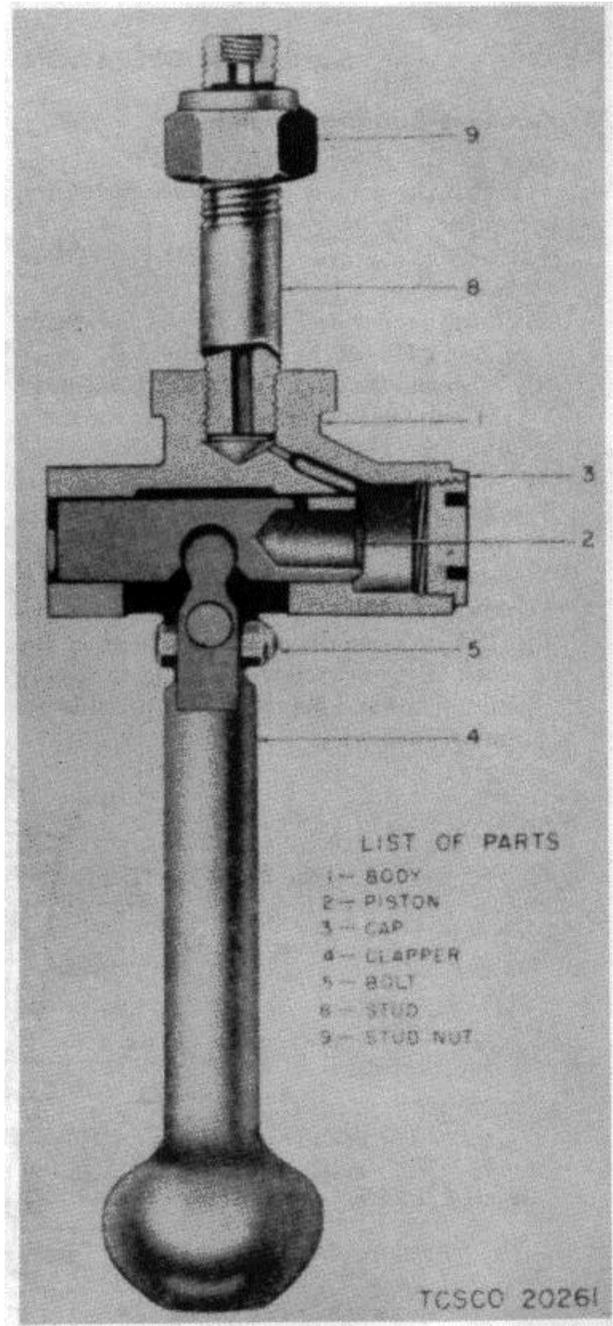


Figure 3. Internal bell ringer.

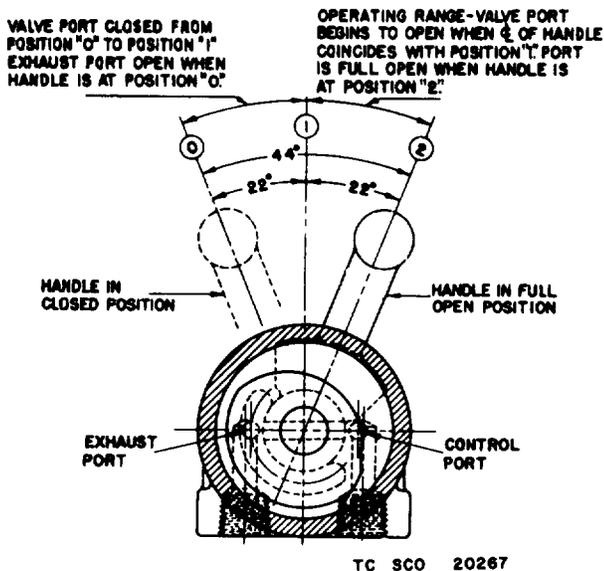


Figure 4. Bell ringer operating valve.

by position of cam edge of rotor lapping control port.

b. When valve is closed, exhaust port opens and pressure is exhausted (fig. 4).

c. An occasional drop of light oil is all this valve will require to provide years of trouble-free service. Refer to paragraphs 105 through 107 for maintenance instructions.

## 26. Speed-Indicating Equipment

a. The speed-indicating equipment is designed to give a continuous indication of train speed.

b. The complete speed-indicating equipment consists of three units.

- (1) A tachometer generator.
- (2) Transformer-resistor box.
- (3) D indicating instrument.

c. The indicator scale is calibrated in miles per hour, thus making it possible to read the train speed at the instrument panel.

d. The generator is driven by the axle of the locomotive.

e. The transformer-resistor box contains the specially designed transformer, resistors, and a rectifier. The resistors are usually in series and one is manually adjustable to compensate for wheel wear. Refer to paragraphs 97 through 99 for adjustment instructions.

f. The indicating instrument is of the D'Arsonval permanent-magnet moving coil type of design. Handle the indicator with care to avoid damaging jewel bearings. Do not hammer on the panel on which the indicator is mounted. Check that the pointer is on the zero-set adjustment. Refer to paragraphs 97 through 99 for adjustment instructions.

## 27. Air System

### a. Compressor.

(1) This 4-YC air compressor is of the two cylinder, two stage, air cooled, pressure lubricated type. It is suitable for continuous service against 115 pounds air pressure at speeds up to 610 rpm. Inasmuch as the locomotive engines operate at idling speeds when the motive power is not needed, and the compressor runs continuously, a load and unload type control is provided to maintain the main reservoir pressure between the desired limits. Refer to paragraphs 110 through 113 for adjustment and maintenance of the compressor governor.

(2) The belts should be maintained tight enough to prevent excessive slippage, but not tight enough to place undue strain on the motor and compressor bearings which will result in excessive heating of these bearings and increase the power required. When belt replacement is necessary, replace all belts with a matched set. Refer to TM 55-2034 for maintenance instructions.

b. *Airbrakes.* Refer to TM 55-2029 for operation and maintenance of the airbrake equipment.

## CHAPTER 3

### MAINTENANCE INSTRUCTIONS

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#### Section I. REMOVAL OF EQUIPMENT FOR SERVICE

##### 28. Engine Group

*a. Michiana WASTEX Lubricating Oil Filter Element.* Remove four nuts from eyebolts at top of filter body. Remove cap. Remove filter element. To replace element reverse this procedure.

*b. Oil Tank-Lube Oil.* After oil has been drained from lube oil tank remove all piping connected to the tank. Remove left rear door. Remove cap screws from legs at bottom of tank. Remove four cap screws holding lube oil tank to panel. Move tank to outer side of hood. Turn tank and remove through small door opening. To replace lube oil tank reverse this procedure.

*c. Lube Oil Cooler.* Disconnect shutter arm assembly. Remove grill and shutter assembly by removing bolts on hood front section. Disconnect piping to lube oil cooler. Remove eight bolts holding lube oil cooler to frame structure. Cooling unit can be taken from locomotive. To reassemble reverse this procedure.

*d. Air Cleaners.* Remove wingnuts on both sides of air cleaner oil sump. Sump will now drop down. Service in accordance with TM 55-1046 and TM 55-1046-1. Replace air cleaner sump in reverse procedure.

*e. Dirt Collectors.* Remove bulb and empty sediments. Replace bulb.

*f. Lube Oil Filter.* Remove four bolts with retaining lugs. Unscrew wingnuts on top of filter body. Replace element. To reassemble use reverse procedure.

*g. Heater.* Remove exhaust pipe by removing metal screws at top of heater. Disconnect water pipes and fuel lines. Remove four 1/4" cap screws at base. This will allow unit to be removed from locomotive. To replace unit reverse this procedure.

*h. Water Heater Tank.* Remove No. 3 door, left hand side of locomotive. Drain tank, disconnect fuel line. Remove four cap screws at bottom legs. Tank can now be removed from locomotive.

To replace tank use reverse procedure.

*i. Muffler.* Remove cap screws in inlet and outlet flanges. Remove cap screws in support straps. Slide muffler unit forward and turn for removal either on left or right hand side No. 1 or 2 door. To replace use reverse procedure.

##### 29. Blower Assembly

*a. Blower.* Remove ten cap screws from panel at right side of cab. Loosen four cap screws in blower base. Loosen adjusting screw. Remove blower drive belt. Remove four cap screws in blower base. Loosen cap screw in bellows band. Remove three sheet metal screws holding bellows band to blower. On No. 1 end turn blower and remove through panel at side of cab. On No. 2 end turn blower 90° lift over governor and remove through side panel.

*b. Motor connection bellows.* Remove band that holds bellows to traction motor. Remove ten cap screws holding bellows to truck center bolster. To replace bellows reverse procedure.

##### 30. Foundation Brakes

*a. Brakeshoe Heads.* Loosen connecting rod turnbuckle. Remove brake head key. The brakeshoe is now free to drop toward rail. To replace use reverse procedure.

*b. Brake Cylinders.* Remove pin from air cylinder push rod. Disconnect air supply line from rear of cylinder. Remove four cap screws holding air cylinder to truck. Slide air cylinder toward bumper. Remove air cylinder at side of bolster. To replace air cylinder, reverse procedure.

*c. Handbrake Staff.* Remove bolt from handbrake staff and chain connection. Remove handbrake head by removing four cap screws. Remove handbrake staff through cab.

*d. Handbrake.* Remove four cap screws retaining handbrake head to cap. Lift handbrake head off from handbrake staff. To replace reverse this procedure.

### **31. Compressor Assembly**

*a. Compressor.* Remove compressor door at side of cab. Remove four bolts retaining compressor door angle support. Disconnect drain line. Disconnect delivery and governor air lines. Loosen four nuts holding compressor to adjusting base. Push compressor inward. Remove belts. Remove four cap screws holding compressor to sub base. Slide compressor out through opening in side of locomotive. To replace use reverse procedure.

*b. Compressor Governor.* Remove panel on left side of locomotive. Disconnect two air pipes from governor unit. Remove two cap screws holding governor to locomotive frame. Governor can now be removed from locomotive. To replace use reverse procedure.

### **32. Drawgear**

*a. Coupler.* Remove yoke pin from coupler chain. Remove coupler pin. Coupler can now be removed from locomotive. To replace use reverse procedure.

*b. Draft Gear Yoke.* Remove six double nuts holding draft gear retainer. Draft gear can now be removed from locomotive. To replace use reverse procedure.

### **33. Journal Bearings**

Remove waste from journal box. Place jack under journal box jacking pad. Raise box by actuating jack until clearance is sufficient to remove brass. To replace brasses use reverse procedure.

### **34. Electrical Equipment**

*a. Main Generator.* Disconnect all wiring, piping, and gauge lines from engine-generator unit. Remove all hood doors. Remove lubricating oil filter and lubricating oil supply tank. Disconnect and remove shutter rod. Remove heater and heater fuel tank. Disconnect air supply line to horn. Remove precleaners. Remove exhaust pipe housing from cab and hood. Remove cap screws which hold U-bolt exhaust clamp to cab front sheet. Remove wind sheet which encloses main generator. Remove hood top. Disconnect radiator piping. Remove radiator front section. Remove cap

screws retaining engine front supports and generator supports. Slide engine generator unit toward bumper until unit clears cab front sheet. The engine-generator unit can now be removed from locomotive. To replace reverse this procedure.

*b. Traction Motors.* Disconnect all air and sanding lines and traction motor leads between truck and main frame. Disconnect handbrake on No. 2 truck. Disconnect speedometer cable. Remove four cap screws from each truck stop casting (two per truck). De-wheel locomotive. Remove traction bellows. Remove plates over traction motor spring retaining ends. Lift traction motor by lifting lug at back of traction motor housing. Remove motor suspension spring hangers. Remove four traction motor gear housing cap screw retainers. Traction motor gear housing can now be removed. Remove eight bolts holding traction motor axle gearing. Tie into front lifting lugs with lifting device. Raise straight up. Traction motor can now be removed from truck proper. To replace use reverse procedure.

*c. Auxiliary Generator.* Loosen auxiliary generator base adjusting screw. Remove belt. Remove wiring at terminal box. Remove four bolts holding generator to generator adjusting base. Lift auxiliary generator up through floor hatch between two main generators. To replace reverse this procedure.

*d. Batteries.* Disconnect all cables. Open center door on each side of cab. Remove retaining bars. Insert battery lifter. Lift batteries and slide out of cab side door. To replace reverse this procedure.

### **35. Radiator**

Disconnect shutter control lever. Dismantle radiator grill and shutter assembly by removing 18 cap screws. Disconnect pipes on oil cooler. Remove cap screws retaining oil cooler. Remove oil cooler. Remove oil cooler support angle at bottom of radiator unit. Remove core by removing four cap screws per core. To replace use reverse procedure.

### **36. Radiator Shutters**

Remove shutter control lever. Remove 18 cap screws retaining grill and shutter assembly. To replace use reverse procedure.

## Section II. LUBRICATION

### 37. Traction Generator

a. The generator is equipped with a single bearing at the commutator end. To insure continued satisfactory operation of this bearing it must be properly lubricated and all dirt or other foreign matter excluded from contact with the bearing. The lubricant used, which is grease, is held in the bearing chamber and around the bearing by two steel labyrinth seals, one at each side of the bearing. The bearing is provided with an overflow for excess grease. Avoid over-lubrication of these bearings as well as under-lubrication.

b. Refer to LO 55-1279, figure 5, for lubrication instructions. If grease leakage or overflow is noticed, a period longer than that recommended between greasings should be allowed. Thoroughly clean the fittings before adding grease so as not to force dirt into the bearing with the grease.

### 38. Auxiliary Generator

This generator is equipped with two bearings, which are held in position on the shaft by the housings and inner bearing caps. Lubrication will be similar to that discussed in paragraph 37.

### 39. Traction Motor

#### a. Armature Bearings.

- (1) The armature bearing housings are arranged for grease lubrication through alemite fittings. Lubricate the bearings with grease as indicated in figure 5. Thoroughly clean fittings before adding grease so as not to force dirt into the bearing with the grease.
- (2) The length of time between greasings and the correct amount of grease for proper bearing lubrication depend upon the severity of service and the number of hours of operation. If grease leakage or overflow is noticed, a period longer than that specified in figure 5 should be allowed.
- (3) Over-greasing of the bearings may be as harmful as under-greasing and is to be avoided. Over-greasing is indicated by leakage of excess grease out through the labyrinth seals where it gets oil to the brushes, commutator, and windings. Examine the labyrinth seals regularly and if grease has been forced out, either decrease the amount of grease to be added or lengthen the time between greasings.
- (4) A careful check of the condition of the bearings when the equipment is dismantled for repair or for routine

inspection will show whether the greasing schedule has been satisfactory or should be changed in the future.

#### b. Axle Bearings.

- (1) *Description.* These bearings are sleeve type arranged for oil and waste lubrication. Figure 6 shows a section through an axle bearing. In order to obtain satisfactory results with these bearings it is important to use a suitable grade of waste, good oil, and to pack the waste into the bearing in the proper manner.
- (2) *Packing the bearing.*
  - (a) The proper packing of bearings is of the utmost of importance; poor packing is responsible for a large percentage of hot bearings.
  - (b) Use long-fiber wool waste previously saturated in oil for at least 24 hours and drained on a screen or grate for several hours. Use oil as specified in figure 5.
  - (c) The oil is drawn up from the oil well to the bearing by the capillary attraction in the strands of waste and it is, therefore essential for proper lubrication to provide a continuous path for the oil flow. This means that longstrand wool waste must be used and that waste must be in actual contact with the journal.
  - (d) The first step in packing the bearing is to prepare wicks from a bunch of oiled waste. Make the pieces of packing into skein forms of sufficient length to reach from the bottom of the waste chamber up to about six inches above the seat for the waste chamber cover. Twist the skeins about one complete turn in order to hold all of the strands of yarn in place to produce a spring wick. Pack as many skeins as possible in the waste chamber, starting at the inner end of the bearing and working outward. It is important that the bearing window be completely covered with the skein. Allow the upper ends of the skein to hang out over the seat

# LUBRICATION ORDER

# LO55-1279

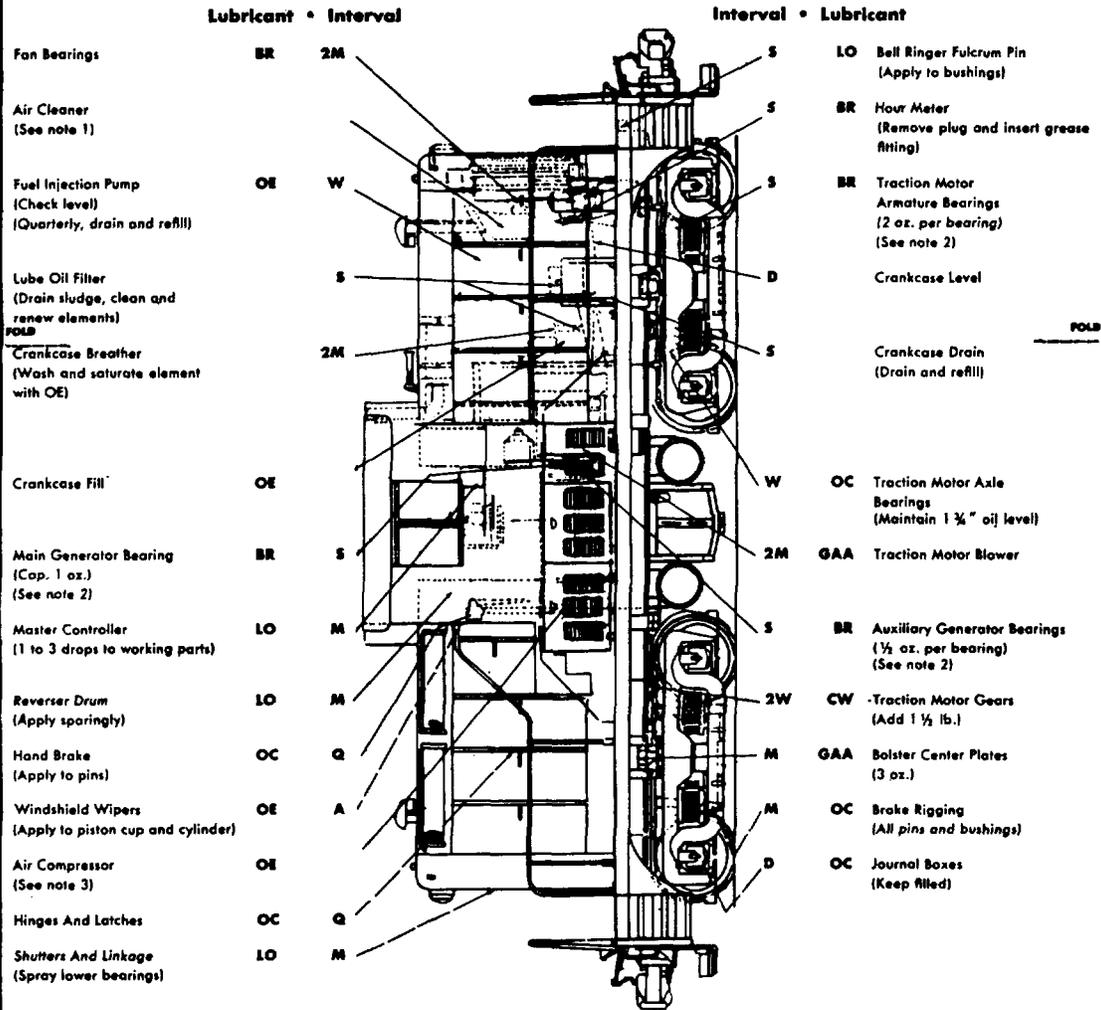
9 September 1953

## LOCOMOTIVE, DIESEL-ELECTRIC

(56-1/2" GAGE, 44 TON, 0-4-4-0, 400 HP, DAVENPORT BESLER)

Intervals given are maximums for normal 8-hour day operation. For abnormal conditions or activities, intervals should be adjusted to compensate. Clean fittings before lubricating. Clean parts with SOLVENT, dry cleaning, or with OIL, fuel, Diesel. Dry before lubricating.

Lubricate points indicated by dotted arrow shafts on both sides of the equipment. Drain crank and gear cases only when hot after operation; check level and replenish when cool.



TCSO 22000

Figure 5. LO-55-1279, Locomotive, Diesel Electric (56 1/2" Gage, 44 Ton, 0-4-4-0, 400 HP, Davenport Besler)

— KEY —

LUBRICANTS	EXPECTED TEMPERATURES			INTERVALS
	Above +32°F.	+32°F. to 0°F.	Below 0°F.	
OE—OIL, engine, heavy duty	OE 30	OE 30	OE 10	D—Daily W—Weekly 2W—2 Weeks M—Monthly 2M—2 Months Q—Quarterly (3 Months) S—Semiannually (6 Months) A—Annually (12 Months)
LO—OIL, lubricating, light	LO	LO	LO	
OC—OIL, lubricating, car and locomotive engine	OC	OC	OC	
3065—LUBRICATING OIL, general purpose	3065	3065	3065	
OSC—OIL, lubricating, steam cylinder compounded	OSC-3	OSC-3	OSC-3	
BR—LUBRICANT, ball and roller bearing	BR	BR	BR	
GAA—GREASE, automotive and artillery	GAA	GAA	GAA	
GG—GREASE, graphite	GG	GG	GG	
CW—LUBRICANT, chain, exposed gear and wire rope	CW-IC	CW-IIA	CW-IA	

FOLD

FOLD

— NOTES —

1. AIR CLEANER—Weekly, remove and wash cups, refill with OE to circular mark. Monthly, wash entire unit and refill.
2. BALL BEARINGS—Lubricate after first month of service and semiannually thereafter.
3. AIR COMPRESSOR—Daily, check oil level. Semiannually, drain and refill. Clean or replace element in air cleaner as required.
4. REVERSER DRUM CONTACTS—(Not illustrated) Monthly, apply a film of LO with a lint free cloth. Remove all excess oil.
5. BRAKE CYLINDERS—(Not illustrated) Lubricate with OSC-3 when assembling the device after overhauling or repairs.
6. BRAKE VALVES—(Not illustrated) Lubricate with GG when assembling the device after overhauling or repairs. When assembled use 3065 sparingly every 3 months.

Copy of this lubrication order will remain with the equipment at all times; instructions contained herein are mandatory and supersede all conflicting lubrication instructions dated prior to the date of this lubrication order.

BY ORDER OF THE SECRETARY OF THE ARMY:

M. B. BODWAY,  
General, United States Army,  
Chief of Staff.

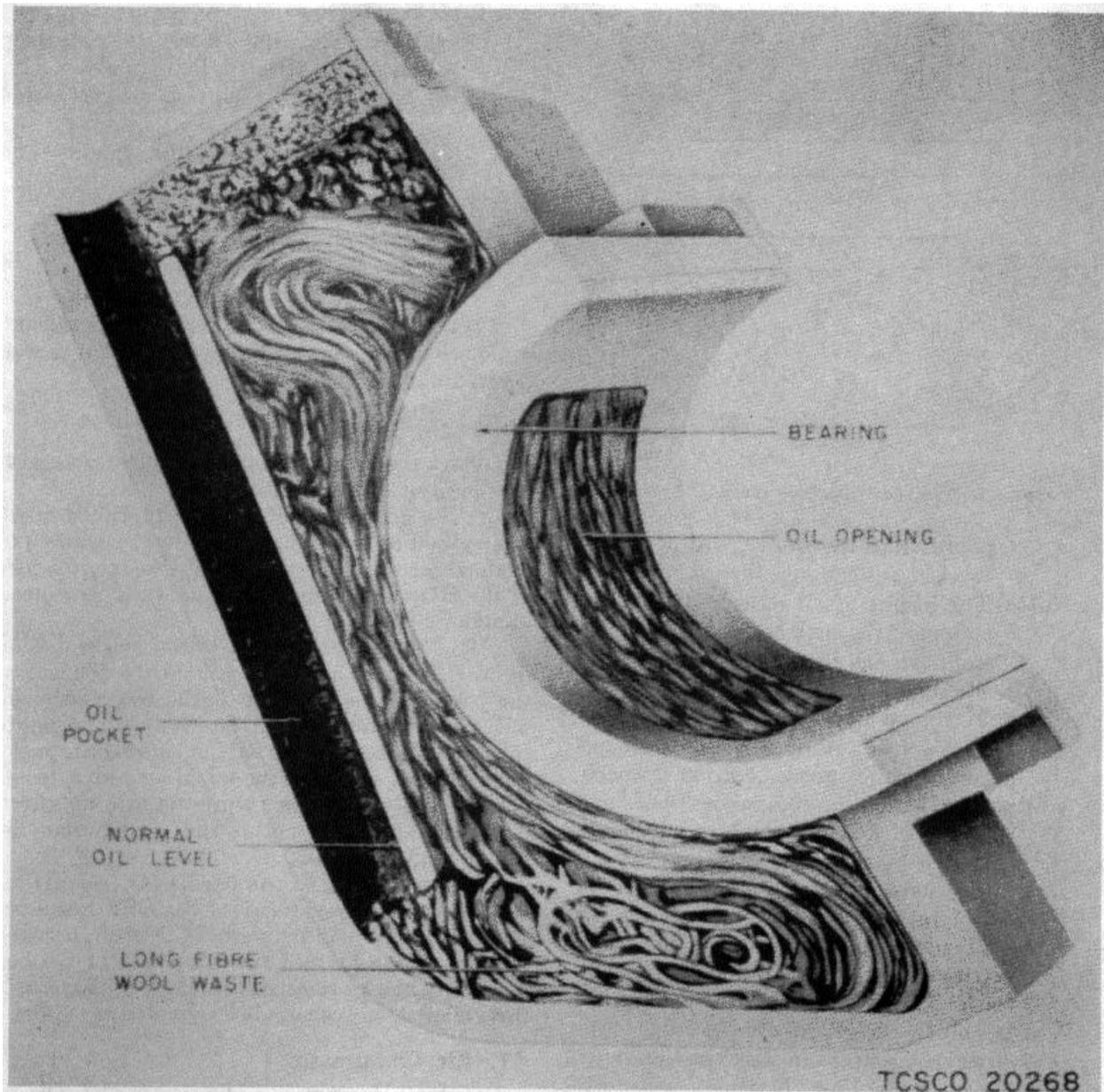
OFFICIAL:  
WM. I. BERGIN,  
Major General, United States Army,  
The Adjutant General.

DISTRIBUTION: ACTIVE ARMY: AFF (1); OS Maj Comd (1); Log Comd (1), A (2); Sch 55 (2); Dep 55 (2); POE (1), OSD (1). NG & Army Reserve: None. For explanation of distribution formula see SR 310-90-1.

TC8CO 22001

GPO 663208

Figure 5 - Continued

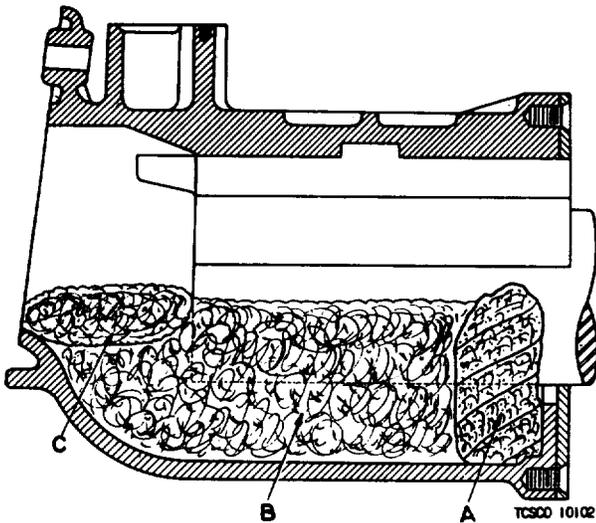


**Figure 6. Packing axle bearings**

- of the cover about six inches or enough to hold them in place.
- (e) After the wick is formed in the chamber, press it over horizontally, tight against the axle, by means of a suitable packing iron and hold in place by forcing the necessary additional packing behind it. Fold the loose upper ends of the skeins over the other waste and tamp down tight.
  - (f) Place a pad of saturated waste, large enough to fill the remainder of

the waste chamber, on top of the wick to catch and hold dirt which might fall in when the bearing housing cover is open.

- (g) After the bearing has been properly packed, fill the well with oil to the proper level.
- (3) Height of oil.
- (a) Pour the oil into the oil pocket and not on top of the waste. If too much oil is



**Figure 7. Method of packing journal boxes.**

poured into the well it will overflow; this is a waste of oil.

- (b) The height of oil measured from the bottom of the chamber, using a flexible gauge, should be as follows:
1. Maximum 2.375"
  2. Minimum 1.125"
- (4) Inspection and oiling periods. Bearings of this type, if in good condition, properly packed with ling-fibre wool waste, and supplied with a good grade of oil, should run from 1,000 to 1,100 miles between oiling periods. It is advisable for each operator to work out in actual service the most suitable oiling schedule to fit the operating conditions of his equipment. Such a schedule may be determined largely by the system of inspection of the other equipment on the traction unit. When inspecting bearings, carefully wipe all dirt from the oil box lid before it is opened.
- (5) Repacking periods. Repack the bearings after they have been in service for 50,000 miles as a maximum, or at least once a year. When repacking bearings, remove all the waste and discard that which is glazed and charred; refill the bearings with good, clean, oil waste to which has been added sufficient new waste to allow for any old waste discarded or destroyed. About once in three months, TEASE UP the waste in the bearings to make it more efficient.

(6) Precautions.

- (a) Use long fibre wool waste. Keep waste TEASED UP.
- (b) Use waste that has been well saturated with clean oil.
- (c) Use a clean oil of high quality and correct grade.
- (d) Keep oil and waste in closed cans.
- (e) Pour oil in the oil well.
- (f) See that oil box lids are closed.
- (g) Do not flood bearings with oil.

c. *Gear Lubrication.* The teeth of the gear and pinion should never appear dry, but should be well covered with lubricant.

**40. Main Journals**

a. Pack the main journals as frequently as service conditions may require.

b. Use a good grade of wool waste soaked in oil, as specified on figure 5, for at least 24 hours and drained for about 6 hours. Keep the temperature of the oil and room in which the waste is drained at about 60° F.

c. Pack a roll of drained waste, marked A on figure 7, tightly half-way around the journal at the back end and bottom of the box as shown. Place packing marked B in position with moderate pressure against the journal but sufficient to make good contact, applying the waste somewhat looser at the sides of the box to prevent wiping effect. The packing should not extend higher than the center of the journal.

d. After packing is completed, pour free oil over the waste along the sides of the box near the center. Place a wad of semidry waste C, figure 7, between the end of the journal and front end of the box as shown, the purpose of which is to serve as a dirt collector and can easily be renewed as required.

**41. Air Compressor**

Refer to TM 55-2034 and figure 5 for lubrication instructions.

**42. Airbrakes**

Refer to TM 55-2029 and figure 5 for lubrication instructions.

**43. Diesel Engines**

Refer to TM 55-1046 and figure 5 for lubrication instructions.

**44. Miscellaneous Equipment**

Figure 5 covers complete lubrication instructions for all equipment not included in the above paragraphs.

### Section III. GENERAL MAINTENANCE

#### 45. Electrical Equipment

a. Maximum service can be obtained from electric machinery only when it is kept dry and clean. This is especially true when copper dust, brakeshoe dust, or other metallic matter may collect in or about the apparatus. Blow out all apparatus periodically using dry compressed air and wipe off parts accessible with clean wiping rags. Washed wiping rags are preferable to cotton waste as they are less liable to leave lint. When using air for cleaning in the vicinity of exposed mica insulation, do not use too high pressure as small flakes of mica will be blown off, finally resulting in complete destruction of the insulation.

b. Oil is very destructive to insulating materials as it collects dust and dirt causing them to break down electrically. When lubricating apparatus take extreme care to prevent the lubricant from getting on insulated parts and if any does get on thoroughly wipe off with clean wiping rags.

c. Keep all screws, bolts, and nuts which secure electrical connections clean and tight to insure good contact. When making a ground connection, thoroughly clean the surface to which connection is to be made of all dirt, paint or rust to assure good electrical contact.

d. Paint all cables exposed to dirt and moisture, especially where creepage is important, with electrical-insulation varnish conforming to Military Specification MILV-1137A. This varnish has high insulating qualities and gives a smooth surface which is easily cleaned.

#### 46. Control Equipment

a. Check control equipment periodically for:

- (1) Loose nuts and screws.
- (2) Cotter pins missing or not split.
- (3) Broken or weak springs.

- (4) Weak contact pressure on interlocks and relay contacts.
- (5) Grease and dirt on insulating materials.
- (6) Worn or burned contactors.
- (7) Loose terminals and connections.
- (8) Broken insulators.

b. When painting control equipment use insulating varnish as specified in paragraph 45d.

#### 47. Running Gear and Auxiliaries

Inspect the trucks and other parts of the running gear equipment as frequently as service conditions may require for loose and missing bolts and nuts, worn wearing plates, worn or broken bearings, defective gears and gear cases, broken springs, etc.

#### 48. Water Cooling System

a. Before filling the system be sure that the drain valves and drain cocks are closed. Use only clean, soft water as free as possible from scale forming minerals. If it is impossible to obtain soft water, treat the available water with some commercial water softener.

b. Replenish the water supply as required to make up the loss from leakage and evaporation.

c. The cooling system is drained by opening all drain valves and shutoff valves wherever they occur in the water piping. Make sure that all parts of the system, including engine block and any water cooled auxiliaries are drained. Refer to TM 55-1046 for instructions for draining the engine.

d. Drain the cooling system periodically to remove the dirt and sediment which accumulates. This should be done at the end of the day's run when all the material is in suspension and will drain with the liquid.

### Section IV. PREVENTIVE MAINTENANCE SERVICES

#### 49. Inspection

a. *Daily Reports*

- (1) Reports by the locomotive operator will be prepared on DA Form 55-226. They serve as the only means for indicating the proper functioning of the equipment. These reports will be thorough and are

required from every man regularly operating the unit.

- (2) The report will cover any special features noticed: such as air leaks, tight brakes, improper functioning of meters and gauges, unusual engine noises, exhaust leaks and exhaust appearance, oil leaks, lubricating oil added, any work

done, engine oil and water temperatures (maximum and average), lubricating oil pressure (idling and full speed), trailing load and engine-cylinder temperatures if pyrometers are installed, etc.

- (3) These reports are valuable and each item will be followed up by the maintainer and the trouble remedied immediately. Abnormal variations in engine-water and oil temperatures, quantities of oil used, engine noises, exhaust pipes overheating, excess current, flashover, etc., will be investigated at once.
- (4) Successful operation of internal combustion engine equipments depends, to a great extent, upon immediate correction of little troubles. If this is done, the overall expense for maintenance will be low.

*b. Inspection Schedule.*

- (1) Inspection work sheets for use in connection with inspection and maintenance of Department of the Army diesel locomotives will be prepared on the appropriate DD Form 862, DD Form 863, and DD Form 864.
- (2) These forms outline procedural steps to be followed in the daily, monthly, quarterly, semiannual and annual inspection of the locomotive. By their use, a progressive program of preventive maintenance is accomplished.
- (3) Correct any defects observed during operation at the inspection period; when required, make correction at the time of failure.

## 50. Sequence Test of Control Equipment

In order to test for the correct functioning of each switch contactor and relay, and to determine if the operation of each unit is in proper sequence with the other units, refer to figure 44 and proceed as follows:

*a. Preliminary.*

- (1) Insulate the main contacts of the G switch.
- (2) With engine dead, close the battery switch.
- (3) Charge the air system and see that air is furnished to the pneumatic apparatus.
- (4) Place the reverse handle of the controller in OFF and the throttle handle in OFF.

*b. Starting Circuit Sequence Check.*

- (1) Close the control circuit breaker.

- (2) Push engine start buttons. Nothing happens.
- (3) Move REVERSE lever to ENGINE ONLY.
- (4) Push No. 1 start button.
  - (a) G1 closes.
  - (b) BP opens.
  - (c) BS closes.
  - (d) G closes.
- (5) Release No. 1 start button.
  - (a) G1 opens.
  - (b) BS opens.
  - (c) G opens.
  - (d) 13P closes
- (6) Repeat (4) and (5) using No. 2 start button and G2 in place of G1.
- (7) Move REVERSE lever to FOR and REV and push start buttons in each position and note that nothing happens.
- (8) Push relay BP1 closed and release. BP opens and holding coil holds BP1 closed.
- (9) Open battery switch. Relay BP1 opens and BP closes.
- (10) Repeat (8) and (9) using BP2 instead of BP1. Other sequence remains the same.

*c. Main Circuit Sequence Check.*

### Caution

**In some of the tests following, it is required to push relays closed. Do not touch the apparatus with the hands, but use a piece of wood or other insulating material.**

- (1) Move reverse handle to FORWARD and move throttle handle to No. 1 notch. Reverser throws to FORWARD. P1, P2, P3, P4, BF1 and BF2 close. The throttle operator does not operate.
- (2) Move throttle handle to No. 2 notch. TH3 and TH23 operate.
- (3) Move handle to No. 3 notch. TH1 and TH21 operate; TH3 and TH23 return to normal. BF1 opens.
- (4) Move handle to No. 4 notch. TH1 and TH21, TH3 and TH23 operate.
- (5) Move handle to No. 5 notch. TH2 and TH22, T113 and TH23 operate. TH1 and TH21 return to normal. BF2 opens.
- (6) Move handle to No. 6 notch. TH1 and TH21, TH2 and TH22 operate. TH3 and TH23 return to normal.

- (7) Move handle to No. 7 notch and all throttle operator valves operate.
- (8) Close T1 by hand. M1, M2, M3 and M4 close.
- (9) Release T1. M1, M2, M3 and M4 open.
- (10) Repeat (8) and (9) using T2 instead of T1.
- (11) Return throttle handle to OFF. All P contactors open. Throttle operator returns to idle position.
- (12) Repeat (1) to (11) with reverse handle in REVERSE and note that reverser throws to reverse. Other sequence should be the same.
- (13) Note that the sander switch operates the sander valve corresponding to the reverser position.
- (14) If possible check that the stop buttons operate the engine shutdown valves.
- (15) Check multiple unit feature by running the above test on a locomotive controlled by another. Check the remote engine stopping circuits for operation as described under "Multiple Unit Operation." If this is not possible, be sure wiring to receptacles is checked by using a bell ringer.

## 51. Testing Motor Rotation

a. Every time the traction motor leads or the power terminals to the reverser are disconnected test the motors for correct rotation when reconnected.

b. This test is very important as it is possible for a locomotive to apparently operate correctly in either direction and still have been incorrectly connected which may eventually produce serious and costly motor trouble.

c. For example, if a field and armature lead of a motor are interchanged the motor would operate correctly when the locomotive was moved in one direction but in the opposite direction the motor field would be cut out by the action of the reverser. If this condition were to continue in service for some time before being found it would probably result in a "roasted out" motor.

d. To make this test, operate the locomotive on the least possible number of motors. This may mean opening cutout switches or shutting down a power plant.

e. If the locomotive can be operated with only one motor the test is very simple. Run the locomotive in the forward direction for a short distance, reverse it and operate in the reverse direction. If the locomotive operates approximately the same in both directions the connections are correct. Repeat with all other motors on the locomotive operating them one at a time.

f. If it is impossible to operate on one motor at a time the following procedure will be followed. Oil the track on which the locomotive is to operate spreading the oil on both rails. Then operate the locomotive (on as few motors as possible) on this section of track in the forward and reverse directions until each of the motors operating has slipped its wheels in both directions. Repeat this same test on the other motors until all motors have slipped their wheels in both directions.

g. The following combinations are the ones most likely to be encountered in making these tests.

- (1) The motor or motors operate the locomotive in the direction indicated by the reversing lever. This indicates the correct connections.
- (2) The motor or motors operate the locomotive in the opposite direction to that indicated by the reversing lever. This can be caused by the reversal of leads to the reverser or by the motor being hung on the opposite side of the axle from that assumed on figure 44. If the reverser leads are interchanged, correct at the reverser. If the latter, interchange the motor field leads at the motor lead connectors and repeat tests.
- (3) One motor tending to drive its axle in one direction and another trying to drive in the opposite direction. If reverser wiring agrees with figure 44, interchange the field leads of the proper motor so the locomotive will operate according to the reverser handle position.
- (4) A motor may operate the locomotive correctly in one direction but slowly or not at all in the opposite direction. This is usually caused by the interchanging of an armature and field lead. Such an error will give correct operation in one direction but will cut the field out of the circuit entirely in the opposite direction. If the two motors are tested at one time,

this motor may act as a brake and try to keep its axle from turning. Check figure 44 and correct at the proper place.

h. In correcting any of the above troubles check with the locomotive diagram, figure 44, and correct the circuit at the proper point. This will avoid future confusion caused by the locomotive wiring not agreeing with the diagram.

## 52. Insulation Tests

### a. *New Equipment.*

- (1) The main generator armature circuit, including the commutating field, and the traction motor circuits and apparatus connected thereto, when assembled on a new equipment should withstand an insulation test of 1,800 volts, alternating current, for a period of 60 seconds to ground.
- (2) All control and auxiliary generator circuits, and apparatus connected thereto except meters and storage battery on new equipment should withstand 800 volts,

alternating-current, for 60 seconds to ground.

b. *Old Equipment.* On equipments which have been in service, it is not considered necessary or advisable to apply the same insulation tests as on new equipments and the following tests are commonly used:

- (1) Main circuits 800 to 1,000 volts, ac, 60 seconds.
- (2) Control circuits 500 volts, ac, 60 seconds.

### Caution

**On locomotives equipped with ground relays, open the ground relay cutout breaker before applying insulation tests to the main circuits.**

c. *Insulation Resistance.* When locomotives are placed in service, the insulation resistance of the power circuits of the generator and traction motors should be at least 1 megohm. If moisture and conducting particles have affected the insulation resistance before the locomotive is placed in service, this circuit should be thoroughly dried out by running at light load and low engine speed and rechecked for insulation resistance.

## Section V. TROUBLESHOOTING

### 53. General

a. A general study of this manual and the actual equipment will enable the operator to diagnose and care for many minor cases of trouble. Some troubles can be corrected by the operators but some obviously have to be remedied by the maintainers. In general the equipment should not be operated under conditions that will result in serious damage to parts. Correct all troubles promptly to obtain the longest life of all parts.

b. If the purpose and proper function of each part of the equipment is learned it will assist in the quick location and remedy of trouble.

### 54. Generator Fails to Crank Engine

If instructions for starting the engine have been observed and the engines fail to start, the trouble may be due to the following:

a. *Low Battery Voltage.* This is indicated by failure of the starting contactors to close or by failure of the starting motor to bring the engine up to firing speed; check battery charge and examine for corroded terminals.

b. *Failure of Contactors to Close.* If fuses are good and battery is charged, check for open circuits in the control wiring. Also check the contacts on the push button.

c. *Starting Switches Close but Engine does not Start.* Check for open circuit in wiring, inspect switch contacts and fuse.

### 55. Falling Off of Power

a. A decrease in engine power should become manifest to the operator by failure to obtain the usual speed with a given load on a given part of the run, or by character of engine noise or by meter indication.

b. The falling off of power may be due to engine conditions. For possible remedies, refer to TM 55-1046 and TM 55-1046-1.

### 56. Loss of Power Indicated by Overspeeding of Engine

a. May be due to failure of the field contactors to operate properly. Check for open circuits in wiring or poor or dirty or corroded contacts on switches.

b. Check for broken or loose wiring at the resistors. Check closing of battery charging contactor.

c. Check wiring and fingers at terminal boards, controller, throttle device, etc.

d. Check line switches to insure that they close properly with good contacts. Failure of line switches to close may be due to poor finger of interlock contact at reverser or controller or failure of reversal to throw to correct position.

#### **57. Complete Failure of Electrical Power**

a. *No Voltage on Main Generator.* The cause may be due to the failure of the field switches to close, burned out resistors in the main or auxiliary generator field circuits or open circuits elsewhere in the field circuit.

b. *Failure of Reverser to Throw (Pneumatic Types).* Throw reverser by hand.

c. *Open Circuit in Control Wires.* Check fingers on controller, interlock fingers on the reverser and control wiring connections.

d. *Faulty Contactor Operation.* May be due to too wide an air gap on magnetic switches, or binding which prevents free movement and good contact.

#### **58. Miscellaneous Troubles**

a. If the engine is running at full speed and load, and the locomotive does not make its usual speed, the trouble may be due to: dragging brakes, airbrake not fully released, head winds, or hot truck journal bearings, or traction motor axle or armature bearings.

b. Do not operate with inadequate supply of lubricating oil nor with insufficient cooling water. Watch for excessive temperatures, hot bearings, low oil pressure, diluted lubricating oil, insufficient cooling water or clogged cooling system, also abnormal loads. Any of these conditions may cause serious damage to the equipment.

#### **59. Failure of Battery Charging**

Failure of battery charging as indicated by the battery ammeter may be due to:

a. Blown charging fuse.

b. Improper voltage regulator operation.

c. Burned-out auxiliary generator field resistor.

d. Open circuits in wiring.

e. Improper reverse-current relay operation.

#### **60. Compressor Fails to Pump Up Air**

If the compressor does not operate properly check as follows:

a. Check angle and drain cocks, piping, air hose, magnet valves, safety valves and other points for leakage. Check for faulty compressor drive.

b. Faulty compressor valve operation can cause failure to maintain pressure, excessive operation of compressor and overheating. Refer to TM 55-2034 for maintenance instructions.

#### **61. Common Causes of Faulty Operation**

Some of the most common causes of faulty operation of switches, control and motors of the auxiliary and main apparatus are:

a. *Interlocks and Control Fingers.* Improper contact at interlocks and control fingers caused by dirty gummy contact surfaces due to use of heavy oil, burning (oxidation) and improper adjustment.

b. *Contractors.* Too wide an air gap (contact opening) resulting in an unnecessarily high closing voltage, binding at bearings, loose shunts or loose springs. Low control pressure or leaky valves on remotely operated devices.

c. *Motors.* Bearing troubles due to improper lubrication or excessive wear; brushholders loose, broken, or assembled too close to commutator; brushes greatly worn, binding, or improper grade; loose connections, broken springs, chafed leads.

d. *General.* Excessive vibration causing breakage; loose connections at terminals, fuses, etc.; blown fuses.

### **Section VI. HIGH POTENTIAL TESTS**

#### **62. General**

Whenever diesel-electric locomotives operate under Interstate Commerce Commission regulations, they must comply with the requirements given in paragraph 253 of ICC regulations for inspection and testing of locomotives other than steam, governing

periodic high potential tests on circuits and windings carrying current of potential over 150 volts. It is mandatory that these tests be performed on all Department of the Army diesel locomotives on an annual basis, and after general overhaul or extensive repairs to the electrical apparatus.

### 63. Preparing for Tests

To prepare the locomotive for these tests, refer to figure 44 and proceed as follows:

- a. Disconnect wires from main ammeters, battery ammeters, charging ammeters, and main voltmeters.
- b. Disconnect cab heater from circuit because of internal radio suppression capacitors. This is accomplished by disconnecting wires 99 and N.
- c. Disconnect all capacitors from the auxiliary generator brushholders to ground.
- d. Disconnect voltage regulators from system, due to radio suppression components. This is accomplished by disconnecting leads 30, 31, 32, and 33 from voltage regulator No. 1 end and leads 34, 35, 36, and 37 from voltage regulator No. 2 end.
- e. Disconnect the grounded lead from the ground relay cutout circuit breaker.
- f. Disconnect all indicating lights from circuit.  
This includes wheel slip indicating light, ground alarm light, both engine warning lights, and battery parallel indicating light.
- g. Disconnect all battery leads at battery.
- h. See that all disconnected leads are not grounded.

### 64. Application of Test

- a. Manually place reverser in forward or reverse position.
- b. The maximum high voltage for the main generator and traction motors for this equipment is 200 volts. A dielectric test of not less than one minute duration shall be applied to all circuits and parts carrying current with potential of more than 150 volts.
- c. The voltage applied to circuits other than motor or generator windings shall be not less than 75 percent above the normal working voltage; the voltage applied to windings shall not be less than 50 percent above the normal working voltage.
- d. Apply 50 percent over voltage between ground (locomotive frame) and G+ for one minute and note that no breakdown occurs.
- e. Apply 50 percent over voltage between ground (locomotive frame) and each traction motor armature and field lead connection for one minute and note that no breakdown occurs.
- f. Make a careful examination of any weakness indicated and remedy all defects before locomotive is put in service.

## Section VII. TRACTION GENERATOR

### 65. General Data

- a. *Operating Limits (Maximum).*
  - (1) Safe rpm ..... 1,450
  - (2) Volts ..... 350
  - (3) Amperes..... 1, 300
  - (4) Shunt field amperes ..... 11.0
  - (5) Battery (auxiliary) field amperes ..... 2.0
- b. *Brushes.*
  - (1) Brush arms per generator..... 6
  - (2) Brushes per arm..... 3
  - (3) Grade of brushes ..... National AX-5
  - (4) Size of brushes (inches).....  $\frac{3}{4} \times 1 \frac{3}{4} \times 2 \frac{1}{4}$
  - (5) Brush tension (pounds) with full length brush..... 6  $\frac{1}{2}$  to 8
- c. **Resistance of Winding (ohms at 25° C.)**
  - (1) Armature..... 0.0077
  - (2) Commutating field ..... 0. 0048
  - (3) Series field..... 0.0029
  - (4) Shunt field ..... 19.70
  - (5) Battery field..... 13.39
- d. *Weights (Pounds).*
  - (1) Generator complete ..... 3,125
  - (2) Armature and shaft..... 1,255
- e. *Bearing.*

Type ..... Railway, Free Fit Ball Bearing

- f. *Normal Pole Bores at (Center of Poles (in.))*
  - (1) Main poles..... 17.180
  - (2) Commutating poles ..... 17. 500

### 66. Description

- a. This generator is shunt-wound, direct-current machine of standard railway construction including a single, housing-supported, antifriction bearing at the front end. It is arranged to be directly connected, through a flexible coupling, to the engine flywheel.
- b. The machine is self-ventilated, air being drawn through openings at the commutator end, circulated through the armature ducts and around the field coils, then discharged by a fan through air outlets at the coupling end.
- c. Four field windings are provided on this machine.
- d. The commutating field is a separate winding from the other three.

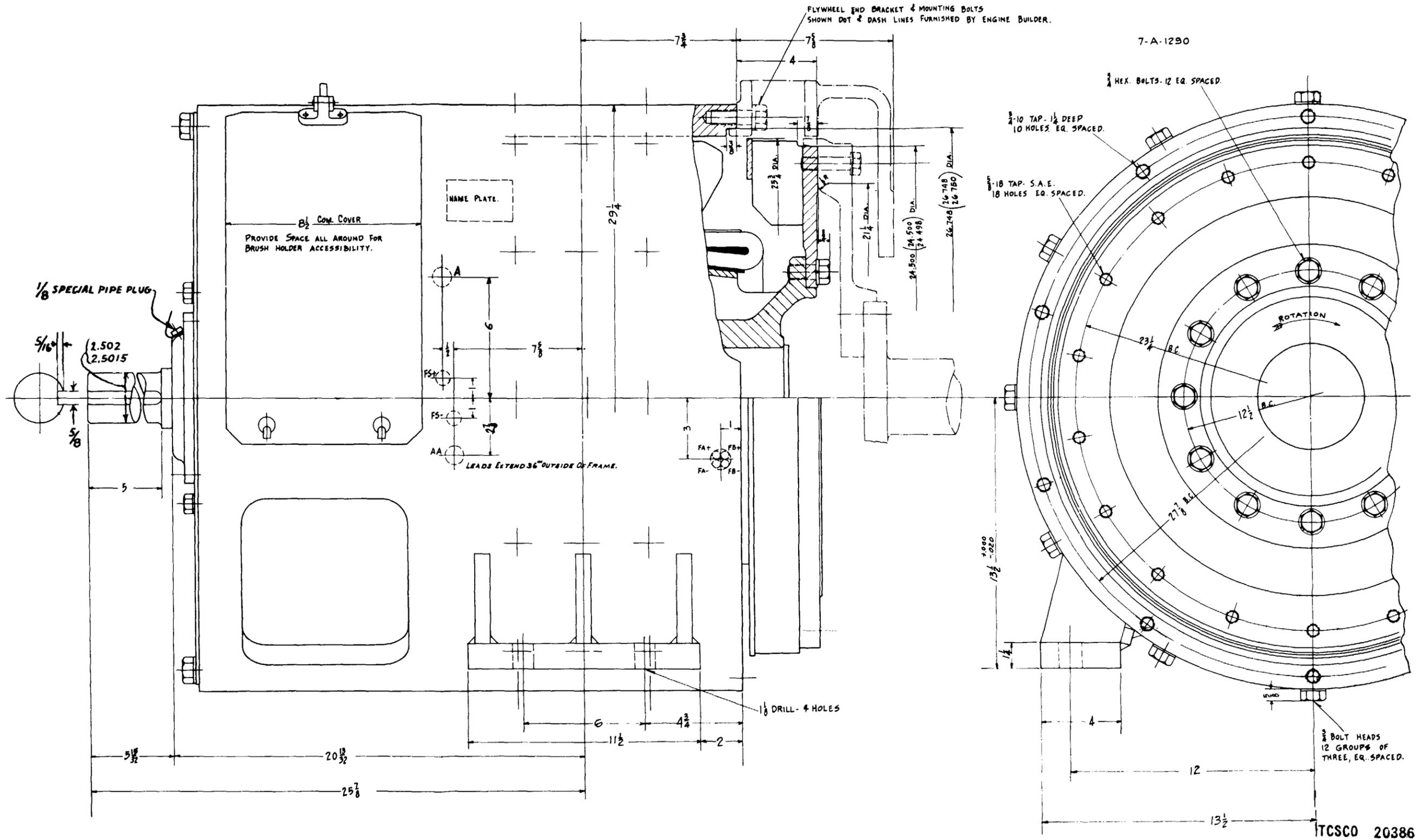


Figure 8. Traction generator outline.

e. In addition to the main shunt field, an auxiliary field and a series field are mounted on the main field poles.

f. The auxiliary field is energized from a battery source, to provide separate excitation for the generator, thus assuring more rapid and positive buildup of generator voltage and improving the voltage regulation for application to this particular class of service.

g. The series field is supplied to be available for starting service in those cases where the generator is used as a motor when starting the engine.

## 67. Cleaning

a. Keep the generator clean and dry. Keep the generator free from dust by occasionally blowing it out with dry compressed air or a hand bellows.

If high air pressure is used do not hold the nozzle of the air hose too close to the windings as the pressure may damage the insulation tape.

b. Wipe as much as possible of grease, dirt, or oil from the windings with a dry cloth. Cleanse with rags moistened with solvent. Dry the windings thoroughly with clean, dry cloths. Parts which are inaccessible to the hand, may be cleaned with a swab moistened with a solvent.

## 68. Bearings

a. The generator is equipped with a single bearing at the commutator end. Refer to paragraphs 37 through 44, for lubrication instructions.

b. At periods ranging from one to three years, take the outer bearing cap off and remove the old grease from the bearing and grease chamber by a wash consisting of equal parts of kerosene and denatured alcohol. Remove all caked or hardened grease. Remove the cleansing liquid by washing with a hot, light oil before repacking the bearing with new grease.

## 69. Brushholder and Brushes

a. The brushholder and brushes can be inspected by removing the commutator cover. Inspect at least once a month to be sure that the presence of grit or dirt has not caused any of the brushes to stick in the brushholders and that the proper spring tension is maintained at the value specified in paragraph 65.

b. Discard brushes when they have worn in length to such an extent that the brush pressure finger will come within one-eighth of an inch of the end of its travel by the time of the next inspection.

c. Brush thickness is very important and the clearance of a new brush in the holder should be approximately 0.004 to 0.010 of an inch. If the clearance is much less than the minimum the carbon will tend to stick in the box and if over 0.025 of an inch the brush will rattle wear away its sides and chip or break. The width of a brush is not so important as it may have as much as one-sixteenth of an inch clearance in the box without causing trouble.

d. Brush pressure on the commutator is maintained by means of flat clock-type springs which exert pressure on fingers which rest on top of the brushes. Brush pressure can be measured by attaching a small spring balance to each pressure finger directly over the brush and pulling straight up in line with the brush travel until the finger is just lifted clear of the brush.

e. If the brush pressure is incorrect, remove the brushholder and adjust as follows:

- (1) Insert a piece of one-eighth of an inch diameter drill rod in one of the holes in the tension barrel for the spring requiring adjustment and relieve the tension on the cotter pin.
- (2) Remove the cotter pin, increase or decrease the tension as required, and replace the cotter pin.

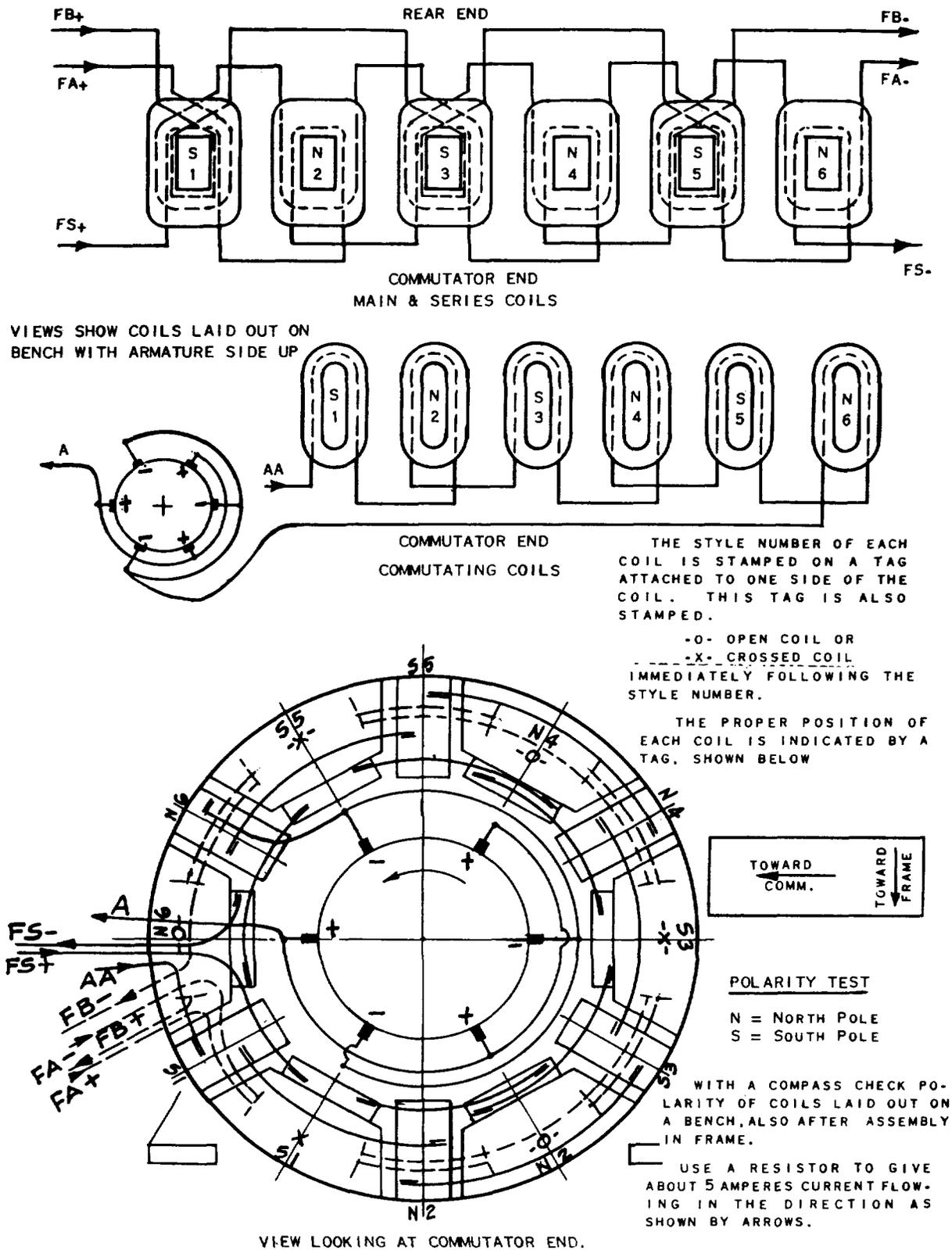
f. Keep the under side of the brushholder carbon box within one-eighth of an inch of the commutator to reduce chances of brush breakage. Adjustment can be made by loosening the clamping block bolt and moving the brushholder to the correct position. A fibre sheet of the proper thickness makes a handy gauge.

## 70. Commutator

a. A commutator which is taking on a polish and shows no signs of wear, does not require any attention.

b. If the commutator is roughened, badly worn, or burned, remove the armature and place in a lathe, then turn, grind or stone to give a uniform surface, after which the mica must be re-grooved with special saws.

c. The mica insulation between the copper segments is grooved or undercut initially to a depth of 3/64-inch; as the commutator wears, or if it is turned or ground, the grooves should be maintained since high mica will spoil the brush fit and



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Figure 9. Traction generator field wiring diagram.

cause sparking. Undercutting can be done to the best advantage by the use of one of the small power-driven saws which are built for this purpose.

d. After the commutator has been turned or stoned and undercut, the burrs which are always formed on the edges of the bar during the process, will be carefully removed with a three-cornered cutting tool, the ends of the commutator bars rounded, the slots cleaned out, and the commutator finally polished with fine sandpaper and then blown off with compressed air. Lift the brushes when smoothing a commutator in the machine and do not replace until all grit has been removed. Never use emery cloth or emery paper on a commutator.

## 71. Dismantling and Assembling Generator

a. *Dismantling Generator from Engine.* In case it is necessary to make internal repairs to an armature, bearing, or field coils, the following procedure will be followed in taking the generator apart.

- (1) Remove electrical connections between the generator and other apparatus.
- (2) Remove all the bolts holding the coupling disk to the flywheel.
- (3) Remove all the bolts holding the generator frame to the engine bell housing.
- (4) Remove the bolts holding the generator supporting feet to the locomotive mountings.
- (5) Slide the generator away from the engine and insert fiber wedges between the armature and poles to prevent the armature from rubbing the poles.
- (6) The complete generator may now be lifted from its mountings and removed from the locomotive.

b. *Removal of Armature.*

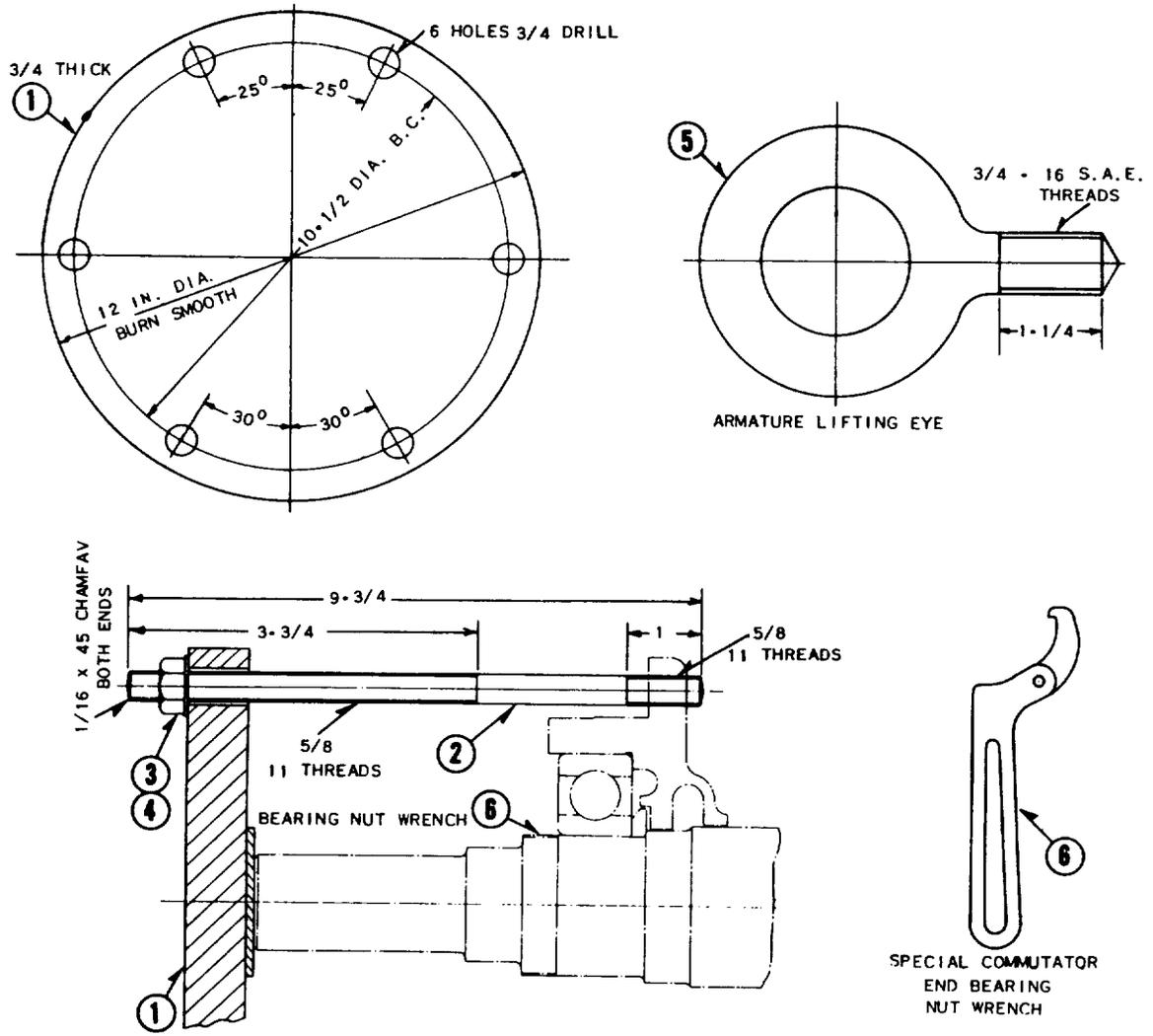
- (1) When necessary to remove the armature from the generator, first dismantle the generator from the engine as described in the preceding paragraph.
- (2) Lift the brushes far enough out of the brush box that they will not slide back on the commutator.
- (3) Protect the commutator by wrapping it with heavy fishpaper.
- (4) Remove the bolts holding the coupling disk to the generator coupling flange. This allows the coupling disk and fan

assembly to be removed and will permit handling of the armature with ropes, without damage to the disks.

- (5) Remove the bolts that hold the front bearing cartridge in the housing.
- (6) Insert the two armature removal studs in two of the tapped holes in the cartridge. These studs are not furnished with the generator, but can be made similar to the long studs shown on the tool drawing, figure 10. These studs help to keep the commutator from striking the brushholders.
- (7) The armature can now be removed from the generator by passing a heavy rope around the armature and moving the armature slowly toward the coupling end of the generator. A piece of pipe will be needed over the shaft extension at the commutator end to permit sliding the armature through the frame far enough that it can be handled entirely from the other end. Care must be taken that the armature does not rub the poles during this operation, and that the commutator does not rub the brushholder box.

c. *Removal of Armature Bearing.* Refer to figure 11 as a guide for proper removal of the bearing.

- (1) Remove the armature from the generator as described in preceding paragraph and block in a horizontal position.
- (2) Remove the bolts which hold the outside bearing cap to the cartridge and remove the cap.
- (3) Straighten the lockwasher and remove the bearing locknut using the special spanner wrench shown on figure 10.
- (4) Pull the bearing and inner grease thrower, using the special puller tool shown on figure 10. Screw the four studs into the cartridge; place the single plate over the studs against the end of the shaft and tighten the nuts evenly on the outside of the plate until the bearing assembly is pulled from the shaft.
- (5) Remove the bearing from its push fit in the cartridge; if necessary, tap lightly around the cartridge with a rawhide mallet.



ITEM	DESCRIPTION AND DIMENSIONS IN INCHES	REQ.
1*	PLATE. FROM 3/4 x 10-3/4 x 10-3/4 STEEL PLATE (BURN SMOOTH TO .12 DIAMETER) .. . . . . .	1
2	STUD. FROM 9-3/4 OF 5/8 DIAMETER STEEL BAR. . . . .	4
3	5/8-11 HEXAGON STEEL NUT . . . . .	6
4	5/8 STANDARD STEEL WASHER. . . . .	6
5	LIFTING EYE. FROM 3/4 EYE BOLT BLANK, S.A.E. THREAD, 3/4-16, 1-1/4 INCH THREAD LENGTH.	2
6	ADJUSTABLE COMMUTATOR NUT WRENCH.	1

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Figure 10. Traction generator bearing puller tools.

- (6) Wrap the bearing in a protective covering leaving the grease in the bearing.

The grease in the bearing will serve to prevent rusting. The bearing must be well cleaned and inspected before reassembly.

*d. Assembling Armature Bearing.* Refer to figure 11 as a guide for proper bearing assembly.

- (1) Block the armature in a horizontal position.
- (2) Clean all parts thoroughly before starting to assemble. Carefully inspect the bearing for cracks, pitting or excessive wear.

#### **Caution**

**Care must always be taken to keep all dirt and grit away from the ball bearing.**

- (3) Place the inside grease thrower and bearing in a high-temperature oil at a temperature of 100° C. (212°F.). Support these parts approximately two inches above the bottom of the oil container to allow dirt to drop below the bearing and to prevent the heat from striking the bearing directly.
- (4) Pack the grease pocket in the bearing cartridge half full with grease. Place the cartridge over the shaft and slide it all the way back against the commutator.
- (5) Remove the grease thrower from the hot oil, wipe off the excess oil. Shrink the thrower on the shaft with the chamfered side out and hold it in place solidly against the shoulder on the shaft with a bucking-up tool until it has cooled.
- (6) Remove the bearing from the hot oil; wipe off the inner and outer fits and slip into place on the shaft. Hold the bearing solidly against the grease thrower until tight.
- (7) Apply the bearing lockwasher and locknut and lock securely.
- (8) Fill the spaces between the balls in the bearing with grease as specified on figure 5.
- (9) Allow the bearing to cool so as to be contracted; then slide the cartridge into place over the bearing.

- (10) Pack the lower half of the grease pocket in the outer bearing cap full with grease. Place the cap and gasket in place and bolt to the cartridge.

- (11) Some portion of the grease in the bearing cap must make contact with the bearing when assembled.

- (12) Check to make sure that the grease fitting is not damaged.

*e. Assembling Generator.*

- (1) Assemble the generator in a horizontal position.

- (2) Protect the commutator by wrapping it with heavy fishpaper.

- (3) When placing the armature back in the frame the two armature removal studs inserted in the tapped holes of the bearing cartridge act as a guide to bring the bearing cartridge into position, thus lining up with the bolt holes in the housing.

- (4) Lift the armature with a heavy rope around the core and move it slowly into the frame. Use a piece of pipe over the shaft extension at the commutator end to guide the armature into place. Take care that the armature does not rub the poles and that the commutator does not rub the brushholder boxes.

- (5) It may be found that some force is needed to pull the bearing cartridge into place in the commutator end housing. To obtain this force use two bolts (longer than the bolts regularly used for holding the cartridge to the housing) to pull the bearing cartridge close enough to its final position in the housing that the regular bolts can be put in and tightened.

- (6) Replace the coupling disk and the fan assembly.

- (7) Remove the fishpaper from around the commutator and lower the brushes.

*f. Lining-up Single-Bearing Generator with Engine.*

- (1) See that the contact faces of the generator coupling disk, the engine flywheel and the bell housing fits are clean with no burrs or rough spots.

- (2) Check the coupling face of the engine flywheel to make sure it is perpendicular to the axis of the crankshaft. This is best done by fixing a surface gage rigidly to the engine bedplate and recording the

**NOTE:**

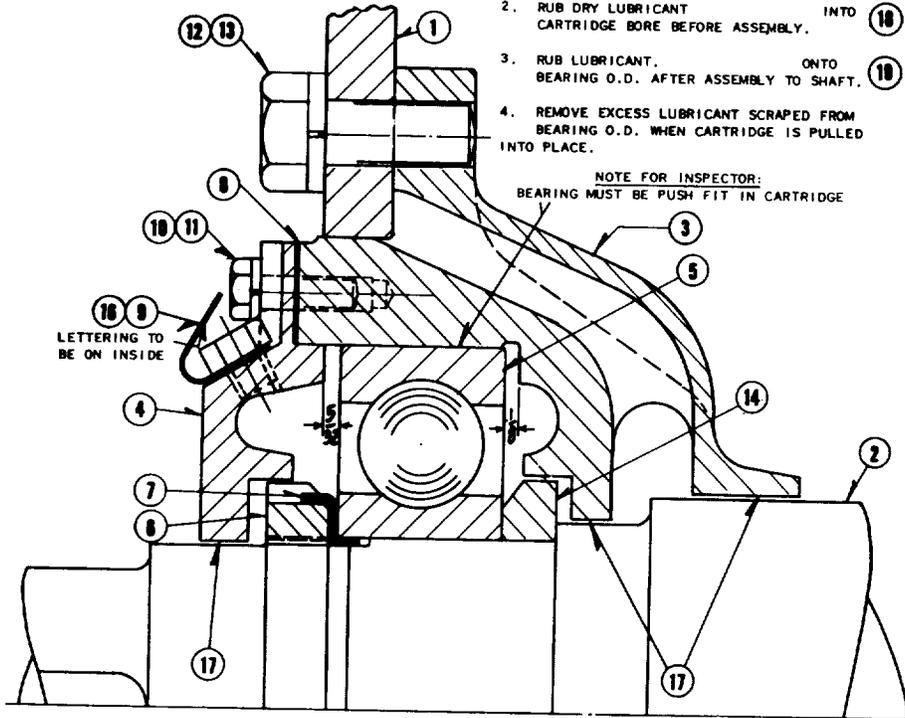
1. ASSEMBLE AND LUBRICATE BEARING

2. RUB DRY LUBRICANT INTO CARTRIDGE BORE BEFORE ASSEMBLY. **18**

3. RUB LUBRICANT ONTO BEARING O.D. AFTER ASSEMBLY TO SHAFT. **18**

4. REMOVE EXCESS LUBRICANT SCRAPED FROM BEARING O.D. WHEN CARTRIDGE IS PULLED INTO PLACE.

NOTE FOR INSPECTOR:  
BEARING MUST BE PUSH FIT IN CARTRIDGE



ITEM	DESCRIPTION AND DIMENSIONS IN INCHES	REQ'D
1	BEARING HOUSING, COMMUTATOR END . . . . .	1
2	GENERATOR SHAFT . . . . .	1
3	BEARING CARTRIDGE . . . . .	1
4	BEARING CAP . . . . .	1
5	FREE FIT BALL BEARING (SEE GENERAL DATA) . . . . .	1
6	BALL BEARING LOCKNUT (80-M/M) . . . . .	1
7	BALL BEARING LOCKWASHER (80-M/M) . . . . .	1
8	GASKET FOR BEARING CAP . . . . .	1
9	1/8 SPECIAL GREASE PLUG . . . . .	1
10	5/16-18 X 1 HEX HEAD STEEL BOLT . . . . .	6
11	5/16 STANDARD LOCKWASHER . . . . .	6
12	5/8-11 X 1-3/4 HEX HEAD STEEL BOLT . . . . .	6
13	5/8 STANDARD STEEL LOCKWASHER . . . . .	6
14	GREASE THROWER OR BEARING STOP . . . . .	1
15	BEARING GREASE . . . . .	*10
16	GREASE NAMEPLATE . . . . .	1
17	SEALING GREASE . . . . .	*1
18	DRY BEARING LUBRICANT . . . . .	*1/2
19	PRESS FIT BEARING LUBRICANT . . . . .	*1/2

\* QUANTITIES OF GREASE ARE IN OUNCES

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**Figure 11. Traction generator bearing assembly.**

total eccentricity shown by the gage on the flywheel face in one complete revolution. The total eccentricity should not exceed .0005 inch.

- (3) Support the armature on the lower main pole pieces by strips of fibre 3/32-inch thick, so placed that they can be withdrawn from the generator as it is assembled on the engine.
- (4) The generator should now be adjusted until it is concentric with the engine shaft. The generator fan will now freely enter the engine bell housing.
- (5) Move the generator toward the engine until the coupling fits are just engaged but with the frame free of the engine bell

housing. Insert the coupling bolts and screw in until just snug.

- (6) Remove the fibre strips that were used to support the armature.
- (7) Engage the frame and flywheel fits and insert all frame bolts.
- (8) Gradually tighten bolts, alternating between coupling and frame fits until all bolts are tight, taking precautions so that fits enter without being forced.
- (9) The generator frame and engine bell housing fit must not be pulled home by the coupling bolts. The bell housing bolts must be tightened at the same time that the coupling bolts are being tightened.

## Section VIII. AUXILIARY GENERATOR

### 72. General Data

#### a. Operating Limits (Maximum)

- |                              |       |
|------------------------------|-------|
| (1) Safe rpm.....            | 3,100 |
| (2) Volts.....               | 40    |
| (3) Amperes.....             | 50    |
| (4) Shunt field amperes..... | 5     |

#### b. Brushes.

- |   |                 |
|---|-----------------|
| (1) Number of brush arms.....                               | 4               |
| (2) Brushes per arm.....                                    | 1               |
| (3) Size of brushes (inches).....                           | 3/8 x 1 x 1 1/2 |
| (4) Brush tension (pounds) with full length brush.....      | 1 to 1 1/4      |
| (5) Minimum radial length of carbon when worn (inches)..... | 1               |

#### c. Bearings.

Type.....Railway Type Free Fit Ball Bearings

#### d. Normal Pole Bores at Center of Poles (inches).

- |                            |       |
|----------------------------|-------|
| (1) Main poles.....        | 5.872 |
| (2) Commutating poles..... | 5.872 |

#### e. Weights (Pounds)

- |                                  |     |
|----------------------------------|-----|
| (1) Complete armature, lbs.....  | 85  |
| (2) Complete generator, lbs..... | 200 |

#### f. Resistance of Windings (ohms at 25° C.)

- |                            |       |
|----------------------------|-------|
| (1) Armature.....          | 0.110 |
| (2) Commutating field..... | 0.034 |
| (3) Shunt field.....       | 5.37  |

### 73. Description

This generator is a four-pole, direct-current, commutating-pole, shunt-wound generator arranged for self-ventilation by means of a fan at the rear end of the armature. Shaft extensions are provided at each end.

### 74. Cleaning

Refer to paragraphs 65 through 71 for leaning details.

### 75. Bearings

a. The bearings are held in position on the shaft by the housings and inner bearing cal)s. Refer to figure 5 for lubrication instructions.

b. During assembly or overhaul. grease bearings as follows:

- (1) Refer to figure 13 for bearing assembly details.
- (2) Completely pack all of the internal space in the bearing with grease.
- (3) Fill the lower half of the housing grease chambers with grease.

### 76. Disassembly and Assembly

a. Disassembly and assembly details, also bearing maintenance, will be similar to that discussed in paragraphs 65 through 71.

b. A special puller is shown on figure 14; its use will be apparent from the drawing.

### 77. Brushholders, Brushes and Commutator

For information on maintenance of brushholders, brushes, commutator, etc., refer to paragraphs 78 through 85.

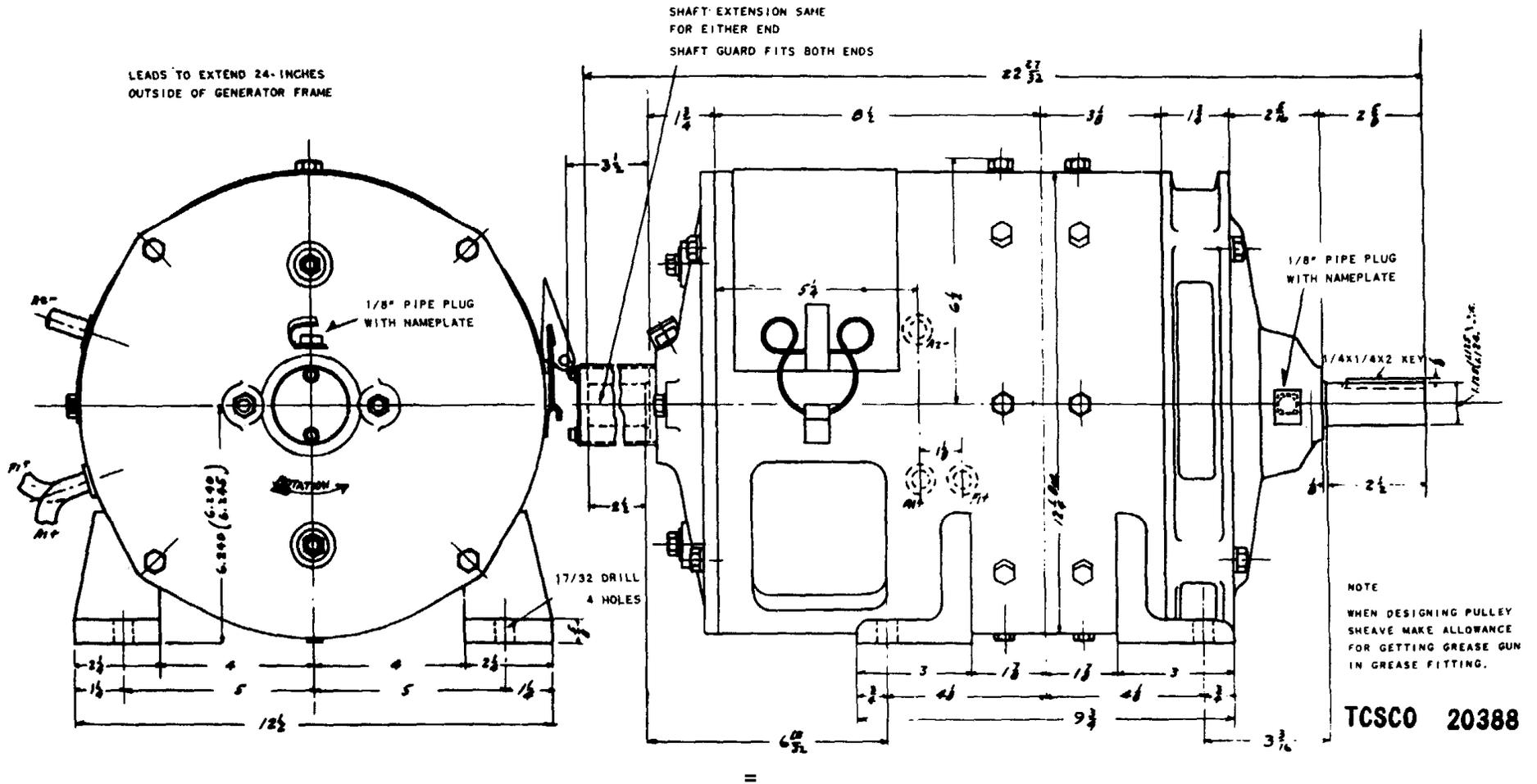
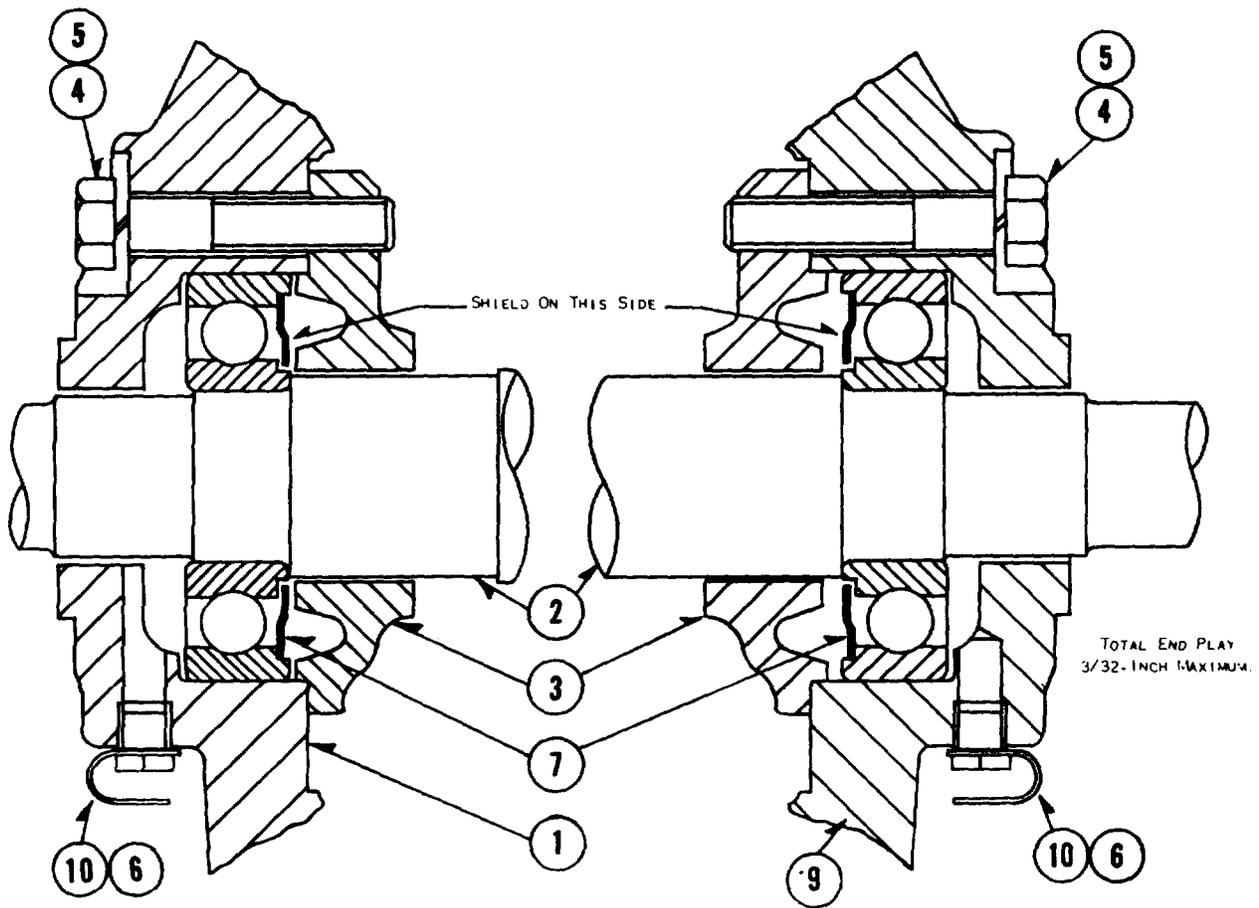


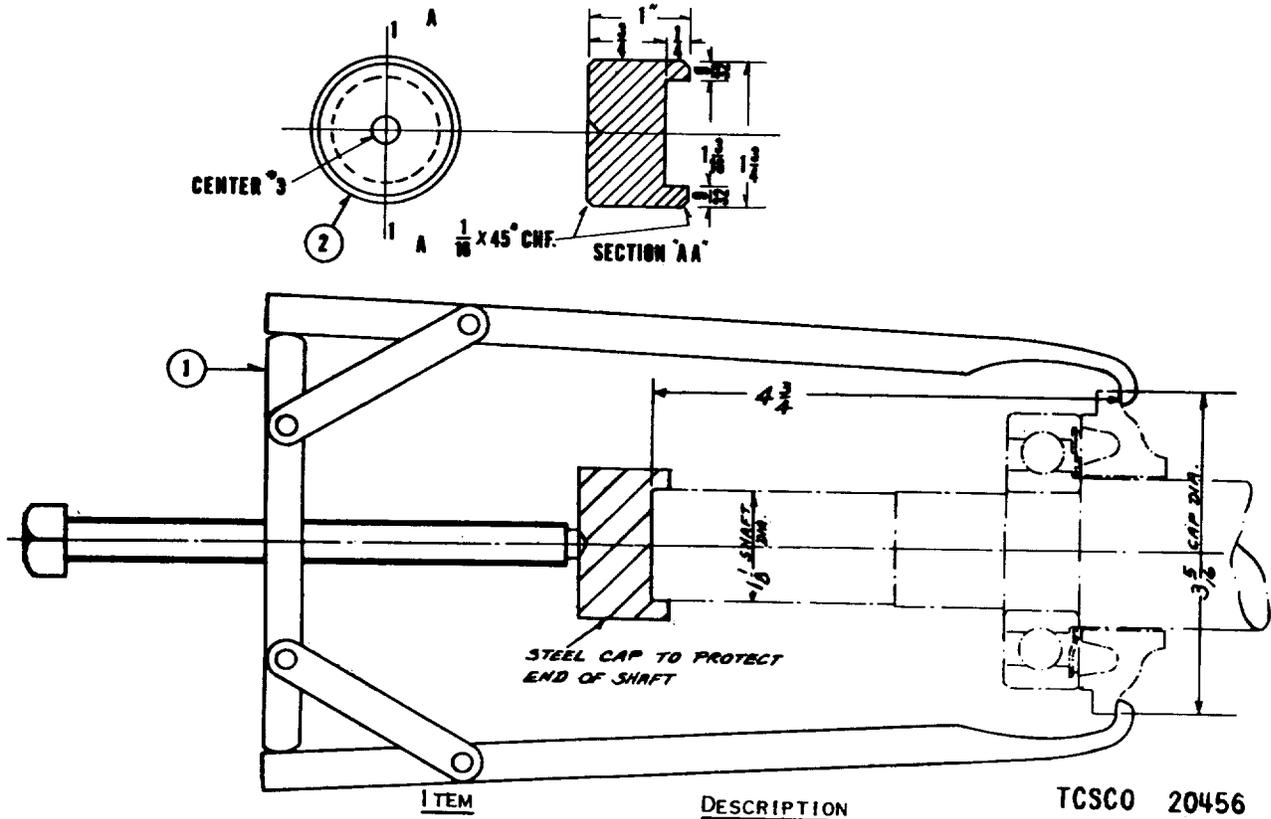
Figure 12. Auxiliary generator outline.



<u>ITEM</u>	<u>DESCRIPTION</u>	<u>REQ'D</u>
1	BEARING BRACKET . . . . .	1
2	GENERATOR SHAFT . . . . .	REF.
3	BEARING CAPS . . . . .	2
4	3/8"-16 x 2" STEEL HEX HEAD BOLT . . . . .	4
5	3/8" STEEL LOCKWASHER . . . . .	4
6	HEX HEAD STEEL PIPE PLUG, 1/8" . . . . .	2
7	30 M/M FREE FIT BALL BEARING . . . . .	2
8	BEARING GREASE . . . . .	4 OZ.
9	BEARING BRACKET . . . . .	1
10	NAMEPLATE NO. 59860 . . . . .	2

**TCSCO 20389**

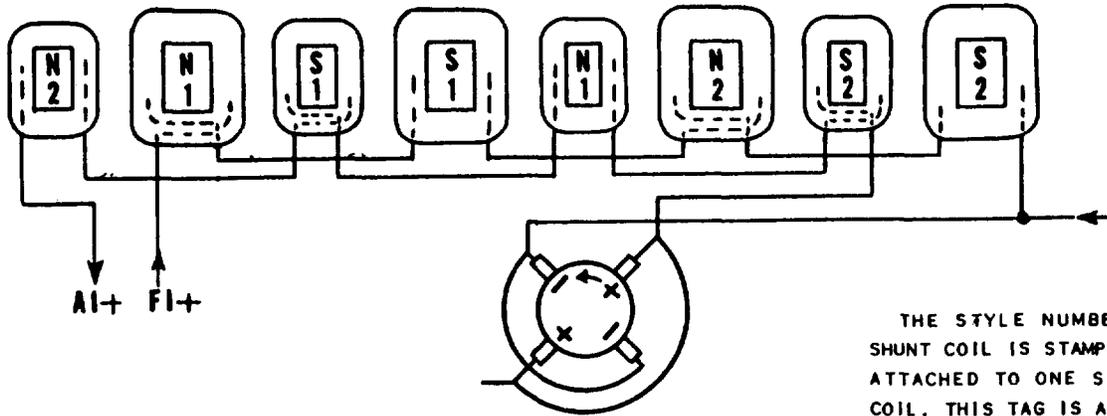
Figure 13. Auxiliary Generator bearing assembly.



ITEM	DESCRIPTION	TCSCO 20456
1	* TWO-ARM ADJUSTABLE BEARING PULLER.	
2	STEEL SHAFT CAP, 1" OF 1-3/4" STEEL BAR	

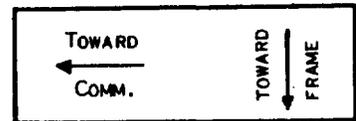
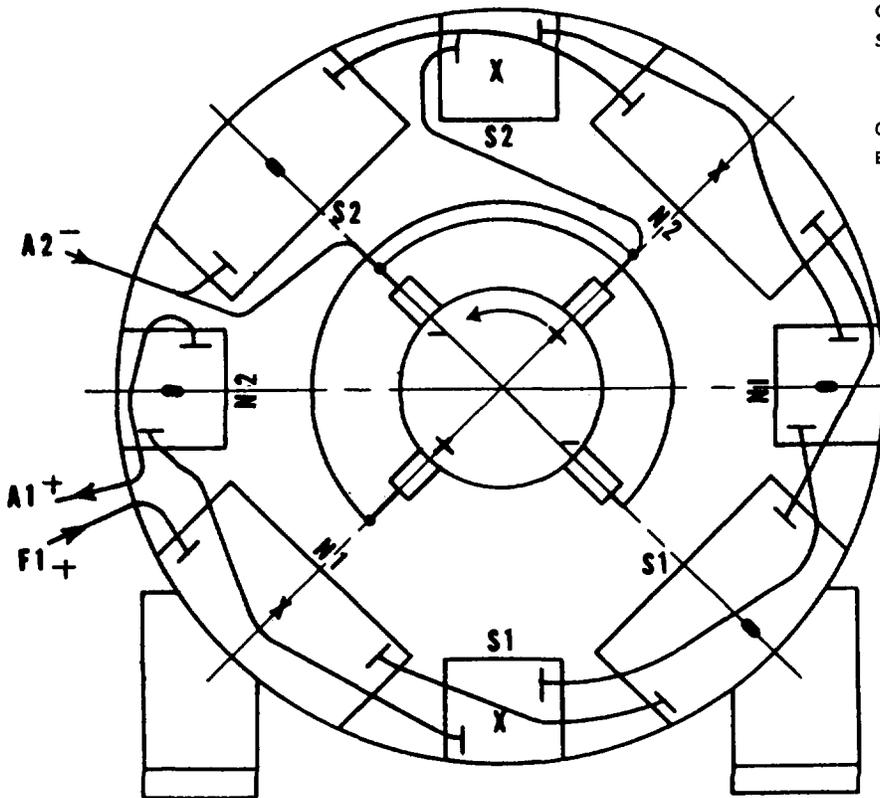
Figure 14. Auxiliary Generator bearing puller.

COILS LAID OUT FLAT ON BENCH WITH ARMATURE SIDE UP



THE STYLE NUMBER OF EACH SHUNT COIL IS STAMPED ON A TAG ATTACHED TO ONE SIDE OF THE COIL. THIS TAG IS ALSO STAMPED -O- (OPEN COIL) OR -X- (CROSSED COIL) IMMEDIATELY FOLLOWING THE STYLE NUMBER.

THE PROPER POSITION OF EACH COIL IN THE FRAME IS INDICATED BY A TAG SHOWN BELOW.



POLARITY TEST

N = NORTH POLE  
S = SOUTH POLE

WITH A COMPASS CHECK THE POLARITY OF COILS LAID OUT ON A BENCH, ALSO AFTER THE ASSEMBLY IN THE FRAME.

USE A RESISTOR TO GIVE ABOUT 3 AMPERES OF CURRENT FLOWING AS SHOWN BY ARROWS ON THE TAG.

TCSCO 20385

Figure 15. Auxiliary Generator field wiring diagram.

## Section IX. TRACTION MOTOR

### 78. General Data

- a. *Operating Limits (Maximum).*
- |                   |  |       |
|-------------------|--|-------|
| (1) Volts.....    |  | 600   |
| (2) Amperes.....  |  | 650   |
| (3) Safe rpm..... |  | 2,650 |
- b. *Brushes.*
- |   |                 |        |
|---|-----------------|--------|
| (1) Number of brush arms.....                           |                 | 4      |
| (2) Brushes per arm.....                                |                 | 2      |
| (3) Size of brushes (inches).....                       | 3/4 x 1 1/2 x 2 |        |
| (4) Brush pressure (pounds) with full length brush..... |                 | 7 to 9 |
- c. *Normal Pole Bores at Center of Poles (inches).*
- |                            |  |        |
|----------------------------|--|--------|
| (1) Main poles.....        |  | 16.375 |
| (2) Commutating poles..... |  | 16.375 |
- d. *Weights (Pounds).*
- |                                   |  |      |
|-----------------------------------|--|------|
| (1) Motor with gear and case..... |  | 3210 |
| (2) Armature complete.....        |  | 760  |
- e. *Resistance of Windings at (Ohms at 25°C.).*
- |                            |  |        |
|----------------------------|--|--------|
| (1) Armature.....          |  | 0.0188 |
| (2) Commutating field..... |  | 0.0060 |
| (3) Series field.....      |  | 0.0126 |
- f. *Armature Bearings.*
- |                         |  |               |
|-------------------------|--|---------------|
| (1) Pinion end.....     |  | .85/MM Roller |
| (2) Commutator end..... |  | .60/MM Ball   |
- g. *Axle Bearings.*
- |   |  |        |
|---|--|--------|
| (1) Type.....   |  | Sleeve |
| (2) Oil level (inches)-The height of oil in the axle bearings as measured from the bottom of the chamber using a flexible gauge should be as follows: |  |        |
| Maximum.....  |  | 2.375  |
| Minimum.....  |  | 1.125  |
- h. *Pinion Application.*
- |                                   |       |       |
|-----------------------------------|-------|-------|
| (1) Teeth.....                    | 13    | 15    |
| (2) Application temperature (°C.) |       |       |
| Shaft temperature.....            | +132  | +136  |
| (3) Advance limits                |       |       |
| Maximum (in.).....                | 0.048 | 0.049 |
| Minimum (in.).....                | 0.040 | 0.039 |

### 79. Description

a. The motors are designed to give the specified performance when operating all in parallel. This gives best conditions in regard to wheel slippage at high tractive effort.

b. This traction motor is of the same type as generally used for electric traction, commonly called axle-bearing. DIRECT-CURRENT, SERIES motor.

c. It is designated as direct-current because the current which operates it flows continuously in one direction.

d. It is designated series because the operating current which operates it flows continuously in windings in series (i. e., first through one and then through the other).

e. One side of the motor is supported by bearings on the locomotive axle and the other side by a suspension nose which is cast on the motor and is supported on the truck frame crosstie.

f. Each motor is connected to its axle through a single set of gears.

### 80. Axle Bearing Clearances and Wear

a. New axle bearings are bored 0.020 to 0.022 inch larger than the axle over the center portion and 0.030 to 0.032 inch larger than the axle near the ends to give a relief bore.

b. The axle bearing seats in the motor are bored to size with an 0.016 to 0.017 inch shim between the caps and the frame in order to give a clamping fit.

c. Wear in the axle bearings is not so serious as wear in the armature bearings. Renew axle bearings that show wear of 1/8 to 3/16 inch maximum. The amount of clearance can be measured by inserting a narrow feeler gauge between the under side of the axle and the bearing; the gauging can be done through the windows provided for this purpose in the axle shield. The end wear must not be allowed to exceed a maximum of 1/4 inch on the commutator end bearing, nor 3/32 inch on the gear case end bearing.

### 81. Removal and Replacing of Axle Bearings

a. In case it becomes necessary to remove the axle bearings while the motor is on the axle, proceed as follows:

- (1) Run the locomotive over a pit if one is available, if not, locate it to the best advantage for working on underside of axle.
- (2) If the bearing being removed is on the gear side it will be necessary to take out the gearcase bolts and drop the lower half of the gearcase.
- (3) Take out the four axle bearing cap bolts and remove the cap. If the cap sticks it



can be loosened by tapping a flat cold chisel in the crack between the cap and the motor frame, first on one side and then the other. Care should be taken to see that the cap is properly supported by a helper or backed up by blocking when it is being loosened in order to prevent its dropping suddenly and causing personal injury. The lower half of the axle bearing will drop down with the cap and can be readily knocked out with a wooden block and hammer. To remove the upper half of the bearing, jack up under the motor frame a sufficient amount to relieve the weight on the bearing then revolve the upper half around the axle until it can be slipped off below. If the bearing sticks in the frame it can be knocked loose by driving down on the flange with a hammer and wooden block.

b. When new bearings are installed, insert shims 0.014 inch thick between the axle cap and the motor frame. Drive the axle caps in straight, as rocking will distort the splines and pinch the bearings. The minimum radial clearance between the axle and the bearing should be 0.010 inch. The assembly shims need not be removed unless the bearing shells become loose in service and it is necessary to restore the clamping action between bearing seats and the axle bearings. At such a time it is desirable to either use thinner assembly shims, or no shims, as may be dictated by the crush which may be necessary to control bearing clearances without bearing-shell distortion.

c. See that a new bearing is perfectly clean and rub a little oil over the surface before putting it in place.

d. Repack with clean new waste and fill oil well to the proper level. Refer to paragraphs 37 through 44. The straps holding the motor nose should not be applied in such a manner that they produce a clamping action as severe stresses in the nose and axle bearings may result. At least an inch clearance on each side of the nose is necessary to allow for the wear of truck parts.

## 82. Hot Axle Bearings

a. Hot bearings will occur occasionally and are usually the result of one of the following causes:

- (1) Lack of oil in bearings.
- (2) Imperfectly packed bearings.

- (3) New bearings with insufficient clearance.
- (4) Grit or foreign substances working into the bearing.
- (5) Motor nose clamped.
- (6) Excessive end play in truck axles.

b. In case of trouble, investigate at once the level of oil in the well and make sure that it is up to the amount specified under OIL LEVEL, in the general data, paragraph 78. Examine the waste packing and make sure that it has not fallen away from the shaft; if it is not in proper shape, repack in accordance with instructions under lubrication, paragraph 39.

c. In the case of new axle bearings, it is well to examine the clearance as bearings too tightly set up are frequently the cause of trouble. If the trouble persists with the bearing freshly packed, oil at the right level, and ample clearances, remove the bearing and examine. If the bearing shows signs of cutting, carefully scrape down to a new surface, or if too badly scored, replace with a new bearing.

d. Before replacing a bearing, which has been cutting, examine the journal carefully. Remove any roughness with fine emery paper, taking care after the operation to remove all traces of grit with a clean rag, and rub over the journal with oil. Do not use grease on a journal which is lubricated by oil and waste, as the grease will glaze over the waste surface and prevent the oil from reaching the bearing.

## 83. Brushholder and Brushes

a. The brushholder and brushes can be inspected by removing the commutator cover. Under no circumstances should a carbon brush be permitted to wear down so far that the brushholder finger bears on the carbon box. Replace any brush which may wear to such an extent, that the finger will be less than one-eighth of an inch at the end of its travel before the next inspection.

b. Brush thickness is very important and the clearance of a new brush in the holder should be approximately 0.004 to 0.010 of an inch; if the clearance is much less than the minimum, the carbon will tend to stick in the box, and if greater than 0.025 of an inch the brush may rattle, wear away its sides and chip or break. The width of a brush is not so important as it may have as much as 1/16 inch clearance in the box without causing any trouble.

c. Brush pressure on the commutator is maintained by means of flat clock-type springs which exert pressure on a finger which rests on top of the brush. The brush pressure can be measured by attaching a small spring balance to the pressure finger directly over the brush and pulling straight up in line with the brush travel until the finger is just lifted clear of the brush. The pressure of the brushes can be checked in the above manner with the brushholder in place in the motor. The brush pressure given on the general data, paragraph 78, is for a new brush.

d. Those brushholders which cannot be easily reached with the spring balance can be checked by comparing the "feel" of those brushholder springs with the "feel" of those checked with the balance.

e. To remove the brushholder for renewal, or accurate adjustment of the brush pressure, first disconnect the cable lead from the holder by removing the tap bolt. When the supporting clamp is loosened, the holder may be lifted out.

f. To adjust the spring pressure, insert a piece of 1/8-inch diameter drill rod in the holder in the tension barrel for the spring requiring adjustment and relieve the tension on the cotter pin. Remove the cotter pin, increase or decrease the tension as required by rotating the tension barrel, and replace the cotter pin.

g. Keep the underside of the brushholder carbon box within not less than 1/8 inch of the commutator to reduce the chance of brush breakage. Adjustment can be made by loosening the clamping block bolt and moving the brushholder to the correct position. A fibre sheet of the proper thickness makes a handy gage.

#### **84. Commutator**

a. A commutator which is taking on a polish and shows no signs of wear, does not require any attention.

b. If the commutator is roughened, badly worn or burned, remove and place in a lathe, then turn, grind or stone to give a uniform surface, after which the mica must be regrooved with special saws.

c. The mica insulation between the copper segments is grooved or undercut initially to a depth of 3/64 inch; as the commutator wears, or if it is turned or ground, maintain the grooves since high mica will spoil the brush fit and cause sparking. Undercutting can be done to the best advantage by the use of one of the small power-driven saws which are built for this purpose.

d. After the commutator has been turned or stoned and undercut, remove the burrs which are always formed on the edges of the bar during the process, with a three-cornered cutting tool, round the ends of the commutator bars, clean the slots out, and finally polish with fine sandpaper and then blow off with compressed air. Lift the brushes when smoothing a commutator in a machine and do not replace until all grit has been removed. Never use emery cloth or emery paper on a commutator.

e. Do not use any lubricant on the commutator as there is sufficient amount of graphite in the brushes to supply all the lubrication required.

#### **85. Dismantling and Assembling Motors**

a. *Tools.* Special tools required when dismantling the traction motor are shown on figure 17. The shop should be supplied with a set of the special tools which may be made from the drawing supplied.

b. *Removal of Traction Motors from Locomotive.*

- (1) Remove the tape from the motor lead connectors. Disconnect all of the motor connectors, taking care to see that all leads are plainly marked so that there will be no trouble when they are reconnected.
- (2) Remove the truck center pin and disconnect the BRAKE, SANDER, and any other connections between the truck and cab. Jack the cab up at one end a sufficient amount to clear and run the truck out from under.
- (3) Remove the gearcase by unbolting the two halves and removing the bolts holding the gearcase to the motor.
- (4) Remove the motor axle cap bolts and take off the axle caps. If the cap sticks, it can be loosened by tapping a flat cold chisel into the crack between the cap and motor frame, first on one side and then the other. Care should be taken to see that the cap is properly supported by a helper or "backed up" by blocking when it is being loosened in order to prevent its dropping suddenly and causing personal injury.

- (5) Remove the straps which hold the motor nose in place on the truck transom; or block up the motor near the link suspension rod and knock out the pin.
- (6) Lift the motor out of the truck with a crane, hooking the lifting chains into the bail cast on the motor frame for that purpose. When hooking up the crane chains, if three chains are employed, care should be taken to so adjust the lengths that the motor will be lifted first on the side next to the truck center, and rotated around the axle a sufficient amount so that the lower lip of the axle bearing housing will clear the axle before the chain attached to the axle side of the motor takes up its slack.

*c. Removal of Traction Motor Pinions.*

- (1) Pinions are most easily removed by means of a pinion puller made especially to fit the pinion.
- (2) If desired, a simple "one man" puller that will meet all requirements can be made from the special tool drawing, figure 17. The puller should be applied as shown on the tool drawing. In a fully equipped service shop, a "power puller" may be available and can be used, if adaptable.
- (3) Care should be exercised when removing motor pinions. Take the following precautions:
  - (a) Do not try to remove a "set" pinion by driving wedges between the pinion and the motor housing or oil thrower. Considerable damage will result to the motor.
  - (b) In order to prevent damage to antifriction bearings avoid all blows with a sledge hammer on the pinion or pinion puller.
  - (c) Never apply a flame to any pinion that is to be put back in service as there is great danger of destroying the original heat treatment.
- (4) In removing a worn pinion that is to be scrapped and is very hard to pull, it may be necessary to apply heat with a torch to expand the pinion and relieve the fit. When an old pinion is heated, great care must be taken to protect the shaft and housing to prevent their being damaged by the heat.

*d. Applying Traction Motor Pinions.* The following instructions cover the method to be used in applying pinions to traction motor shafts having a tapered fit.

(1) *Preliminary precautions.*

- (a) Check the seat on the shaft and the pinion bore. Remove all burrs, enlargements and galled spots.
  - (b) Check the pinion fit on the shaft with Prussian Blue. Scrape or stone the pinion bore until at least 75 percent of the area is in contact. The best way to check the fit is to blue the shaft, place the pinion on the shaft about 1 inch from its final position and then give a quick shove home. The pinion can be removed by lightly driving a metal wedge between the pinion face and the oil thrower or the motor housing. This should only be done with pinions applied cold to the shaft.
  - (c) For pinions with a keyway the key should be a tight fit in the keyway of the shaft. The keyway in the pinion may be 0.002 inch larger but not smaller than the key. The clearance between the top of the key and the bottom of the keyway in the pinion must be at least 1/64 inch. Round off the corners of the key to prevent cutting into the fillet of the keyway. Round the corners on the lead of the key and the lead of the pinion keyway to prevent galling. Try the cold pinion on the shaft to make sure that the key will not bind and prevent the pinion from moving to its proper position.
- (2) *Cold stand-off.* Clean the shaft and the pinion bore thoroughly with benzol or solvent to remove all traces of oil and Prussian Blue. With the pinion and the shaft at the same temperature, place the pinion on the shaft about 1 inch from its final position and then give a quick shove home. Measure the distance the pinion stands off from the end of the shaft with micrometer depth gauge. Mark the points of measurement and mark across the end of the shaft so that after heating the pinion, it can be mounted in exactly

the same angular position on the shaft and measurements made from the same points. Remove the pinion from the shaft by lightly driving a wedge between the pinion face and the oil thrower or motor and bracket.

(3) *Heating.*

(a) Heat the pinions uniformly and for a sufficient length of time to soak thoroughly. Heat the pinion about 10° C. above the application temperature given in the motor general data, paragraph 78. This allows sufficient time to remove the pinions from the heating source, clean the bore and check the temperature before applying.

(b) The approved methods of heating pinions in the order of preference are given below:

1. Induction heater.
2. Electric oven.
3. Gas oven.
4. Oil (only as a last resort).

(c) If oven facilities are not available, an electric roaster will work satisfactorily on all pinions up to an outside diameter of 12 inches. Pinions must never be heated above 200° C.

(d) If oil is used to heat the pinions, they must be thoroughly cleaned with benzol and dry rags to remove all traces of oil from the pinion bore before applying to the shaft.

(4) *Application.* Remove the pinion from the heating source and place near the shaft to which it is to be applied. Clean the shaft and pinion bore very thoroughly with clean dry rags to remove all traces of oil. Check the pinion temperature with an electric pyrometer placed as close to the pinion bore as possible. As soon as the pinion temperature comes down to the prescribed application temperature the pinion should be applied on the shaft in exactly the same angular position and in the same manner as for the cold stand-off. The same mechanic who applied the pinion cold should apply the pinion hot in order to obtain the same force or push. Measure the hot stand-off of the pinion

from the end of the shaft in the same manner and the same position that the cold stand-off was taken. The difference between the hot and cold stand-offs gives the advance of the pinion on the shaft. This advance must fall within the application limits. The application temperature given in paragraph 78 is estimated only and may have to be adjusted by experience to maintain the advance within the proper limits. If the advance is not within the proper limits, the pinion must be pulled and re-applied.

(5) *Fastening.* If the pinion is equipped with a nut, apply the lockwasher and nut as soon as the hot advance is taken. Screw the pinion nut home tightly with a wrench having a purchase leverage of 4 to 6 feet.

e. *Removal of Armature from Motor.* If it is necessary to remove the armature from the motor, the following procedure is to be followed:

(1) Take off the pinion nut to provide means of lifting the armature. Pull the pinion if the pinion end bearing is to be dismantled. Refer to removal of traction motor pinions, c above.

(2) Remove tile commutator covers and lift brushes far enough out of brush box so that they will not slide back against commutator.

(3) Protect the commutator by wrapping it with heavy fishpaper.

(4) Remove the bolts holding the bearing cartridge to the lousing at the commutator end.

(5) Turn the motor so that the shaft is in a true vertical position with the pinion end up. Support the motor on blocks to avoid damaging the commutator end bearing cap.

(6) Remove the bolts holding the pinion end housing to the frame.

(7) Insert three 3/4-inch bolts in the three tapped holes equally spaced around the housing. Tightening up on these bolts pulls the housing out of the frame fit.

(8) Screw a special lifting nut on the pinion end of the shaft and lift the armature out of the frame with both bearing assemblies intact.

f. *Removal of Armature Bearings.* The armature may be clamped in a wooden saddle in a horizontal

position or it may be placed on a bench and wedged at the sides for stability.

- (1) *Removal of the Commutator End Bearing.* The commutator end ball bearing is pulled off as shown on figure 17. The procedure is as follows:

- (a) Remove the bolts which hold the outside bearing cap to the bearing cartridge and remove the cap.
- (b) Remove the two setscrews in the bearing locknut and remove the locknut using the special wrench.
- (c) Remove the bearing cartridge, bearing, and oil thrower by applying the puller as shown on the tool drawing.
- (d) Wrap the bearing and grease thrower in a protective covering, leaving the grease in the bearing. The grease in the bearing will serve to prevent rusting. The bearing must be cleaned and inspected before reassembly in the housing.

- (2) *Removal of the Pinion End Bearing.* The pinion end roller bearing is removed as shown on the tool drawing, figure 17. The procedure is as follows:

- (a) Remove the outer bearing stop using the puller shown on figure 17.
- (b) Remove the outer bearing cap.
- (c) Remove the housing, bearing outer race, and roller assembly.
- (d) Remove the outer bearing race from the housing, tap the housing with a rawhide mallet and slip the bearing out. If it is too tight in the housing to be removed in the above manner, the bearing can be tapped out, using a brass bar on the outer race.
- (e) Most of the work required on an armature can be done with the inner race in place. Be sure to thoroughly clean the race, thrower, and cap before assembly.
- (f) The inner race and cap may be pulled when necessary, using the puller shown on the tool drawing, figure 17.
- (g) Place the inner race in the bearing and wrap in a protective covering leaving the grease in the bearing. The grease in bearing will serve to prevent rusting. The bearing must

be cleaned and inspected before reassembly.

- g. *Cleaning and Inspection of Armature Bearings.*

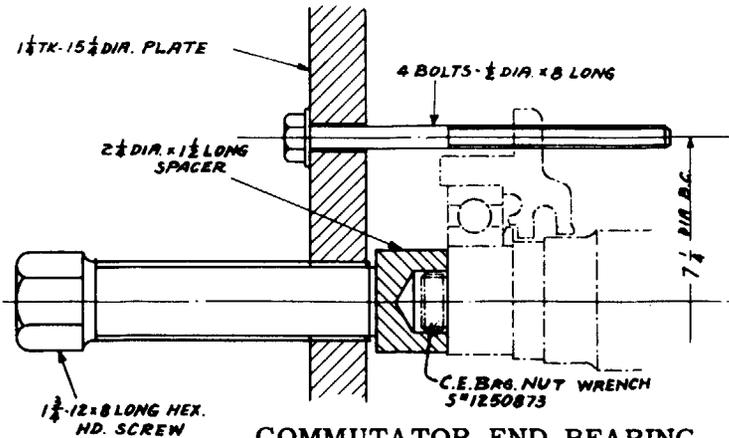
- (1) Clean the bearings in gasoline also by means of dry, compressed air.
- (2) Final cleaning will be in clean gasoline after which the bearings will be blown off with dry compressed air. Hold the cage or inner race and rotate the outer race while directing the compressed air around the rollers, balls, cages or races. Next hold the outer race and rotate the cage or inner race.
- (3) If the bearing is not to be re-assembled immediately, grease and wrap in a protective covering to keep out dirt and moisture.
- (4) In handling bearings during overhaul use clean lintless cloths for keeping both the hands and the bearings clean. Do not use waste on the bearings.
- (5) Before re-assembling the bearings, carefully inspect for:
  - (a) Cracked races or cages.
  - (b) Cracked or pitted rollers or balls.
  - (c) Excessive wear of cages or races.
  - (d) Loose cage rivets.

*h. Heating of Bearings in Oil for Assembly.* The oil container for heating of the bearings and details must have a perforated support approximately 2 inches above the bottom to allow any dirt to drop below the bearings and to prevent the heat front striking the bearings directly. This container must be kept clean. Use a high-temperature oil such as compressor oil.

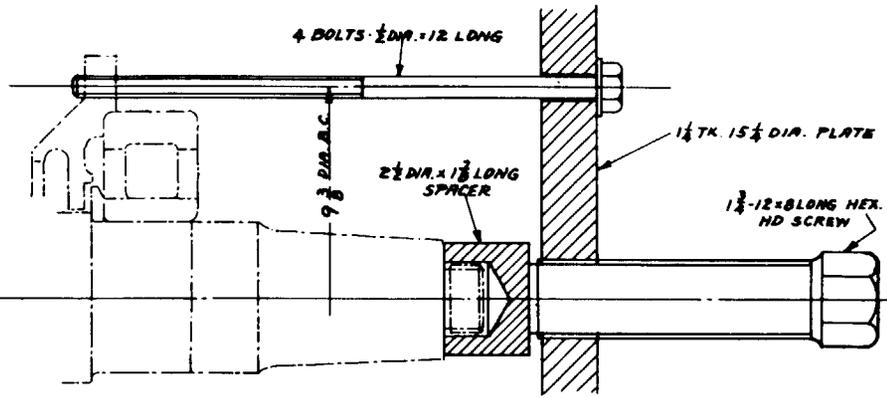
*i. Assembly and Disassembly.* If for any reason a bearing inner or outer race does not pull readily from its fit do not use a flame on the bearing. Instead pour hot oil over the inner race, housing, or cartridge, to expand them enough to ease the fit and permit pulling.

- j. *Removal and Replacing of Field Coils.*

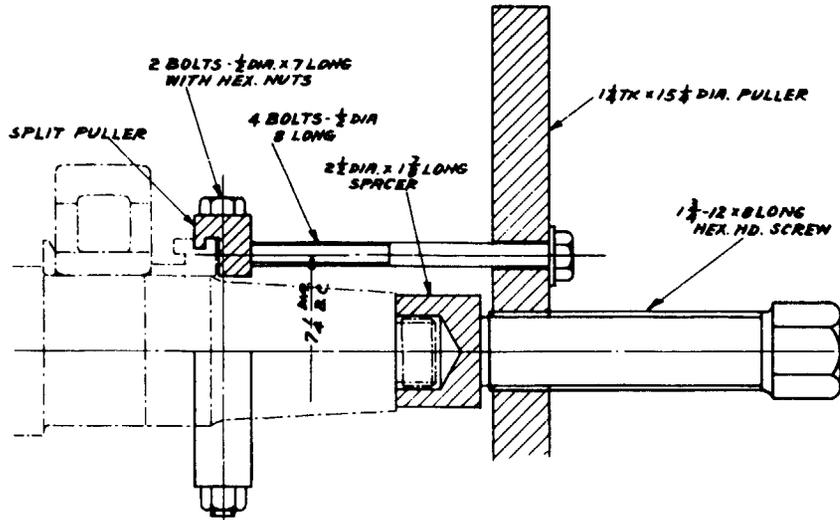
- (1) In case one of the field coils has to be removed, proceed as follows; (assuming motor frames have been dismantled and armature removed).
  - (a) Strip the insulation off the connections of the leads between the coil to be removed and the adjacent coils, unsolder the connections by the use of a blowtorch. Take care to protect the coil from the flame by pieces of asbestos sheet.



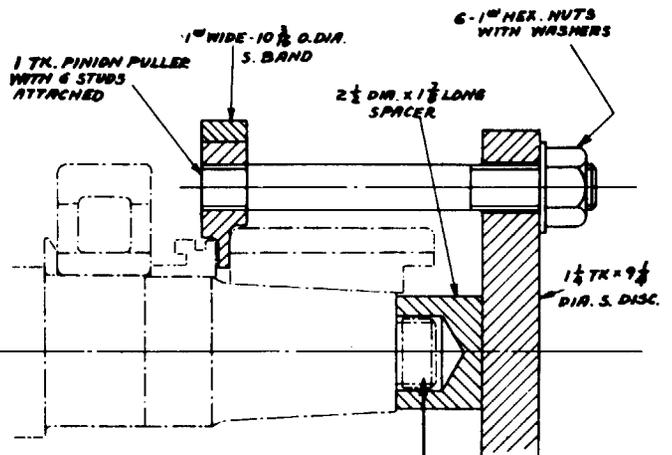
COMMUTATOR END BEARING PULLER



PINION END BEARING PULLER



GREASE THROWER PULLER



PINION PULLER

PINION NUT WRENCH - 5°1409919  
ARM. LIFTING EYE - 5°1239666

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Figure 17. Traction motor pinion and bearing tools.

- (b) Remove the tap bolts which hold the pole piece of the coil which is to be removed, lift out the pole, and then remove the coil.
- (2) When replacing coil, the procedure should be the reverse of that just described and the following points should be carefully noted.
  - (a) It is important that the Main Coil Spring and the wide Main Coil Washer be placed between the pole tip and the coil with the washer between the coil and coil spring.
  - (b) Be sure to place the Commutating Coil Spring and the wide Commutating Coil Washer back of the commutating coil before putting it in place. Take care that these items do not slip in between the pole and its seat when it is bolted to frame. The narrow Commutating Coil Washer should be placed between the pole tip) and the coil.
  - (c) Make sure that the coil is turned right side up and right end to, when placing it in position. Check for proper polarity according to the field wiring diagram, figure 18.
  - (d) See that the pole seat and back are clean and free from chips before putting the pole in place, and make sure that the pole is pulled "home" to its seat by the tap bolts.
  - (e) Measure the final pole bore at the center of the face of the pole being replaced and the pole diametrically opposite. Check with the NORMAL POLE BORE values given on the general data, paragraph 78.

k. *Assembly of Commutator End, Armature Ball Bearing.* Refer to the bearing assembly, figure 19, as a guide for proper bearing assembly.

- (1) Place the armature preferably in a vertical position. A hole, a little larger than the armature diameter, cut in a low wooden table or bench, together with some wooden wedges to keep the armature from dropping through, serves very well.
- (2) Clean all parts thoroughly before starting to assemble. Carefully inspect the bearing for cracks, pitting, or excessive wear.

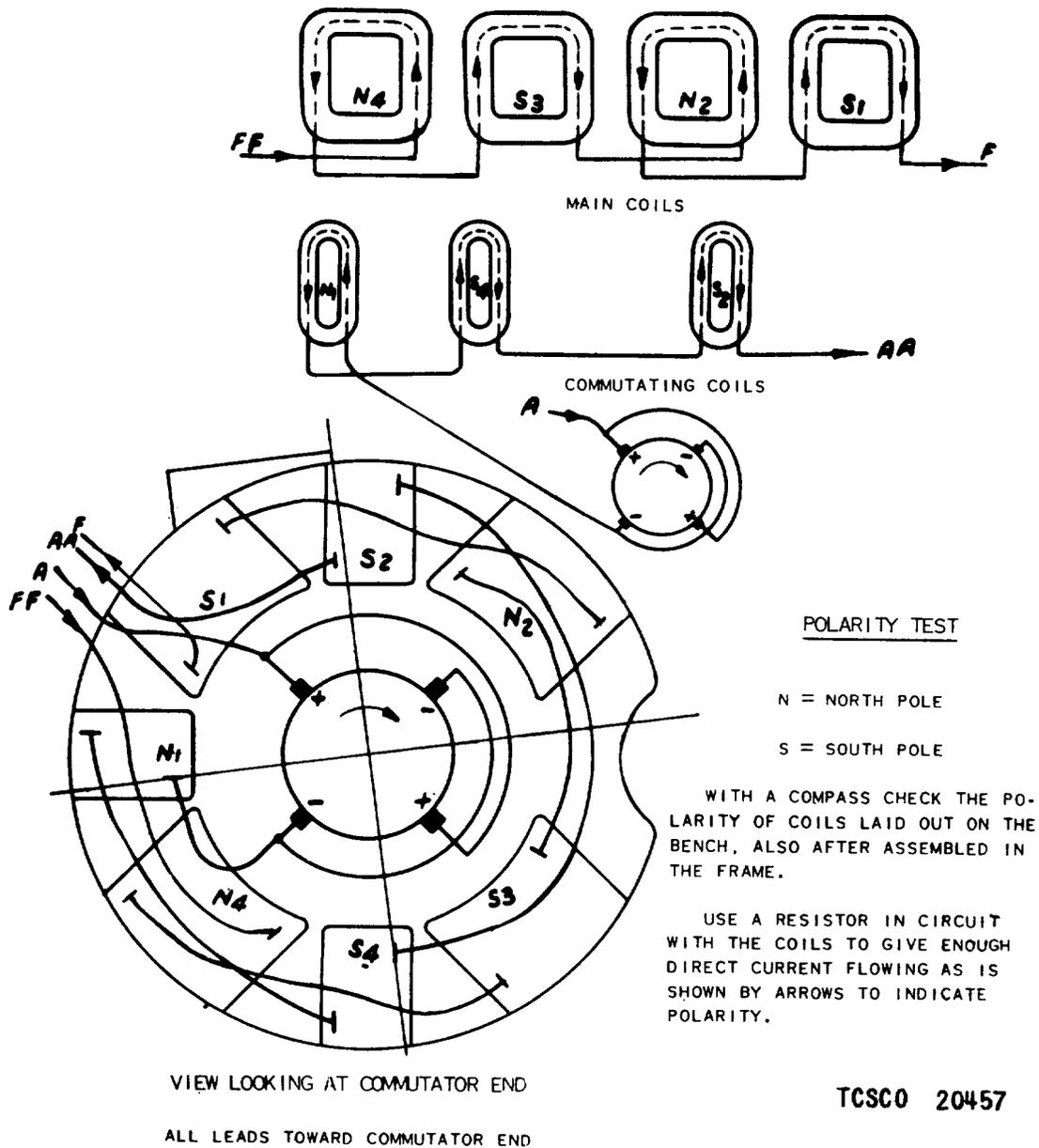
### Caution

**Care must always be taken to keep all dirt and grit away from ball bearings.**

- (3) Place the bearing, cartridge, and grease thrower in a high-temperature oil at a temperature of 100° C. (212° F.). Use compressor oil.
- (4) Remove the bearing cartridge from the hot oil, wipe off the excess oil and drop into place over the shaft.
- (5) Remove the grease thrower from the hot oil, wipe off the excess oil and shrink on the shaft with the chamfered side out and hold in place solidly against the shoulder on the shaft until it has cooled.
- (6) Pack the lower half of the grease pocket in the bearing cartridge full of grease as specified in figure 5.
- (7) Remove the bearing from the hot oil, wipe off the inner and outer fits, and immediately drop in place while the cartridge bore is still expanded. Do not force this assembly—the bearing must slip into place. Hold the bearing solidly in place against the grease thrower until tight.
- (8) Apply the bearing locknut and tighten the setscrews. Strike the bearing nut with a hammer, again tighten the setscrews and peen the nut to lock the setscrews.
- (9) Fill the spaces between the balls with grease.
- (10) Fill the grease pocket in the outer bearing cap half full with grease. Bolt the cap with its gasket in place to the bearing cartridge.
- (11) Some portion of the grease in the bearing cap must make contact with the bearing when assembled.
- (12) Check to make sure that the grease fitting is not damaged.

l. *Assembly of Pinion End, Armature Roller Bearing* (fig. 19).

- (1) Place the armature in a vertical position. A hole, a little larger than the armature diameter, cut in a low wooden table or bench, together with some wooden wedges to keep armature from dropping through, serves very well.
- (2) Clean all parts thoroughly before starting to assemble. Carefully inspect the



**Figure 18. Traction motor field wiring diagram.**

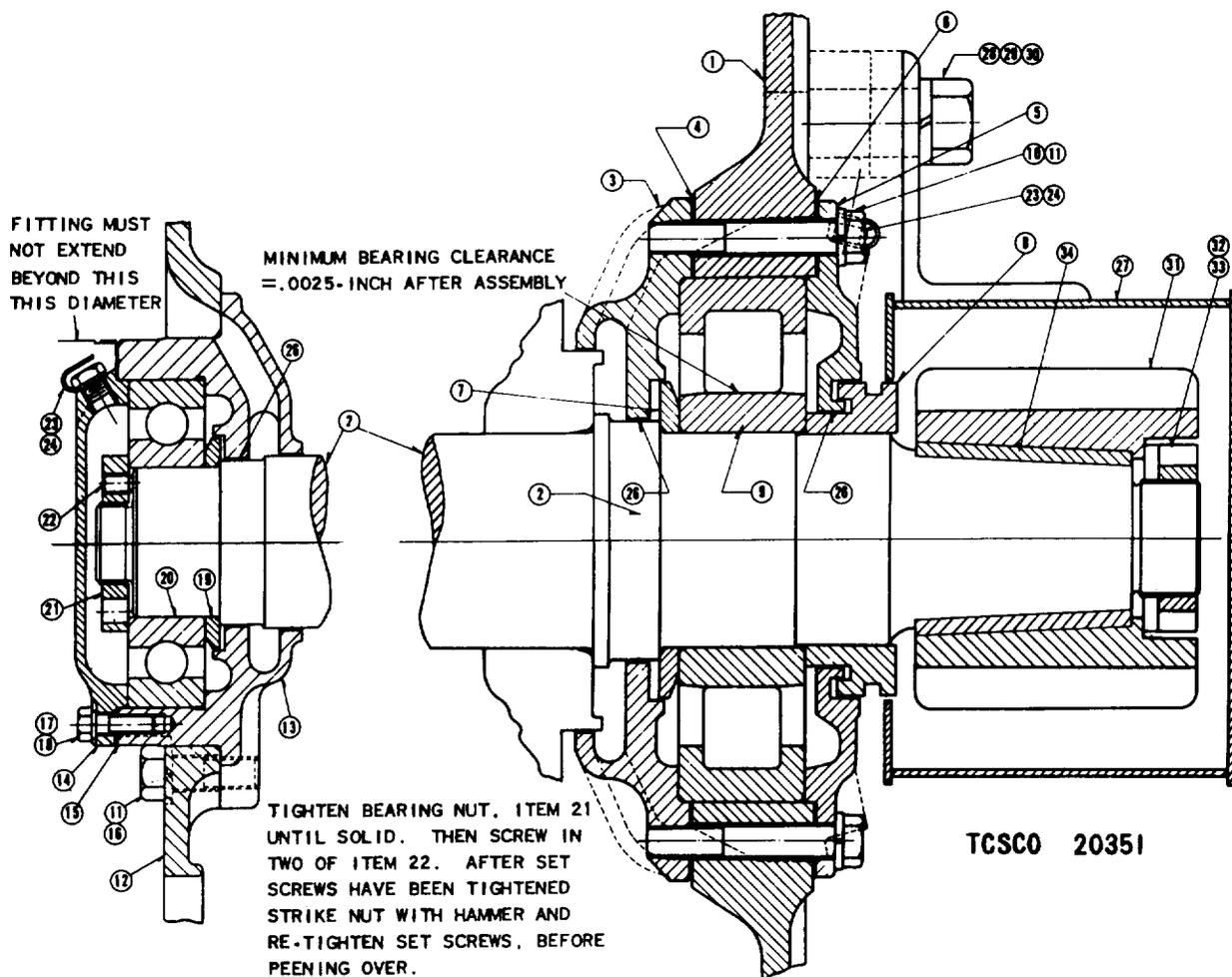
bearing for cracks, pitting, or excessive wear.

**Caution**

**Care must always be taken to keep all dirt and grit away from roller bearings.**

- (3) Place the grease thrower and inner bearing race in a high-temperature oil at 100° C. (212° F.). Use compressor oil.

- (4) Place the inner bearing cap over the shaft.
- (5) Remove the grease thrower from the hot oil, wipe off excess oil, and shrink on the shaft with the chamfered side out and hold in place solidly against the shoulder on the shaft with the bucking-up tool until it has cooled.



ITEM	DESCRIPTION AND DIMENSIONS IN INCHES	REQ.	ITEM	DESCRIPTION AND DIMENSIONS IN INCHES	REQ.
1	PINION END HOUSING . . . . .	1	18	5/16 STANDARD STEEL LOCK WASHER . .	4
2	MOTOR ARMATURE SHAFT . . . . .	1	19	GREASE THROWER, COMMUTATOR END . .	1
3	BEARING CAP, PINION END, INNER . .	1	20	60/MM FREE FIT BALL BEARING (SEE GENERAL DATA) . . . . .	1
4	GASKET FOR BEARING CAP, P.E., INNER	1	21	BEARING NUT . . . . .	1
5	BEARING CAP, PINION END, OUTER . . .	1	22	5/16-18 x 1/2 CUP POINT SET SCREW . .	2
6	GASKET FOR BEARING CAP, P.E., OUTER	1	23	1/8 SPECIAL GREASE PLUG . . . . .	2
7	GREASE THROWER, PINION END . . . . .	1	24	GREASE NAMEPLATE . . . . .	2
8	BEARING STOP . . . . .	1	25	BEARING GREASE (SEE GENERAL DATA) .	SET
9	85/MM FREE ROLLER BEARING (SEE GENERAL DATA) . . . . .	1	26	SEALING GREASE . . . . .	SET
10	1/2-13 x 3-1/4 HEX HEAD STEEL BOLT . .	4	27	GEAR CASE . . . . .	1
11	1/2 STANDARD STEEL LOCK WASHER . . .	8	28	1-8 x 2-1/2 HEX HEAD STEEL BOLT . . .	1
12	COMMUTATOR END HOUSING . . . . .	1	29	1-8 x 3-1/4 HEX HEAD STEEL BOLT . . .	2
13	BEARING CARTRIDGE, COMMUTATOR END .	1	30	1-INCH STANDARD STEEL LOCK WASHER . .	3
14	BEARING CAP, COMMUTATOR END, OUTER .	1	31	PINION (SEE GENERAL DATA) . . . . .	1
15	GASKET FOR BEARING CAP, COMM. END .	1	32	PINION NUT . . . . .	1
16	1/2-13 x 1-1/2 HEX HEAD STEEL BOLT . .	4	33	2-INCH STD. STEEL LOCKWASHER (PINION)	1
17	5/16-18 1 HEX HEAD STEEL BOLT . . . .	4	34	PINION KEY . . . . .	1

Figure 19. Traction motor armature bearing assembly.

- (6) Remove the inner race from the hot oil, wipe off the excess oil and apply to the shaft using the bucking-up tool as before.
- (7) Fill the spaces between the rollers in the bearing and fill the grease chamber in the caps about one half full with grease as specified in figure 5.
- (8) Tap the bearing in place in the housing using the outer bearing cap to determine approximate location.
- (9) Slide the housing and outer race and roller assembly into place, being careful not to score the inner race with the rollers.
- (10) Check the internal radial clearance of the bearing. See the bearing assembly drawing, figure 19, for proper clearance.
- (11) Apply the outer bearing cap and bolt in place.
- (12) Heat the outer bearing stop in an oven to a temperature of 150° C. and slide into place as shown on the bearing assembly drawing. As it cools, tap with a hammer to make sure of tight contact against the inner bearing race.

*m. Armature Assembly into Frame.*

- (1) It is important that the frame be place(d so that it is in the true vertical position. Otherwise, the commutator end bearing cartridge and the pinion end housing may enter their respective fits in a COCKED position.
- (2) Wrap a piece of fishpaper or other protecting material around the

commutator and secure with friction tape. This serves to protect the commutator from the brushholders when dropping the armature in place.

- (3) Screw the two armature removal studs into the commutator end cartridge to be used as a guide in lining up the holes in the cartridge with those in the frame.
- (4) Pick up the armature, using the special armature lifting eye, and lower into the frame, being careful not to score the commutator or the bearing and to get the studs entered in the proper housing holes.
- (5) Put the pinion end housing bolts in place.
- (6) Remove the studs from the commutator end cartridge and put in the proper bolts.
- (7) Pull the commutator end cartridge fit and the pinion end housing fit into the frame at the same time.
- (8) Remove the protective paper from the commutator and turn the armature by hand to make certain it is free.
- (9) Check for proper clearance of one-eighth of an inch between brushholders and commutator.
- (10) Lower the brushes and fit to the commutator, using a medium grade of sandpaper.
- (11) Blow out carbon dust with dry, compressed air.
- (12) Replace the commutator covers.

## Section X. MISCELLANEOUS CONTROL EQUIPMENT

### 86. Master Controller

*a.* The fingers are cam operated double break and require no attention other than to see that the contacts are clean and that no springs are broken. The finger board is easily removed by taking out the two screws at each end of the finger board. All rollers should be examined occasionally to see that they turn freely. The contact pressure is 7 ounce minimum on each contact.

*b.* To remove the drums from the backplate and cam switches, remove the dowel pin from the top plate at rear left center, then remove the two bolts at the rear corners of the top plate and the corresponding two bolts from the bottom plate. The drums will then be free and can be removed by moving them forward.

*c.* When reassembling the drums, first insert the dowel pin and then tighten the two bolts at the rear corners of the top plate. This positions the drums with respect to the cam switches. Tighten the two bolts at the rear corners of the bottom plate last.

### 87. Reverser

*a. Description.* The reverser consists of a drum (with insulated copper segments) capable of rotation through a small angle, two air cylinders with pistons for drum rotation, control magnet valves, power and control fingers and an insulating

base. For care of magnet valves, refer to paragraph 88.

b. *Fingers.*

- (1) The pressure of the fingers on the contacts should be approximately 5 to 6 pounds for the main contacts and 1 1/2 to 3 pounds for the interlock fingers. The finger pressure can be measured by means of a small spring balance attached to a piece of bent metal strap which can be slipped under the finger.
- (2) If the segment under the fingers is to be cleaned, do not lift the fingers far enough off the drum surface so as to strain the spring and reduce the tension; such a common source of trouble should be carefully avoided.
- (3) If the contact fingers and drum segments are allowed to operate completely dry they will start to cut in a comparatively short time. Spread a little light machine oil occasionally over the drum contacts with a piece of cloth, and operate the drum a few times; wipe off any surplus oil around the contacts or segments. Oil the drum bearings at intervals with a light oil.
- (4) The finger pressure is varied by changing the bend in the finger spring where the flat spring type finger is used. To increase the pressure, it is necessary to remove the finger by removing the screws which hold it in place, and give the spring a little greater set. The fingers will maintain their pressure for a long period of time if they are not abused. Fingers of the compensated type cannot be adjusted for spring tension. A damaged finger must be replaced.

c. *Cylinder Maintenance.*

- (1) Pistons are properly oiled when the reverser is assembled at the factory and ordinarily will function for a long period (six months or a year) before it requires any additional lubrication. When lubrication is necessary, use only oil as specified on figure 5. The use of unsuitable oil will lead to trouble from gummed pistons which will cause sluggish action or sticking.
- (2) In order to remove the piston rod and pistons it is necessary to first remove the four tap bolts which hold the drum

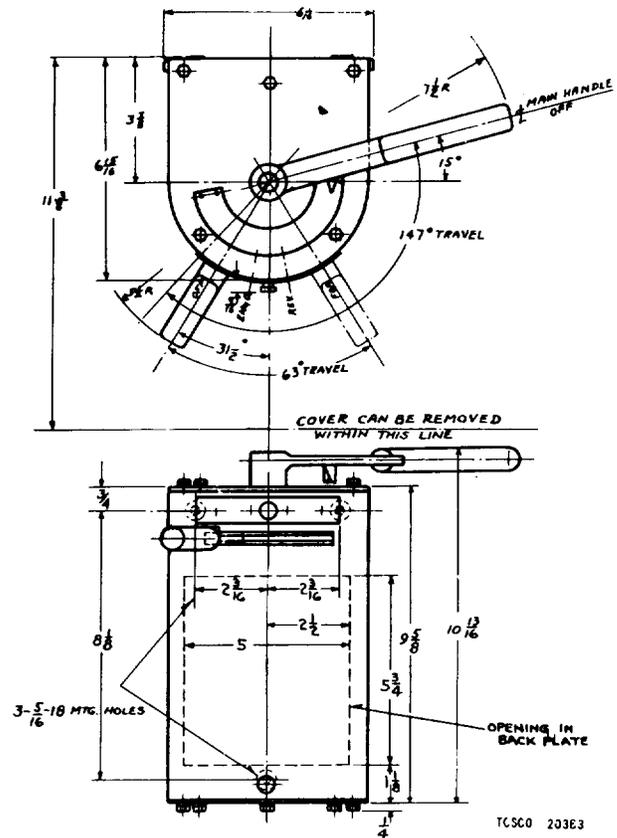


Figure 20. Control outline.

bearings in place and lift out the drum. Next the tap bolts in each cylinder head should be taken out and the head removed, care being exercised not to injure the paper gaskets which are under them. Remove the nut and lockwasher on one end of the piston rod, after which the piston rod with one piston attached can be shoved out of the cylinder by pushing on the end of the piston rod with a screwdriver. The remaining piston in the cylinder can easily be pushed out from the other end. It is not advisable to push the piston past the opening in the center of the cylinder as the leather may be injured.

88. Magnet Valves

a. *General Description.*

- (1) The sander and engine shutdown are provided with magnet valves which govern

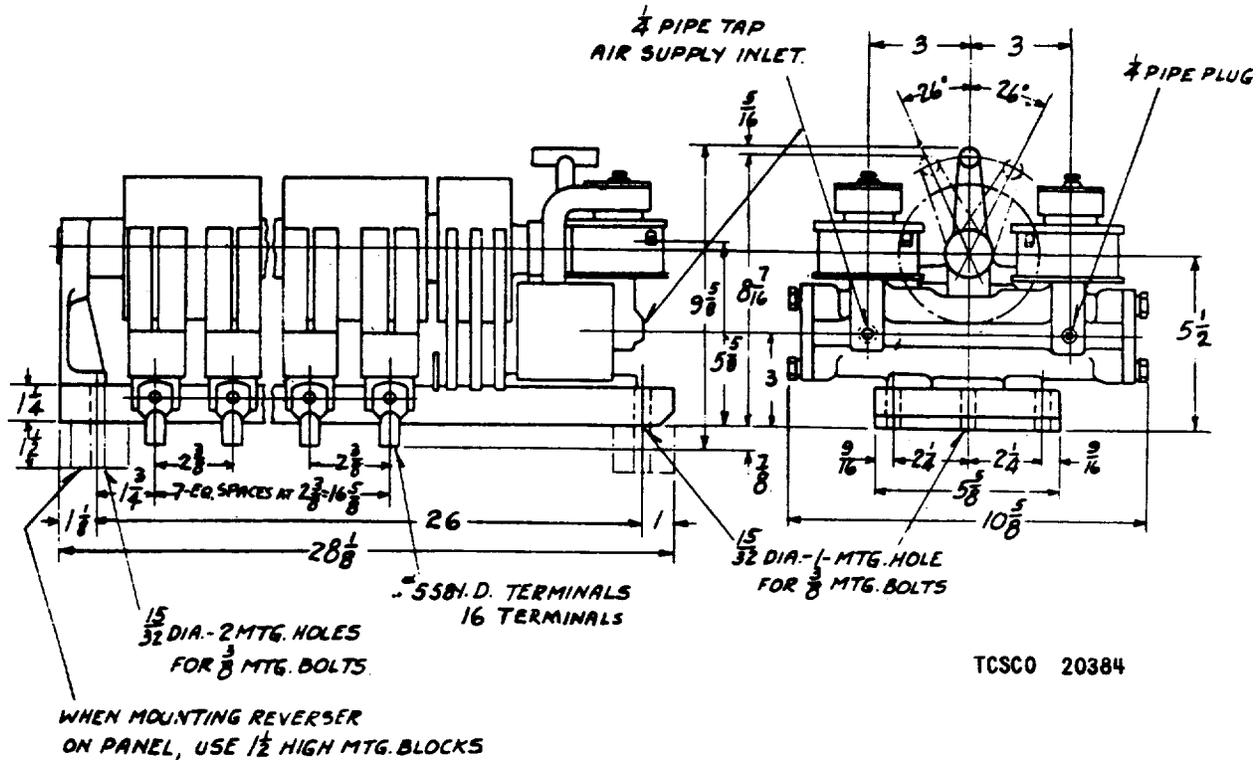


Figure 21. Reverser outline.

the admission of air to and the exhaustion of air from the air-operated cylinders. Magnet valves fall naturally into two general classifications as to operating principle: namely standard and inverted valves.

- (2) The standard valve when energized, admits air from the pressure line through a small port or seat allowing the air to pass through the valve and into the air cylinder which actuates the complete piece of apparatus. In this valve the full pressure of the air line or reservoir acts continuously in the cylinder, as long as the magnet coil is energized, while another valve on another seat prevents the air from escaping through the magnet valve exhaust port.
- (3) The inverted valve energized, acts to shut off the air from the supply line and allows air to escape from the cylinder through an exhaust port in the magnet valve. Sequence switches usually use both types of valves at the same time, due to the opposed direction of travel of the pistons in the air cylinder, the magnet valves

being alternately energized or deenergized depending upon the direction of motion necessary.

- (4) Figures 22 and 23 illustrate the general principle of magnet valves, using a typical cross section of a standard valve, the chief distinction between the standard and inverted valves being that in a standard valve one bushing with two seats (upper and lower) and two valve stems are used, while in an inverted valve two bushings and one floating valve with two faces actuated by a pushrod and operating between the bushings are used. The construction of corresponding valve parts is similar and the following description, therefore, applies to all the valves.
- (5) Figures 22 and 23 show the diagrammatic cross-sectional view of a standard magnet valve with the operating parts in the position which they occupy when there is no current passing through the coil. Under this condition the spring (a) pushes the valve (b) up against the seat (c) and prevents any air from passing from the control air supply to the operating cylinder

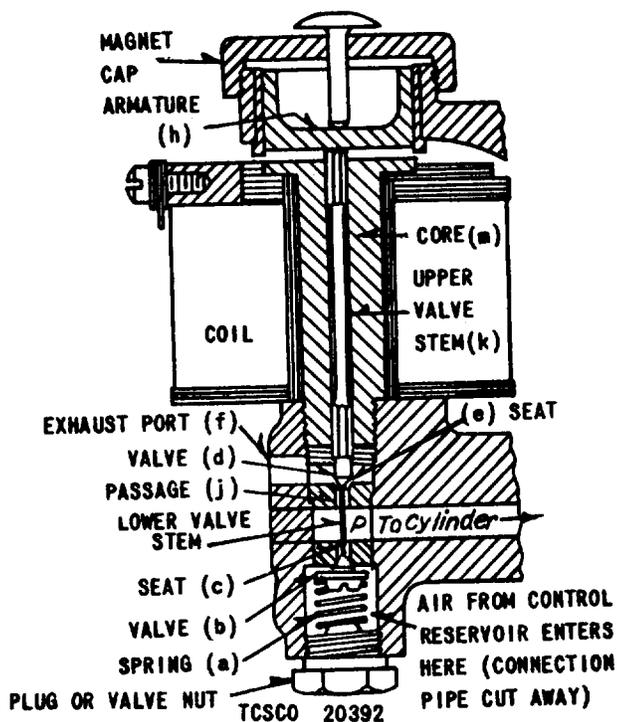


Figure 22. Cross section of open-coil type standard magnet valve.

The spring (a) not only closes the valve (b) but at the same time lifts the valve (d) off its seat (e) and leaves a clear opening for the escape of air from the operating cylinder through the passage (j) and (f) to atmosphere. When the magnet coil is energized the armature (h) pushes down on the stem (k), opens the valve (b) and admits air from the supply to the operating cylinder through the passage (p), and at the same time closes the exhaust valve (d).

(6) The maintenance procedure for all valves is practically the same.

b. *Inlet valve leakage.*

(1) Occasionally a valve will "blow" (i. e., give out a hissing sound) due to leakage of air, if this occurs when the magnet coil is de-energized and the air blows out of the magnet exhaust port (f), it is an indication that the lower (inlet) valve is not seating properly. This trouble is caused generally by the presence of a little dirt on the valve seat and in most cases can be "cured" by pressing down the pinion and

the top of the magnet valve and releasing it quickly several times. If the blowing persists shut off the air from the apparatus and unscrew the plug at the bottom of the magnet valve. Carefully lower the plug straight down and the spring and lower valve will drop down with it. Wipe the valve perfectly clean and with a small stick and piece of cloth also clean the valve seat.

(2) When replacing the lower valve, spring, plug or valve nut, first remove the cap over the armature so that in case the valve stem does not properly enter the hole in the stem (k), it is free to be lifted by the advancing stem instead of being damaged. If the inlet or exhaust valve is not tight, the difficulty can sometimes be overcome by inserting a small screwdriver in the top slot and spinning it a few times on the seat.

c. *Exhaust Valve Leakage.*

(1) In case a standard valve "blows" through the exhaust port when the coil is energized it is a sign that the exhaust valve (d) is not seating properly on the seat (e). This may be due to any one of the following causes which are mentioned in

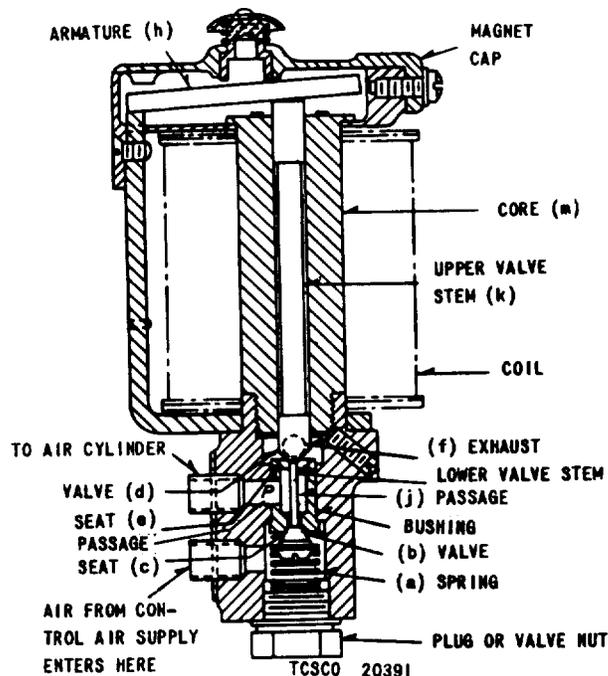


Figure 23. Cross section of open-coil type standard co-ordinated magnet valve.

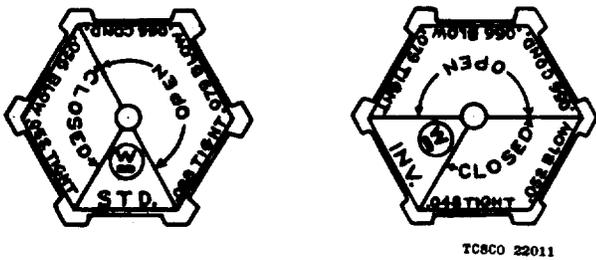


Figure 24. Valve setting gage.

the order of their usual liability of occurrence.

- (a) Dirt on the valve seat (e).
- (b) Weak battery or low voltage applied to coil.
- (c) Dirt under the magnet armature (h).
- (d) Valve stem (k) worn down so that armature strikes the core (m) before the valve seats.

- (2) To remove stem (k) it is not necessary to shut off the air. First remove the cap over the armature and lift out the armature which is not fastened in any way. Next place a finger on one hand over the magnet valve exhaust port (f) and press down on top of the valve stem with a finger of the other hand and then raise the finger quickly. The valve stem will be raised by the air pressure and can be readily lifted out and the end of the valve wiped clean.
- (3) A weak battery will sometimes give a sufficient pull to unseat the lower valve but not enough to close the exhaust. The obvious remedy is to charge the battery.
- (4) Another possible cause of a blowing exhaust valve, i. e. worn down stem (k), is very unlikely to occur until after the equipment has been in service for several years. If this stem is found to be too short it can be slightly stretched by "peening" the shank.

d. *Valve Gaging.*

- (1) In order to obtain satisfactory operation from the electro pneumatic valves, it is necessary to maintain the "travel of the valve" and the final gap between the magnet armature and core, within certain limits.
- (2) After a considerable period of service the valves wear down and it is necessary to refit or replace them. In order to accurately determine their condition a

simple gage, figure 24, is employed. This gage is used for both standard and inverted valve by turning it over, depending on type of valve to be checked.

e. *Checking and Adjusting Standard Valves.*

(1) *Upper valve stem.*

- (a) Gage, figure 24, is used to check and adjust the final gap and length of new upper valve stems. Remove the magnet cap and insert the gage as shown on figure 25. Flat-file the top of the upper stem until the 0.056-inch gage will admit air to the cylinder with a slight leak out the exhaust and the 0.052-inch gage will close the exhaust valve tight. The final air gap is then between the two, or approximately 0.054 inch. New stems have excess length and should be ground to a tight seat before adjusting the gap. Directions for grinding are included in h below.

- (b) In service, it is permissible to allow the upper stem and seat to wear until the final gap is approximately 0.032 inch. The 0.066-inch gage will at this point fail to unseat the lower valve to admit air to the cylinder and the upper stem must be stretched by peening or a new stem used.

- (2) *Lower valve stem.* The same gage, figure 24, is used, after the upper valve stem has been adjusted, to adjust the travel and the length of the lower valve stem. Use the 0.088-inch gage. This will probably cause the valve to unseat and blow due to excess length of the lower stem. The upper end of lower stem should then be flat-filed until the 0.088-inch gage will not touch but the 0.070-inch gage will unseat the lower stem. The total gap is then approximately 0.086 inch and the travel is 0.086 inch minus 0.054 inch or 0.032 inch. In service, it is permissible to allow the lower stem to wear as long as the condemning gage 0.066 inch makes the lower valve blow when the upper stem is new. If it does not, the travel has then reached 0.012 inch and the lower

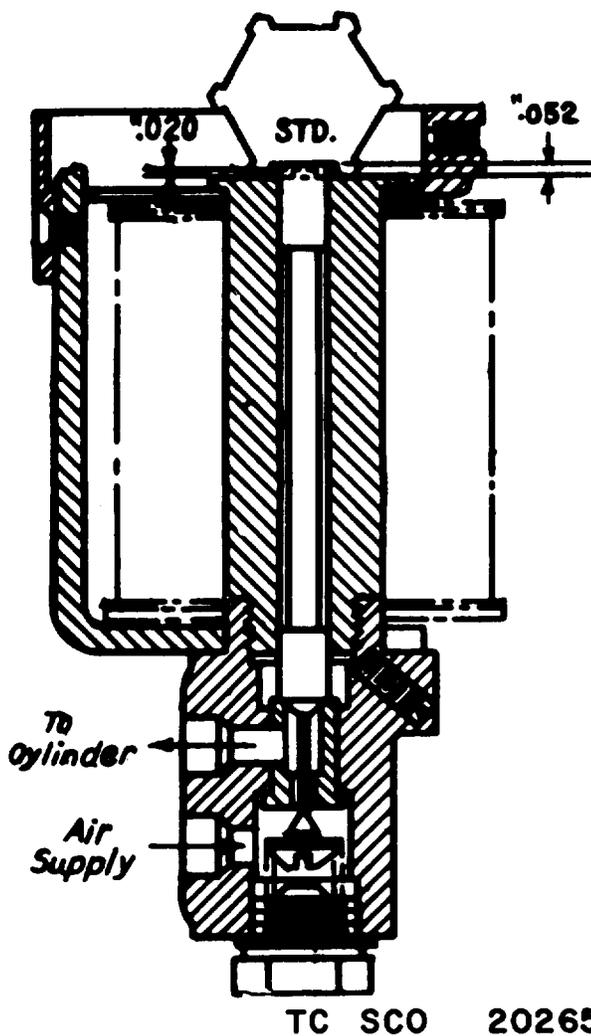


Figure 25. Gage in proper place for checking and adjusting standard valves.

stem must also be stretched by peening or a new stem used.

f. *Checking and Adjusting Inverted Valves.*

- (1) Gage, figure 24, is used to check and adjust the final gap and the length of new pushrods. Remove the magnet cap and insert the gage as shown on figure 26. Flat-file the top of the pushrod until the 0.052-inch gage discharges the cylinder with a slight leak out the exhaust and the 0.049-inch gage will discharge the cylinder with the inlet valve tight. The final air gap is then between the two, or approximately 0.050 inch. New pushrods have excess length and valves should be ground to a tight seat before adjusting the

gap. Directions for grinding are included in *h* below.

- (2) The same gage is used to check the travel of the floating valve. This travel is set at the factory between 0.017 inch and 0.027 inch, by proper machining of the bushings and floating valve. To check this travel, the 0.079-inch gage will close the lower port and should not make the valve blow, the 0.066-inch gage should cause a slight leak; both checks being made with the cylinder charged.

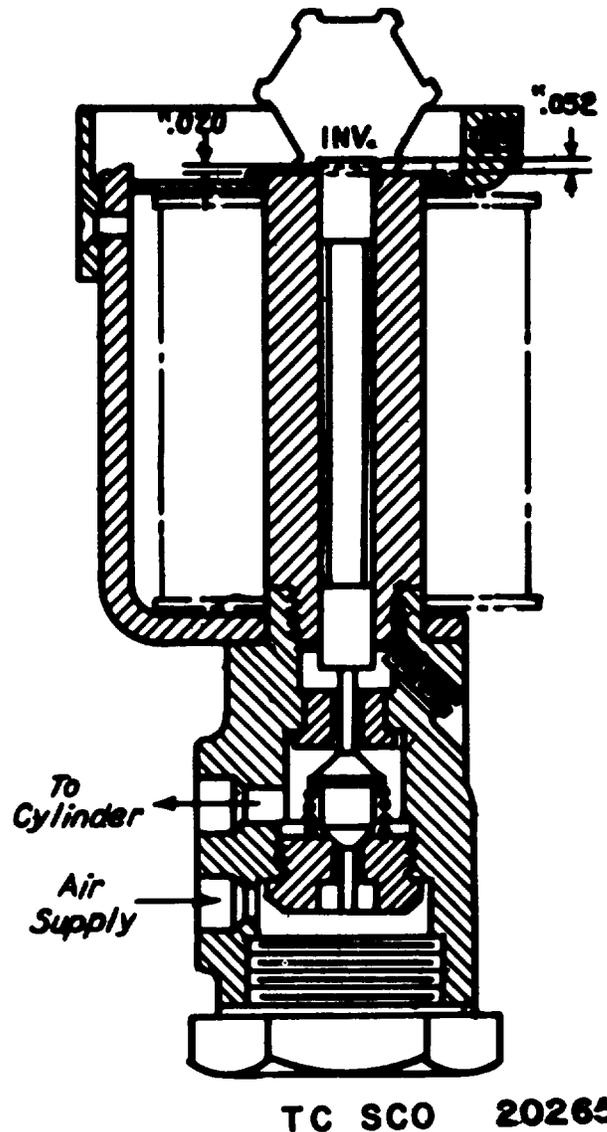
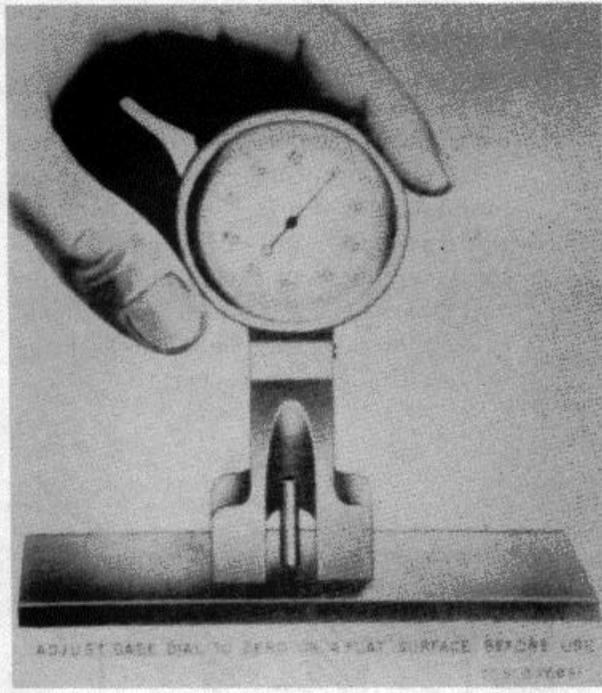


Figure 26. Gage in proper place for checking and adjusting inverted valves.



**Figure 27. Micrometer dial gage for adjusting magnet valves.**

- (3) In service, it is permissible to allow the pushrod to wear until the final gap is approximately 0.032 inch. Some magnet cores (used with clapper type armature) are made with bronze residual stops, 0.020 inch in height above the core face. Obviously, on cores using these pins, the final air gap setting would be 0.012 inch more than the height of the residual pins. The 0.056-inch gage will at this point fail to unseat the exhaust port to discharge air from the cylinder and the pushrod must be stretched by peening or a new rod used. No adjustment of the floating valve is possible, therefore when the maximum travel exceeds the limit of approximately 0.012 inch, a new valve must be ground in.

*g. Standard Micrometer Dial Gage.* A more accurate method of measuring valves is by use of a standard micrometer gage with a special fixture, as shown on figure 27. This is especially convenient where there is a large number of valves to be overhauled, as the amount of material to be removed from new valves can be determined directly rather than by the cut and try process.

*h. Grinding Valves.*

(1) *Standard valve* (fig. 28).

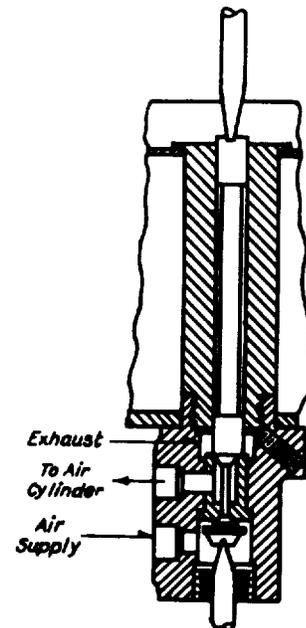
- (a) Use prepared grinding compound for this purpose, or make a thin paste of very finely ground pumice and machine oil. Apply a little grinding compound on the valve seat, put valve in place and spin back and forth with a screwdriver until seat is tight. Remove pumice before testing for a leaking valve.
- (b) When grinding the lower valve, leave the upper stem in place to act as a guide. After grinding, clean the stems and valve seats thoroughly, by using a little gasoline and blowing out with air.

(2) *Inverted valve.*

- (a) Use compound as described in (1)(a) above. Spin valve with grinding tool as shown in figure 29 for grinding lower seat and with screwdriver for upper seat.
- (b) Clean pushrods and seats as described in (1)(b) above.

*i. Valve Bushings.*

- (1) Valve bushings are furnished with the vertical portholes pilot drilled and the valve seats completely machined.



**Figure 28. Method of grinding standard valve.**

- (2) Install bushings, and grind the valves as outlined in h above. Drill the horizontal hole to the same size as the original bushing after installation.

## 89. Magnetic Contactors

### a. Description.

- (1) Magnetic contactors are magnetically operated switches used for the purpose of closing and opening the auxiliary or power circuits; they are operated by low voltage from the battery circuit.
- (2) Each contactor has stationary and movable contacts, an electro-magnet for bringing the contacts together, and, in addition, high voltage contactors have BLOWOUT COILS to extinguish the arc, and arc shields and barrier to protect the metal portions of the switch.
- (3) The stationary and moving contacts are made of hard drawn copper of sufficient section to give long life. Burning at opening and closing occurs only at the tips of the contacts and does not affect the current-carrying surfaces; a slight wiping action when closing insures a clean low-resistance contact area. A steel compression spring insures positive contact pressure, regardless of wear, and also causes quick opening of the contacts.
- (4) The arc shields and barrier are made of heat resisting materials. The arc shields can be removed readily for inspection of contacts.

### b. Maintenance.

- (1) Do not oil or lubricate any part of this contactor. Keep all parts clean; accumulation of dirt will interfere with the operation.
- (2) Copper contacts normally wear to give the best contact surface without attention; however, if rough blistered contact tips keep the heels of the contacts from closing, smooth tips with a fine file. Do not file heel of contact.
  - (a) Contacts may burn at the heel because of improper rolling action of moving contact on stationary contact. This may be caused by a weak or broken finger spring. It should be replaced immediately.

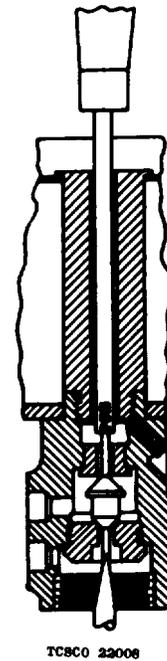


Figure 29. Method of grinding inverted valve.

- (b) Contacts wear quickly as the result of too small a travel and very little wiping action. This may be caused by insufficient free movement of the armature or too strong a finger spring.
  - (c) Renew contacts when tips of old contacts are worn thin, when contacts are burned at the heel or when the contact is badly worn. Contacts worn until the arc damages contact bolts will be difficult to remove without damaging the switch.
- (3) Renew arc shields before the heat resistant material is burned away sufficiently to expose the metal poles; the shield may be removed easily by taking out a single bolt.
  - (4) Keep the flexible copper shunt tight. If it becomes loose, there is danger of the shunt burning at the point.
  - (5) Remove the operating coil by removing the armature, disconnecting the terminal leads and removing a screw and nut. Coils are designed to operate the contactor successfully at from 60 percent to 110 percent of normal voltage and to stand 110 percent voltage continuously without overheating; coils are impregnated to make them resistant to moisture and oil.

- (6) Keep the sealing surface of the magnet core and armature clean.
- (7) Adjust the interlocks so as to make contact at the correct point.
- (8) After the locomotive has been run an inspection can be made of contactor condition immediately upon shutdown by feeling the temperatures of the contacts and interlocks by hand; adjust the warmer ones. This same method of inspection can be applied to other contacts.
- (9) Determine the PULL-IN voltage at overhaul and set the contactor to PULL-IN at not more than 60 percent of normal voltage.
- (10) Faulty or erratic operation may occur due to too high a PULL-IN voltage or binding of parts.
- (11) The arcing shield or chute which surrounds the main contacts can be released readily and slid out from its position; it is provided for the purpose of directing the arc and preventing it from coming in contact with the blowout poles and other metal parts of the switch. The parts of the arc chute are all made of arc-resisting, insulating material, but they will gradually wear away necessitating occasional renewing. Renew the sides before they have burned away sufficiently to expose the metal pole pieces.
- (12) Securely fasten the copper shunt which carries the current from the moving contact to the contactor terminal, and if broken or badly worn, replace promptly.

## 90. Interlock

### a. Description.

- (1) An interlock is an auxiliary switch, mounted on a main circuit electro-pneumatic switch or electro-magnetic contactor, which establishes or disconnects a control circuit at the time of operation of its particular switch. There are two general classes; the IN interlock, which completes a control circuit when the main contacts of the switch are closed; and the OUT interlock which establishes a control circuit when the main contacts are opened. A single main switch or contactor can be equipped with IN interlocks, OUT interlocks or a

combination of both depending on the sequence required.

- (2) There are three general types, the butt type commonly used on magnetic contactors and the sliding type and cam types usually used on pneumatic switches. With the butt type a small metal arm is attached to the armature of the switch. The arm actuates a pivoted insulated block on which are mounted spring supported contacts. As the switch operates, the contacts bridge control terminals and thus establish the circuit. With the sliding type, the control wires are terminated at compensated fingers mounted on the base of the switch. An insulated block, which carries small conducting segments, is attached to the piston arm of the switch. As the switch operates the segment slides under two fingers to complete the circuit. With the cam type, the control wires are terminated at the stationary and spring fingers mounted on the base of the switch. A block attached to the piston arm carries small cams. As the switch operates, the cams close or open the spring fingers to make or break the circuit to the stationary fingers.
- (3) Interlocks have a very important function in the overall performance of the apparatus. The failure of an important interlock is sufficient to prevent operation. Trouble can be avoided by periodic inspection.

b. *Inspection.* The following examination of the interlocks should be made at inspection periods:

- (1) See that the control terminals are tight.
- (2) See that the interlock contacts are clean and not worn or burned.
- (3) See that there is a deflection of the spring in the interlock finger or bar when the contact is made.
  - (a) On the butt type this can be obtained by adjustment of the length of the interlock arm.
  - (b) On the sliding type this can be accomplished by putting a slight set in the fingers.
  - (c) On the cam type this can be accomplished by adjustment of the gap between

fingers. This should normally be 1/8 inch when open.

lowers the dropout voltage without affecting the pickup. Increasing this air gap raises the dropout voltage without affecting pickup.

### 91. Relay Panel Type UV-56

a. This relay panel consists of either two relays and two resistor tubes on an insulating base or one relay and a resistor tube on a base. The relays are exactly alike in mechanical details and coils but may be adjusted to operate at different voltages. The correct operating voltages are indicated on figure 44. Each coil is connected in series with one of the resistor tubes.

b. The relay is a clapper type device mounted on hardened pivot bearings which are covered by a felt washer to exclude dust and dirt.

c. The pivot points are used to minimize friction and a counter weight is attached to the armature to balance the moving parts and minimize the effect of vibration. The moving and stationary contacts have contacts with silver tips.

d. These relays are adjusted to two voltages. One is the so-called pickup voltage which is the voltage at which the coil overcomes the pull of the spring and pulls in the armature. The other voltage is the dropout which is the voltage at which the tension of the spring overcomes the pull of the coil and pulls the armature back away from the coil.

e. Three adjustments are required to calibrate these relays. One is the tension of the spring, the second is the air gap when the relay is closed, the third is the air gap when the relay is open or deenergized. These adjustments have been made at the factory and should not need to be changed. These adjustments have all been soldered so that the vibration on the locomotive will not change them.

f. The effect on the pickup and dropout voltages of the three adjustments are as follows:

- (1) Increasing the tension of the spring raises both the pickup and dropout voltages. Decreasing the tension lowers both the pickup and dropout voltages.
- (2) With the relay de-energized, increasing the air gap (by means of the stop screw) raises the pickup voltage and does not affect the dropout. Decreasing this air gap lowers the pickup voltage without affecting the dropout.
- (3) With the relay picked up, decreasing the air gap (by means of the residual screw)

g. Another adjustment (which may or may not be used) is the jumper on the resistor tube but this adjustment is determined at the factory and must not be changed. If a new resistor tube is installed, take care that it be assembled with the identification band at the lower end of the relay panel and note the position of the jumper on the old tube. After replacing with a new tube install the jumper on the tap corresponding to the tap on the old tube.

h. If possible remove the relay panel to a bench with a source of variable voltage with a range covering the pickup and dropout voltages. It is possible to adjust these relays on the locomotive if the circuit to the traction motors is broken or it may be possible to adjust them while the locomotive is in operation.

i. Maintain the pickup and dropout voltages shown on figure 44 by changing the proper adjustment. This will only be required at infrequent intervals provided the adjustments are resoldered to prevent locomotive vibration from affecting them. Keep the fingers in adjustment as they wear. The fingers should deflect 1A/6 inch when in contact with their studs. Keep the air gap between finger and contact stud at not less than 3/32 inch and relay should not "float." either in or out.

### 92. Relay Panels Type UR

a. The relays are simple and rugged and have a clapper type armature with a rocking pivot. The armature is held in position by the same compression spring which provides the calibration. The contacts should deflect 1/16 inch on closing and have a gap of 32 inch when open.

b. The coil resistances and the relay pickup voltages are specified on figure 44. The dropout value is not important. The shunt coils of these relays are usually connected in a bridge circuit and therefore carry very little current during normal operation. For the circuit arrangement, refer to figure 44.

c. Maintenance consists mainly of visual inspection to see that the relay is clean and the parts free to move in the proper manner. Be sure all connections are tight and wires not broken.

### 93. Type M Resistors

a. Type M resistors are used in the circuits where large resistor capacity is required. This resistor is built of tubular units having steel center supports insulated by sections of porcelain. A resistance ribbon is wound edgewise in the form of a helix about the sections of porcelain. The units are mounted on insulated tie rods supported on a strap steel frame. Each unit may be removed easily without disturbing any of the other units.

b. The resistors limit the amount of current flow through the respective circuits and thus have an important part in the overall performance of the equipment. Electrical characteristics of the equipment can be upset by the adjustment of a resistor in an important circuit. All resistance values are properly adjusted when the unit is first put in service. Adjustments will only be made by one who is thoroughly familiar with the performance of the complete equipment.

c. At light and heavy inspections examine the complete resistor assembly for broken porcelains and resistance ribbons. Check that all connections are tight and properly made and that the resistance ribbon is properly and securely clamped in the end terminals. Clean the mounting insulators and frame terminal bar.

d. At general overhauls, in addition to the above inspections, tighten the mounting bolts and clean the insulating terminal bar, then paint with insulating varnish.

e. When replacing a resistor tube, care should be taken to have the terminal clamps and resistor ribbon clean, smooth and bright before making connections. Use new terminal clamps when replacing tubes.

### 94. Control Resistors

a. The control resistors, which carry only low values of current, consist of resistance wire wound on tubes. The tubes are of various ohmic values as specified on figure 44.

b. The control resistors also have an important function in the overall operation of the electrical apparatus. The characteristics of the equipment can be disturbed by changing the values of the control resistors in important circuits. The resistors are properly adjusted when the equipment is first placed in service and should not be tampered with. Adjustment will be made only by

one who is thoroughly familiar with the performance of the complete equipment.

c. At light and heavy inspections examine the resistor panel carefully for loose connections. Take the resistor tubes from the panel and check for broken or open circuited tubes. Care must be exercised in replacing the tubes and making proper connections.

d. Replace broken or damaged tubes only with tubes having identical style number.

### 95. Switches and Fuses

a. Inspect all hand switches and fuses (if used) regularly, to cover:

- (1) Switch jaws, fuses and fuse clips making good contact.
- (2) Leads firmly soldered, terminals and bolts tight.
- (3) Panels or bases clean, free from oil and dust.
- (4) Correct fuses in use, spare fuses available, and auxiliary apparatus tested if one fuse blows frequently.
- (5) Any springs correctly in place and operating.
- (6) Apparatus tested for proper operation.
- (7) Contacts clean and smooth.

b. Cover in this inspection all items such as control and miscellaneous switches and fuses, traction motor cutout switches, weight transfer and sander foot switches, buttons for engine stop or other circuits, headlight hand switches and fan or traction blower switches, and train line jumpers and receptacles.

### 96. Voltage Regulator Panel

a. *Description.*

- (1) This voltage regulator is of the vibrating type. It varies the auxiliary generator shunt field currents to hold constant voltage on the auxiliary circuits regardless of auxiliary load or engine speed.
- (2) The regulator has a powerful magnetic circuit which is excited by a single coil on the stationary frame. The moving iron armature is supported by a flat stainless steel hinge spring which is spot welded to the armature iron. The two arms of this spring fit over dowel pins located in the edge of the top plate of the stationary frame. The spot-welding of the hinge spring and the location of the

dowels is done in accurate jigs at the factory in order to maintain the air gap at the bottom of the armature within close limits. If the hinge spring should become damaged, the armature iron and hinge spring assembly must be replaced as a unit as it cannot successfully be repaired. The armature rocks on two stainless steel ball pivots which are pressed into the edge of the top plate.

- (3) Reference to figure 44 will indicate the connections of the resistors used in conjunction with the regulator. When the engine is not running, the regulator spring holds the moving contact against the right hand stationary contact. This causes the resistor in series with the auxiliary generator field to be paralleled by the R. H. stationary contact.
- (4) If the engine is started and brought up to idling speed the voltage of the auxiliary generator increases to the value for which the regulator is adjusted. When this occurs the magnetic pull of the regulator coil overcomes the spring tension and the moving contact swings away from the R. H. contacts. This breaks the current flowing through its resistor and lowers the auxiliary generator field current, thus lowering the generated voltage slightly. The magnetic pull the regulator coils is weakened and the spring again closes the contacts. This vibrating action is rapid enough so that no flicker will occur in the lights.

*b. Maintenance.*

- (1) The sparking is fundamentally normal and will in time produce slight pitting on the graphite contact surfaces.
- (2) Adjust the contacts that have worn so that the gap between them is greater than one-eighth of an inch by moving the stationary contact outward by the use of one of the extra flat washers provided under the head of the contact holding screw. Mark the contacts before removing stationary contact so that it can be put back without rotating it with reference to the moving contact. After spacing the contact out or when new graphite contacts are installed, carefully sand to insure a good contact surface over the entire face. Use a strip of No. 00 sandpaper between the two surfaces while pressing the contacts lightly together.

**Caution**

**Do not press the contacts together too tightly as this procedure deflects the supporting springs and sanding operation will result in misalignment of faces in normal operation which occurs at very light contact pressure.**

- (3) Unnecessary and excessive contact sanding will only shorten the useful life of the contact and require more frequent renewal. The contacts should not be sanded until the contacts are to be spaced out by washers.
- (4) Replace the moving contact before the worn surface reaches the edge of the groove at the center of the contact. Replace the stationary contact when the worn surfaces are within 1/32" of the brass cylinder in the contact.

**Caution**

**When tightening or replacing the moving contact or tightening any of the screws in the moving armature assembly always hold the armature firmly with one hand while using the screw driver or socket wrench with the other. This is to prevent twisting the stainless steel hinge spring (fig. 30).**

- (5) If it should be necessary to replace the regulator coil, remove the regulator panel from the main panel and do the work on a workbench where the renewal of parts can be facilitated under adequate and suitable conditions. To remove the coil, remove the top screws holding the bottom plate of the frame to the core, and the single screw holding the plate to the panel. After removing the coil leads, it may be slipped off the core. When installing the new coil, see that the mating surfaces of the bottom plate and core are clean and free from burrs and that no shred of insulation becomes pinched between them. Never touch a file to these surfaces or the accuracy of the armature air gap will be lost. When replacing the bottom plate, set all three screws up fingertight, before finally tightening any of them with screwdriver.

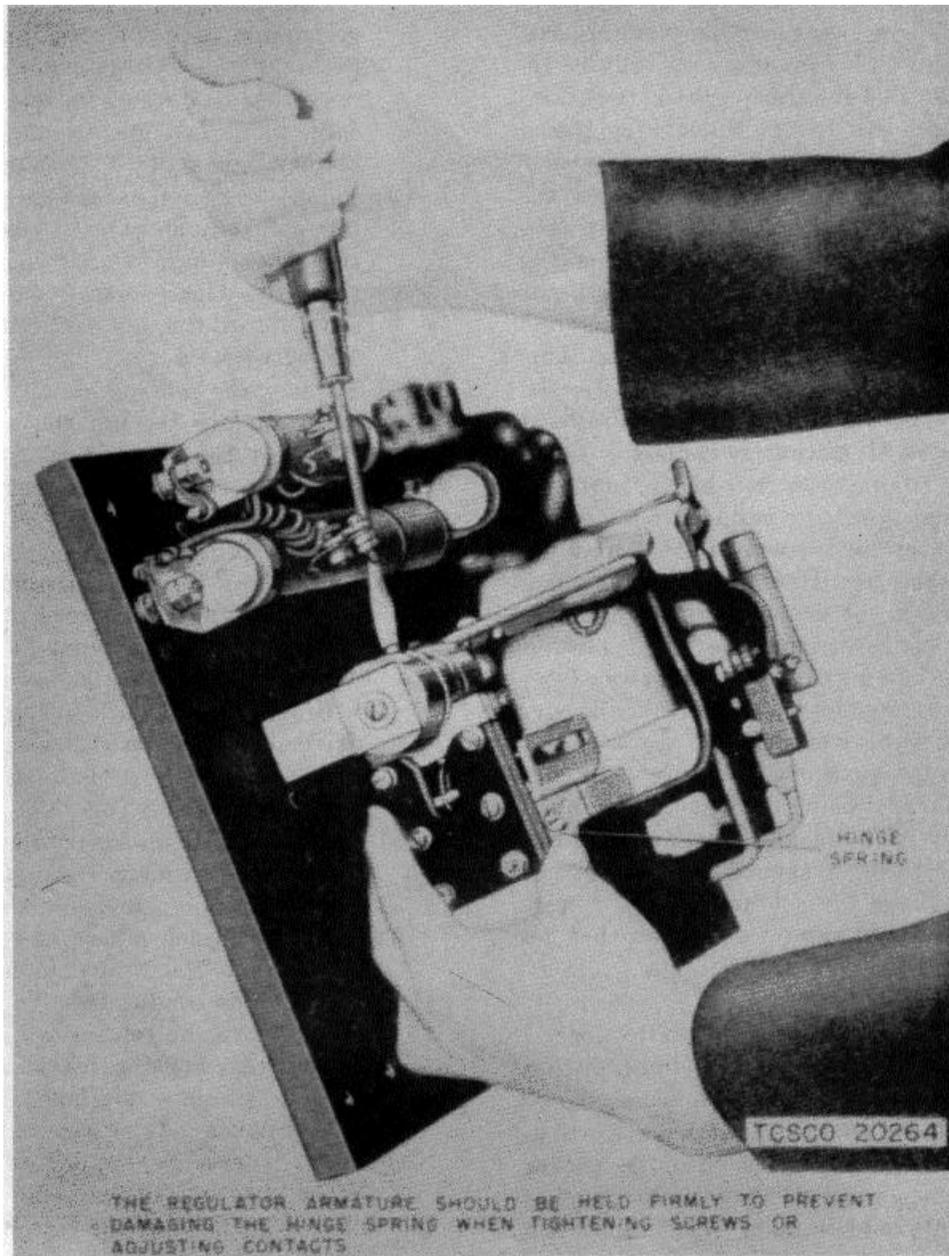


Figure 30. Method of holding regulator armature when tightening screws.

- (6) The reverse current relay located on the right side of the panel is used to connect the auxiliary generator across the battery when the generated voltage reaches a predetermined value and to remove the auxiliary generator from the battery circuit when the engine speed falls to a value so low that the regulator can no longer maintain the proper voltage, as when the engine is shut down. The relay carries the auxiliary generator current through its contacts. The contacts are sufficiently large to carry full current without overheating.
- (7) The coil of the reverse current relay is wound in two sections; a shunt section and a series or current section. The shunt coil of the reverse current relay is connected in series with a ballast resistor across the generator voltage. When the voltage rises to the pull-in setting, the relay closes and connects the auxiliary generator to the battery and load. The load current through the relay series coil aids in holding the relay closed.
- (8) When the engine stops, the auxiliary generator tries to motor from the battery. This reverses the current through the series coil which then opposes the shunt coil and causes the relay to open, which in turn disconnects the auxiliary generator from the battery and load.

c. *Relay Armature and Contacts.* The relay has a clapper-type armature with a rocking pivot which is practically friction-free. The armature is held in position by the same compression spring which provides part of the calibration. A brass residual button on the end of the iron core maintains the proper magnetic gap when the armature is closed. The moving contact is a bridge which connects two stationary contacts when the armature closes. The stationary contacts are threaded studs to permit adjustment. All contact surfaces are silver.

d. *Inspection.*

- (1) Inspection of the regulator panel consists largely of a visual inspection to make sure that all parts are in proper working order. Changes in adjustments without good cause should not be made.
- (2) The reverse current relay will normally require no attention for long periods of

time. The relay contacts are made of silver and should not require cleaning or dressing.

- (3) If the relay contacts are changed or replaced at any time, they should be carefully set.

e. *Putting the Relay in Service.* Before putting in service, test as follows:

- (1) Be sure the battery and generator are both connected with the same polarity.
- (2) Insulate the contacts of the A contactor.
- (3) Start the engine and close the auxiliary generator cutout breaker.
- (4) Measure the voltage from N to AG. This should be about 37 volts.
- (5) Measure the voltage between the contacts of the A contactor. This should be 5 or 6 volts. If it is 60 or 70 volts, it indicates that either the generator or the battery is connected with the wrong polarity.
- (6) If the preceding tests show that all is clear, remove the insulation from the A contactor. Stop and start the engine several times while observing the operation of the reverse current relay to be certain it is operating properly.

f. *Adjustment and Setting.*

- (1) Check panel wiring and lettering against figure 44.
- (2) Check the resistance of coils and resistor tubes. The regulator coil resistance is 4.5 ohms at 25° C. The shunt section of the reverse current relay coil has 18.8 ohms resistance. Resistor tube values are shown on the diagram.
- (3) With 37 volts across AG to N (make AG positive), adjust regulator spring so contacts float. Coil must be warm. The change in voltage to move the movable contact from the right hand stationary contact to the left hand stationary contact must not exceed 1/2 volt. When making this adjustment, be sure the stationary contacts are adjusted so that the lower edge of the armature overlaps the frame 1/8 inch and the contact gap is 1/16 inch. All points of the contact surfaces must make contact, simultaneously.
- (4) Regulator auxiliary panel should hang parallel to the main regulator panel and

should not drop more than 3/6 inch due to its own weight when the main panel is in position on the locomotive.

- (5) Set reverse current relay armature gap to 1/16 inch at center of coil core. Adjust stationary contacts to just touch the movable contact and lock them. Re-adjust armature gap to 5/32 and lock it. Contact gap should then be 13/64.
- (6) Adjust armature spring so relay closes

with 35 volts across AG to N (make AG positive). Coil should be warm.

- (7) Set contact spring tight as possible and still permit relay to seal at pick-up voltage without fail. Relay must not float in or out.
- (8) With 32 volts across AG to N, pass current through relay B3 to AG. (Make B3 positive.) Relay should drop out at 4 to 12 amperes without floating.

## Section XI. SPEED INDICATING EQUIPMENT

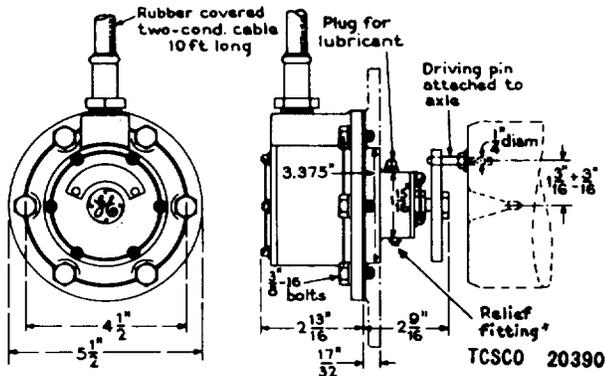


Figure 31. CM-4 Generator assembly method.

### 97. Installation

*a. Mounting Generator.* Install a driving pin on the end of the axle as shown in figure 31. Bolt the special journal box cover into position. Turn the generator rotor so that the driving arm engages with the pin on the axle. Carefully position the generator against the journal box cover checking that there is clearance between the pin and generator. Bolt the generator, with the drain hole down, to the journal box cover using standard 3/8-16 bolts. Check that the generator shaft is concentric with the wheel axle. Gaskets are provided to make an oil-tight connection. Place a piece of 3/4-inch hose, clamped at both ends, over the generator cable for protection.

*b. Transformer-Resistor Box.* Mount the transformer-resistor box in any convenient location which is protected from dirt and moisture. Particular attention must be paid to the temperature of tile site. It is recommended that the site have a temperature range of 75° ± 10° F. The temperature should never rise above 120° F. Temperatures up to 120° F. will not damage the box but will introduce temporary errors in proportion to the rise. Figure 32 shows the mounting dimensions of the transformer-resistor box. On

installation measure the wheel diameter and set the wheel-wear adjustment in the transformer-resistor box. Refer to paragraph 98.

#### c. Indicator.

- (1) The temperatures where the indicator is mounted should never exceed 140° F. Indicator will operate more accurately at a temperature of 75° ± 10° F. Figure 32 shows mounting dimensions.
- (2) Handle indicator with care to avoid damaging jewel bearings. Do not hammer on the panel on which the indicator is mounted.

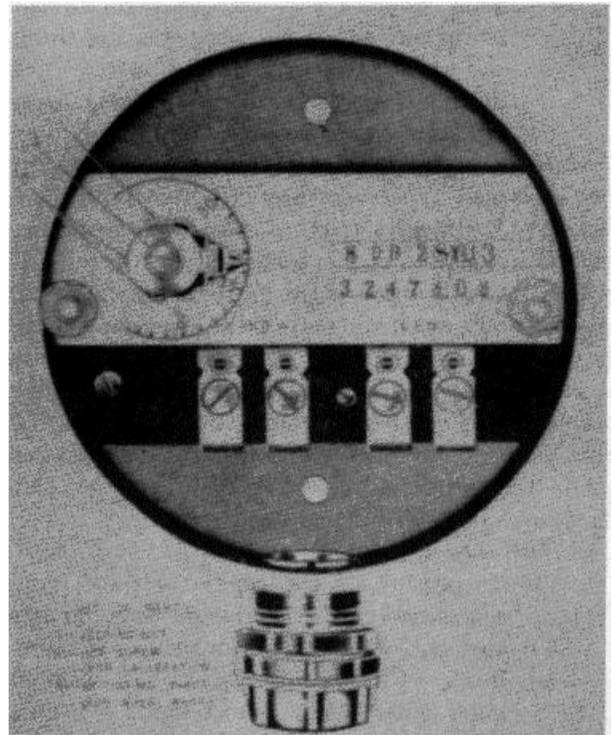


Figure 32. Transformer-resistor box with dimensions.

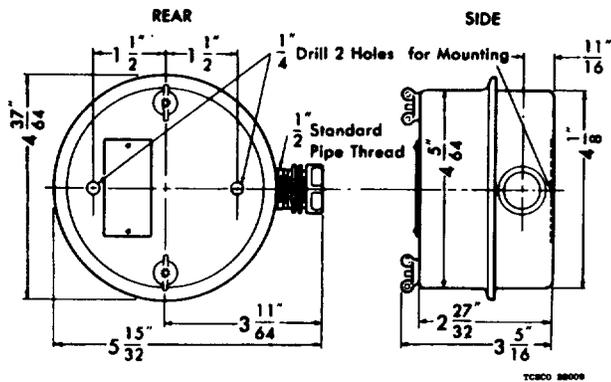
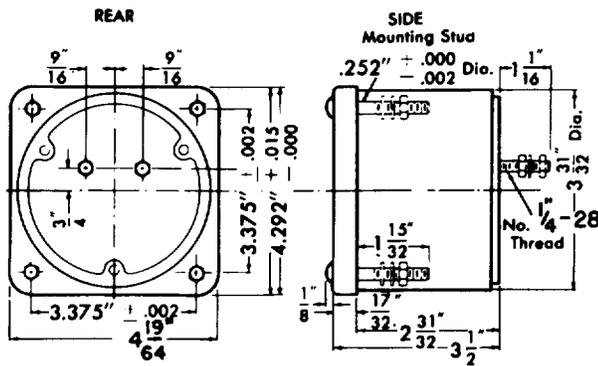


Figure 32 - Continued.



TCSC0 22005

Figure 33. Speed indicator mounting dimensions.

- (3) Check that the pointer is on the zero mark. If it is off, make the zero-set adjustment. Refer to paragraph 98.

d. Connections.

- (1) Make connections in accordance with figure 34, using No. 14 Awg, or larger, stranded copper wire.
- (2) Make a good ground connection between the locomotive frame and the truck on which the generator is mounted. The resistance of the ground circuit may be checked by temporarily disconnecting the auxiliary ground lead to the transformer-resistor box at the point X on connection diagram (fig. 34) and inserting an ohmmeter. The resistance as measured at this point should be less than 10 ohms.

98. Maintenance

a. Adjustments (fig. 32). Measure the wheel diameter at regular intervals and adjust the transformer-

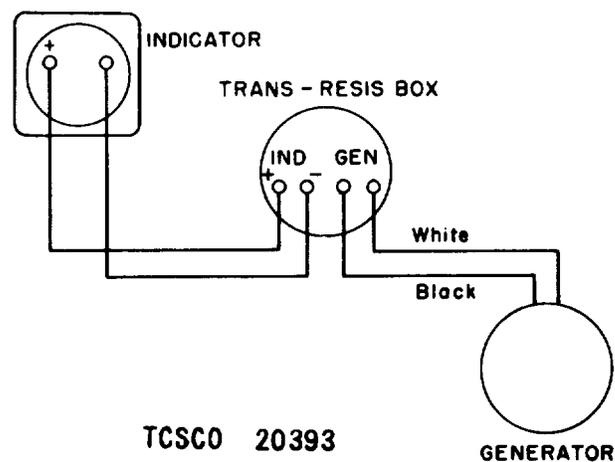
resistor box setting, if necessary. To make the adjustment, loosen the locking nut, taking care not to disturb the setscrews on the hub of the dial, and set the dial to correspond with the diameter of the wheel driving the generator. Tighten the locking nut. Check setting to see that it has not been disturbed when locking.

b. Zero-Set. The indicators are equipped with an external zero-adjusting screw in the front of the case. The pointer may be set on zero, when the indicator is de-energized, by turning the zero adjuster with a screwdriver at the same time gently tapping the front of the cover.

c. Calibration. Each indicator is calibrated with a particular transformer-resistor box and the two must always be used together. However, generators of the same type may be interchanged with no effect on the accuracy of the system. Check the speed-indicator calibration occasionally by observing the time over a measured mile. To check the operation of the equipment when it is removed from the locomotive, a calibration curve (fig. 35) shows the relation between generator rpm and instrument indication in miles per hour for wheel diameters between 30 inches and 40 inches.

d. Generator. It is important that a watertight joint be maintained at the point where the cable enters the generator. Do not remove the leads from the generator unless it is necessary to replace either generator or leads. If it is necessary to remove the generator, disconnect the leads at the connection box. On replacing the cover plate of the terminal box, cement the cover gasket in place with gasket cement. Take every precaution to see that no water is allowed to enter the generator.

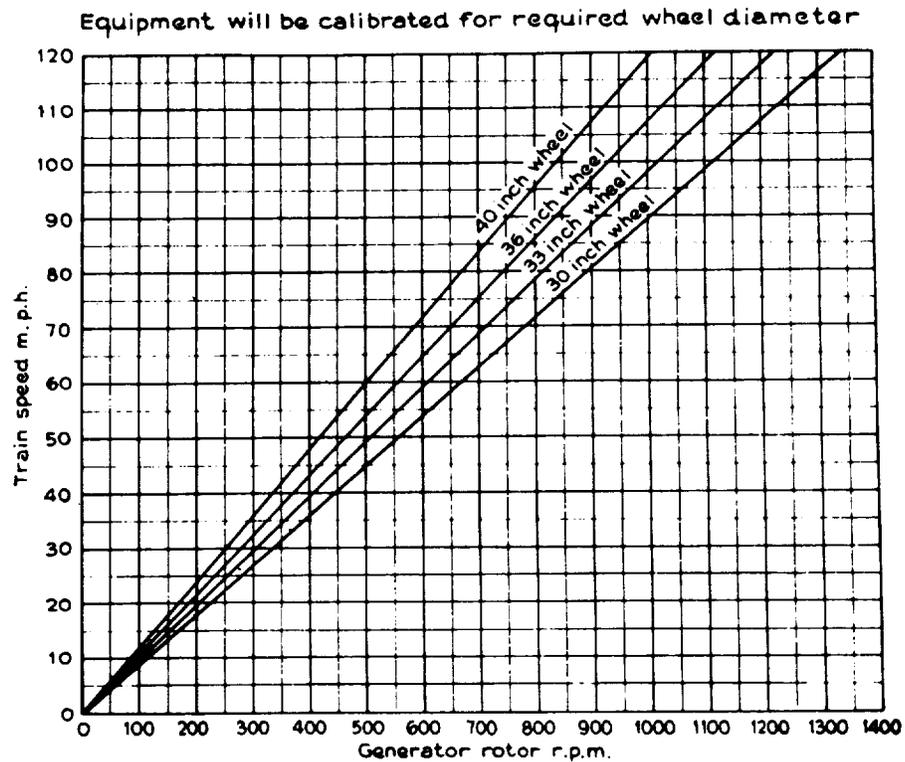
e. Lubrication. The generator is permanently lubricated; therefore, it will be necessary to lubricate it only at overhaul with high-temperature grease.



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Figure 34. Wiring diagram for type CM-4 generator.

**Electric Speedometer  
Journal Box Typo - Direct Drive**



TCSCO 22006

Figure 35. RPM-MPH calibration curve.

**99. Troubleshooting**

Trouble	Probable Cause	Remedy
No reading-permanent or intermittent.-	Loose connections and/or poorly soldered joints outside instrument. Poorly soldered joint inside instrument	Check external connections and resolder if necessary. Remove for repair.
Pointer off zero (instrument deenergized). -	Open resistor or rectifier..... Slight shift in springs..... Damaged spring.....	Replace transformer-resistor box. Reset to zero by zero-set screw in front of case. Examine springs. If they are deformed replace instrument.

*Note:* The above covers only those defects which can be remedied with simple tools such as a screwdriver and a soldering iron. Complete repair should not be attempted except by qualified personnel. Always remove both indicator and transformer-resistor box when either is defective, so they may be recalibrated together.

**Section XII. KEROSENE BURNING HEATERS**

**100. Cleaning Wicks and Burners**

Remove burner drum and raise the wick even with the top of the tubes. Scrape all carbon crust from the top of the wick with the edge of the cleaning tool furnished with the stove. (Do not try to clean the wick too thoroughly as this unnecessarily wastes it. A certain

amount of char on the edge of the wick gives a perfect flame.) Turn the wick down into the wick tubes as far as it will go. Remove the screw top by taking hold of the wire handles and turning a quarter turn to the left (fig. 36). Scrape inside and outside of



**TC SCO 20847**

**Figure 36. Dismantling burner for cleaning.**

the screw top thoroughly, being careful to remove all dirt and carbon from the flange on which the drum and combustion tube rest. Brush all loose particles of carbon or scale from the wick tubes and flange. Wipe with a dry cloth and replace burner top and drum. See that holes in combustion tubes are clean and open.

**101. Correcting Sticking Wicks**

When wick tubes become covered with gummy oil, causing the wick to work hard and keeping the drum from seating properly, clean in the following manner:

a. Remove oil reservoir and drain feed line. Loosen burner clamp) setscrew. Remove wick tube from feed pile, unscrew top and take wick out. Place the wick tubes in pan of boiling water deep enough to cover them. Add about one-half pound washing soda or any good cleaning compound. Do not use lye as it will damage the brass tube and do not boil in aluminum vessels as soda dissolves aluminum.

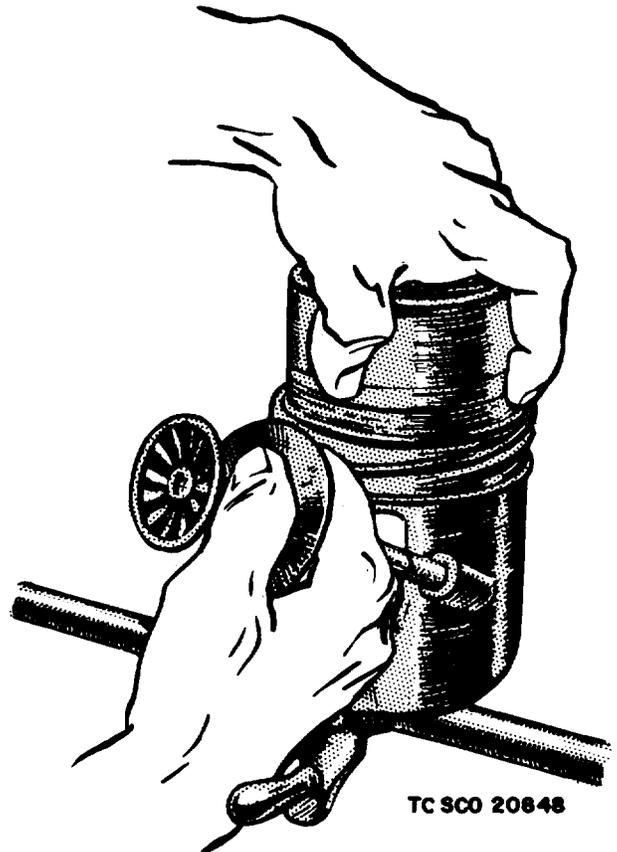
b. Boil vigorously for one hour then all gummy substance will either be boiled off tubes or so thoroughly loosened that it can be easily scraped away. Clean out

the feed pipe by twisting a wire through it to loosen all sediment, then rinse with clean oil. Take the wick tubes from boiling water, turn upside down to drain, then replace on feed pipe taking care that the hook is placed under the feed pipe and that the setscrew is tightened firmly without forcing.

c. Replace feed pipe, cap, wicks, and reservoir. After resetting wicks the burner will be ready for operation. If the burners are occasionally cleaned in this way they will operate in a satisfactory manner indefinitely.

**102. Re-Wicking Burner**

When it becomes necessary to re-wick use the same type wick or equal. Remove the drum, press the indicating pointer through the hole in the dial; while holding it there, turn handwheel to the right until the wick carrier is lifted as high as it can go. Lift out the oil wick and insert the new. Press the wick downward until the carrier engages with the teeth on the lower end of the handwheel spindle (fig. 37). Turn the wick down until top



**TC SCO 20848**

**Figure 37. Re-wick burner.**

edge is 1/6 inch above the wick tube, then release indicator pointer.

### 103. Cleaning Heater Units

a. Operating the heater with too high a flame will cause the heating units to be covered with smoke and soot. This results in a great reduction in efficiency. Clean the heating units as well as the burner parts thoroughly, and remove all soot.

b. The heater casing can be easily raised for cleaning or inspecting.

c. When cleaning the heating units, be sure to cover the burner to protect it from falling soot.

### 104. Care of Heater When Not in Use

a. When the heater is not to be used for several months, (carefully drain to prevent rusting. To make sure that no water remains in the heating unit unscrew the pipe connections at the lower part of the heater. Unscrew the cap at end of oil feed line and drain.

b. Should heater not produce hot water satisfactorily, examine all piping to see that it is arranged properly.

#### Caution

**Do not place combustible material on the heater, or permit such material to accumulate around heater. If heater is not connected to a flue be sure that flue connection opening in top of heater is always open so heat can pass through.**

## Section XIII. INTERNAL BELL RINGER ASSEMBLY

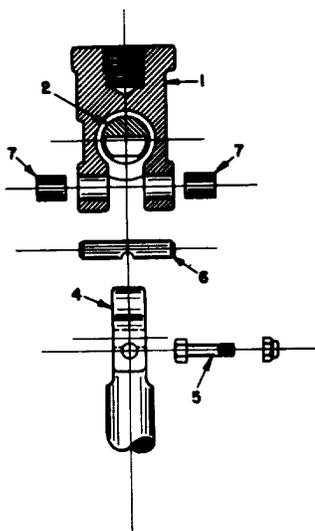
### 105. Bell Ringer

a. Remove ringer from bell and clean thoroughly, removing all traces of dirt and gum.

If piston shows excessive wear, repairs to ringer are required.

b. To disassemble, (fig. 38) remove bolt (5) and push out fulcrum pin (6). Slide out piston (2) and remove cap (3), shown on figure 3. The original body bore is reamed and burnished

to 1.000 inch diameter plus 0.001 inch maximum, minus 0.000 inch minimum and the hardened and ground piston is 0.9990 inch minimum, 0.9998 inch maximum at port end. If repairs are made, body can be reamed and burnished to 1.025 inch diameter plus 0.001 inch maximum, minus 0.000 inch



1 - Body      5 - Bolt  
 2 - Piston    6 - Fulcrum Pin  
 4 - Clapper   7 - Oilite Bushings  
 TCSCO 22007

Figure 38. Bell ringer sectional view.

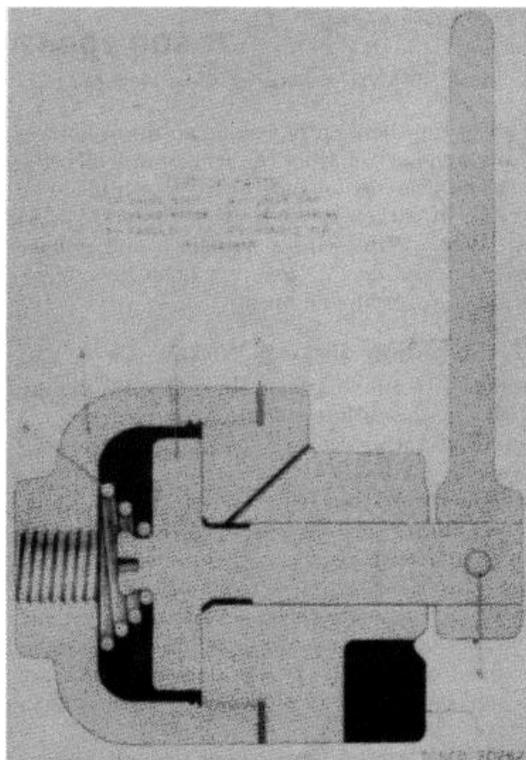
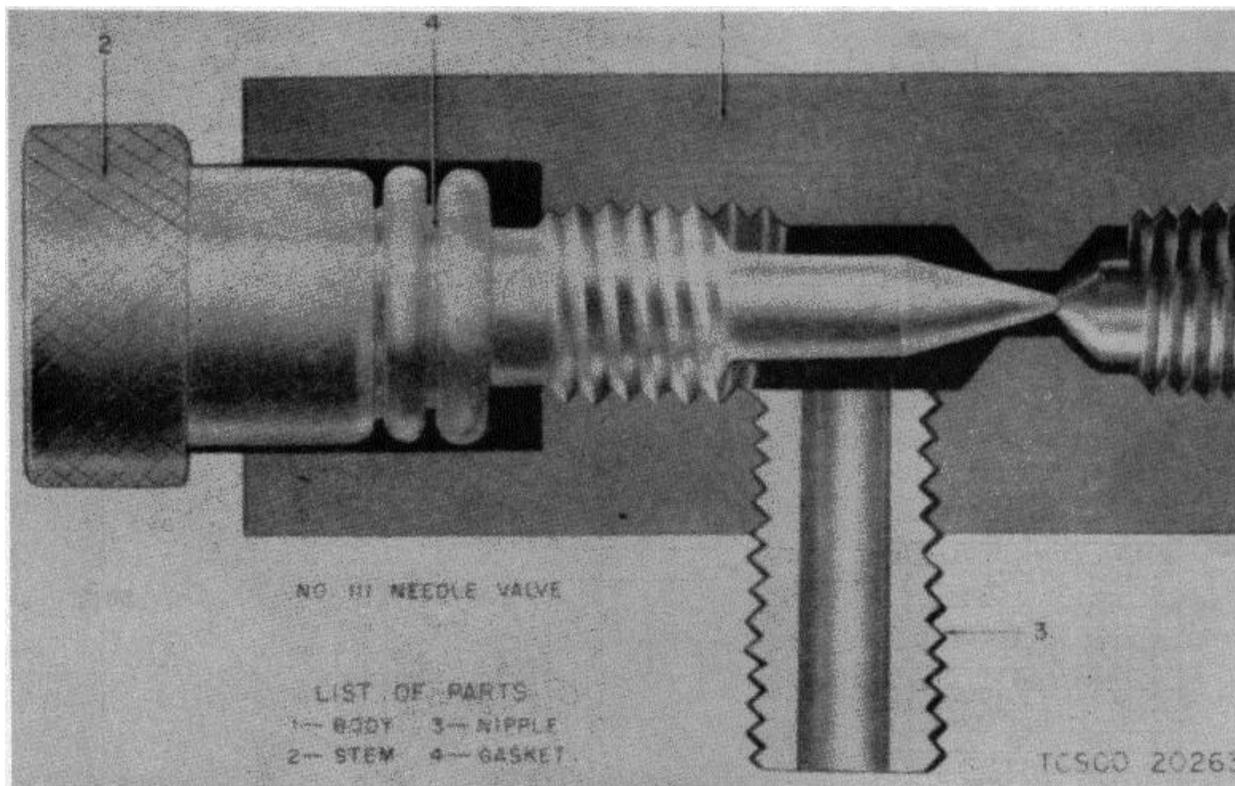


Figure 39. Bell ringer operating valve.



**Figure 40. Bell ringer needle valve.**

minimum and fitted with oversize piston 1.0248 inch diameter maximum, 1.0240 inch minimum at port end.

c. If clapper fulcrum pin shows excessive clearance in the oilite bearings (7), pin and bearings should be replaced. After bearings are pressed in place, peen over metal on outside to hold bearings in place. Ream bearings to 0.3760 inch diameter after pressing in if fulcrum pin does not revolve freely. Before reassembling, all parts must be clean. Lubricate with light oil and test assembled ringer.

#### **106. Bell Ringer Operating Valve**

a. An occasional drop of light oil is all this valve will require to provide years of trouble-free service.

b. To disassemble valve drive out handle pin (6) and remove handle (3). Unscrew cap (4) from body (1) and push out rotor (2). Refer to figure 39.

c. Seating surfaces on rotor (2) and body (1) may be lapped in, or refaced, many times before valve has to be condemned.

d. When seats are refaced remove all sharp edges and burrs. Renew gasket (7) if damaged.

#### **107. Bell Ringer Needle Valve**

To adjust cadence, close needle valve screw and gradually unscrew until proper cadence is acquired. Do not unscrew more than two full turns as opening through body to ringer is maximum. The O-ring gasket prevents air leaks and holds valve adjustment.

### **Section XIV. OIL FILTER**

#### **108. Description**

a. The lubricating oil filter has a radial flow repackable wastex element. The cover is held to the top ring by means of four steel eyebolts. These bolts,

when loosened, swing away from the cover so as to permit its removal easily. The cover is sealed by means of a wide vellumoid gasket.

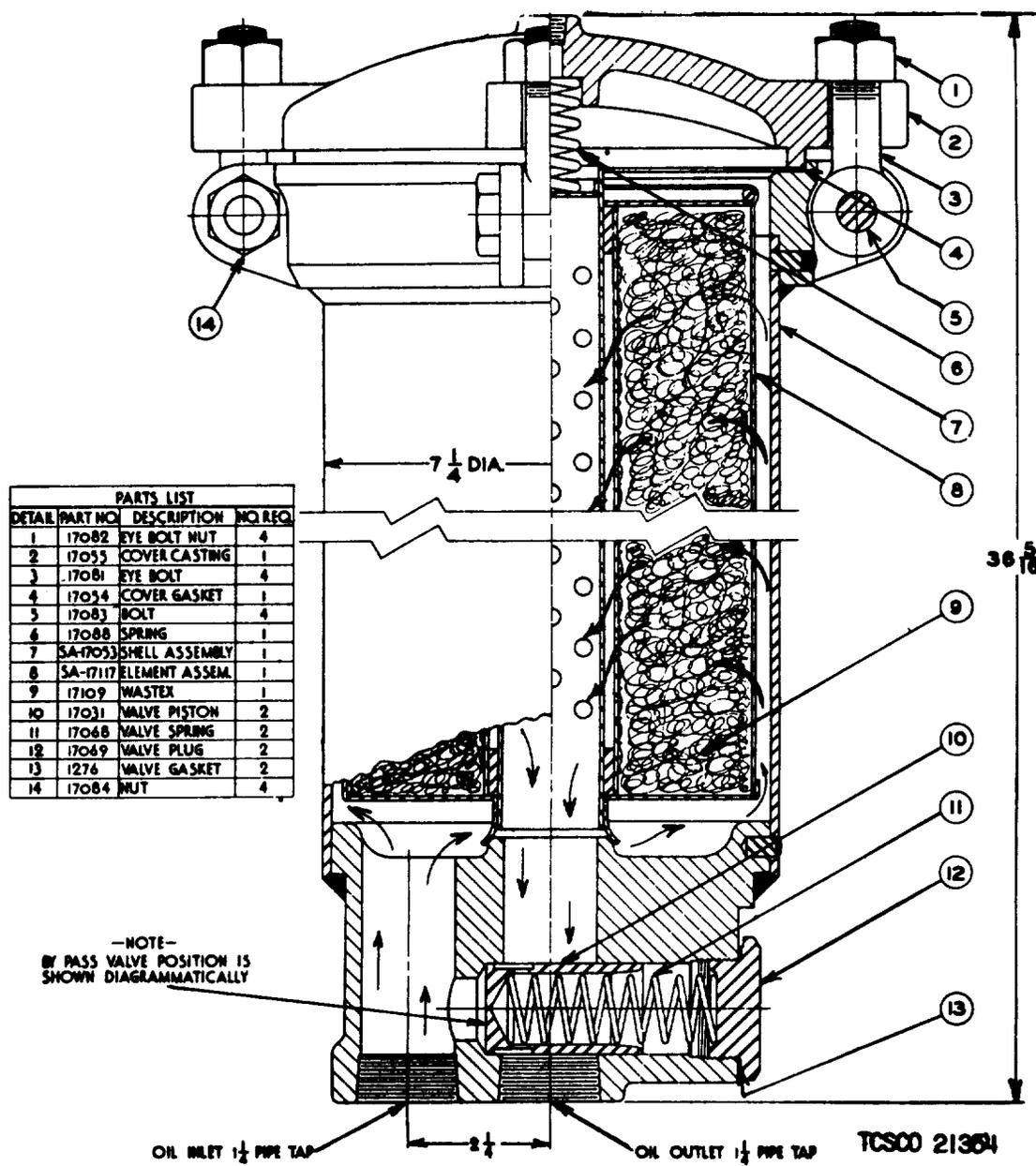


Figure 41. Oil filter.

b. The filter has differential valves incorporated in the base casting to limit the differential pressures across the element. This also insures a constant supply of oil irrespective of filter element condition. The oil flow through the element is radially from the outside-in, the element center tube contains micromesh screen which prevents any filtering material being carried through into the clean oil outlet.

c. The element is readily serviced by removing the old wastex material and repacking with new. The

condition of the engine, operation and type of oil used determine the length of time that the element functions efficiently. Change element as specified on figure 5.

#### 109. Replacing Wastex in Filter Elements

a. Remove cover casting and lift filtering element from filter.

b. Remove wire ring and washer from the end of element.

c. Remove the dirty wastex and the center screen covered tube. These can be slipped straight up off the inner center tube.

d. Remove the dirty wastex from the screen covered tube being careful not to damage the screen.

e. Wash screen covered tube and replace in element. Repack element with wastex. Pack evenly and firmly to eliminate voids through the filtering material. Use a blunt-end stick to pack wastex down firmly. It must be packed evenly around center tube so

that it does not push the center tube over to one side. Check the packing frequently during packing by trying the upper steel washer on the center tube.

f. Replace top washer and retaining wire and install element in filter housing.

g. Replace top casting and gasket. Check gasket and if it is not in good condition replace with new one. Tighten the four nuts on the top evenly. Start engine and check cover for leaks.

## Section XV. COMPRESSOR GOVERNOR

### 110. Governor Details

a. This governor is of the pneumatic double safety valve type and consists of two distinct positions; the operating portion and the pipe bracket. Pipe connections to the compressor and to the main reservoir are provided for in the pipe bracket so that the operating portion may be removed for repairs or replacement without breaking any pipe joints.

b. Referring to the diagrammatic view (fig. 42), with the compressor in operation and main reservoir pressure building up, main reservoir pressure is delivered to the face of the cutout valve (38), also to underside of the tail valve (43) of the cut-in valve (39), via the main reservoir pipe connection, passage r, chamber A, through strainer (49) to passages a and q.

### 111. Cutting-Out Operation

a. The main reservoir pressure building up against the face of cutout valve (38) eventually becomes sufficiently high to overcome the tension of the cutout valve regulating spring (35), causing valve (38) to lift from its seat and, due to the construction of this valve, the slight lifting from seat exposes an increased area, causing the valve to lift quickly, at the same instant delivering pressure via port e to the face of the cut-in valve (39). The main reservoir pressure now acting upon the full area of valve (39) will overcome the tension of its regulating spring (35), causing the valve (39) to lift with a snap, forming a seal at its upper seat which will close communication from the compressor unloading device to the atmosphere (through ports g and d) and, at the same time, connect main reservoir pressure to the compressor unloading device through port g.

b. At the same time, main reservoir pressure will be connected to the cutout regulating spring chamber F through port f, resulting in equalizing the air pressures on each side of cutout valve (38), whereupon the

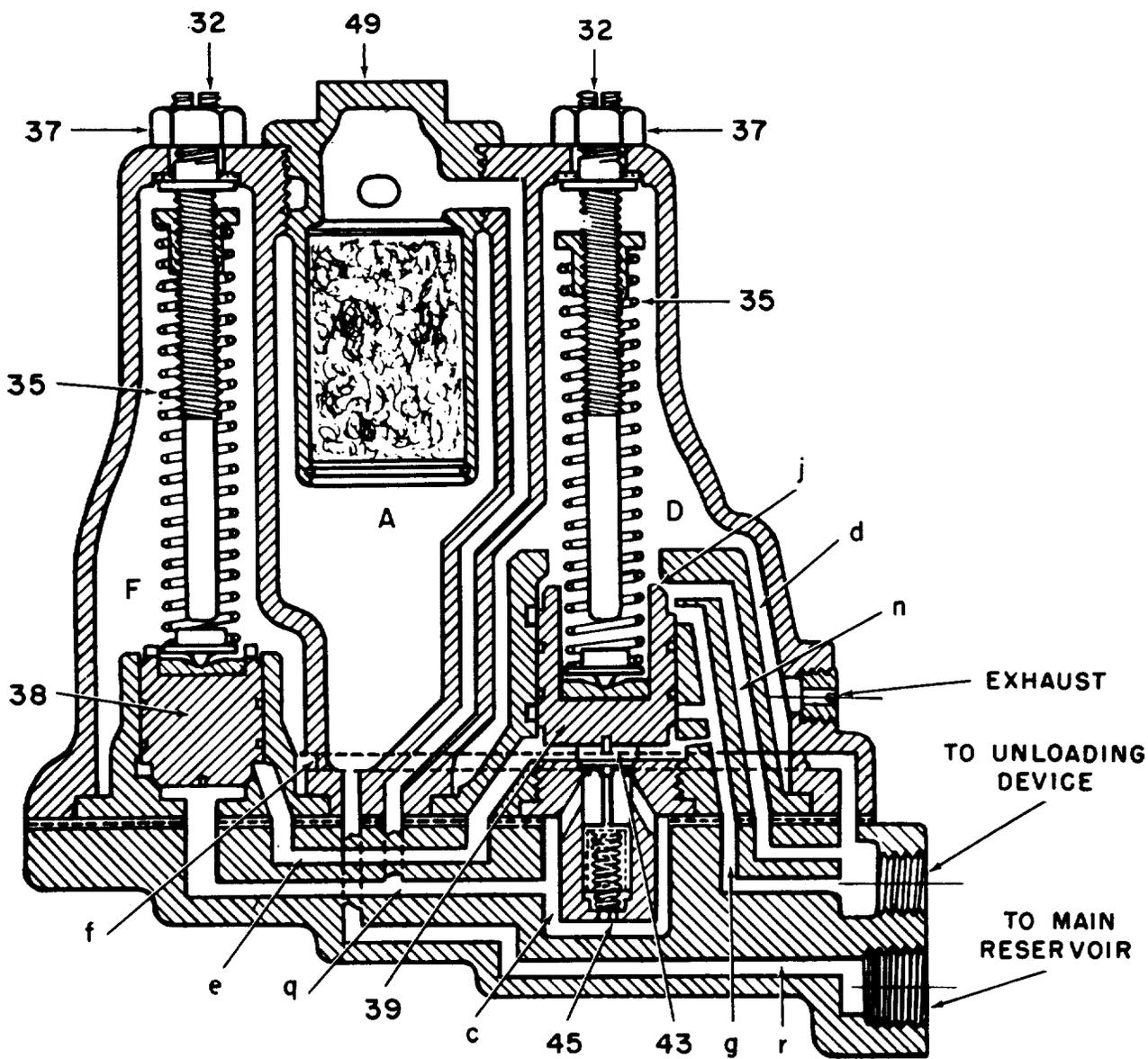
tension of the regulating spring (35) will then move the cutout valve to its seat.

c. After cutout valve (38) has been returned to its seat, the main reservoir pressure will continue to be supplied to the compressor unloading device through passages a, q and c, past tail valve (43), and through port g to the unloading device. The unloading device remains in the cutout position, allowing the compressor to run without load, until the main reservoir pressure is reduced to a point where the force exerted by it against the face of the cut-in valve (39) is equal to a fraction below the tension of the regulating spring (35).

### 112. Cutting-in Operation

a. When the force of the main reservoir pressure, which is acting upon the full face area of the cut-in valve (39), is reduced to a fraction below the tension of the regulating spring (35), cut-in valve (39) will be moved to its normal cut-in position, seating the tail valve (43) against the tension of its spring (45), closing communication between the main reservoir and the compressor unloading device and, in turn, opening communication between the unloading device and the atmosphere, through passage g, port j, through passage d to Ex.

b. Communication is also opened between the cutout regulating spring chamber F and the atmosphere, through passages f and in, port j, cut-in regulating spring chamber D, and passage d to Ex, thereby freeing spring chamber F of main reservoir pressure. The cutout valve (38) which is now held to its seat only by the tension of the regulating spring (35), will immediately rise from its seat upon a slight increase of main reservoir pressure above the setting of the regulating spring.



- |                            |                    |             |
|----------------------------|--------------------|-------------|
| 32 — REGULATING STEM (2)   | 49 — STRAINER      | e — PORT    |
| 35 — REGULATING SPRING (2) | A — PASSAGE        | g — PORT    |
| 37 — CHECK NUT (2)         | D — SPRING CHAMBER | j — PORT    |
| 38 — CUT-OUT VALVE         | F — SPRING CHAMBER | n — PASSAGE |
| 39 — CUT-IN VALVE          | a — CHAMBER        | q — PASSAGE |
| 43 — TAIL VALVE            | c — PASSAGE        | f — PORT    |
| 45 — TAIL VALVE SPRING     | d — PASSAGE        | r — PASSAGE |

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Figure 42. Diagrammatic view of the NS-16 governor.

### 113. Regulation and Adjustment

a. Loosen checknuts (37 and 37') and screw cutout regulating stem (32) down until the desired cutting-out point is reached. Then screw down cut-in regulating stem (32') to as nearly the same tension as can be judged under ordinary observation. If, when the cutting-out point is reached, the range is not as desired, screw the cut-in regulating stem down to raise the cutting-ill

point or to decrease the range and back it off to lower the cutting-in point or to increase the range.

b. This governor needs very little attention after being properly adjusted except to be cleaned and oiled at some stated interval, say once a year. When cleaning and oiling the governor, a few drops of good oil should be placed on the surface passed over by the cutting-in and cutting-out valves. See also that the exhaust opening is free from dirt or gum.

## Section XVI. BATTERY INSTRUCTIONS

### 114. Ventilation

a. A free flow of outside air over and around the battery helps to dissipate heat and to prevent excessively high operating temperatures, especially if the voltage regulator is not functioning properly or if the locomotive is operating in a very warm climate. A well ventilated battery compartment promotes long battery life.

b. The screens (which should be 1/4-inch mesh) over the ventilating openings, must be kept clean and not allowed to fill up with dirt or paint. Therefore, before placing the battery trays in the compartment make sure that all ventilating openings meet these requirements. Lack of ventilation is one cause of high battery temperatures.

### 115. Blocking and Cables

a. Arrange battery terminal leads and intertray connectors to prevent undue strain on the battery terminal posts.

b. The cables should not rest on the intercell connectors, and should be of ample length, and arranged to prevent crushing between trays, or trays and battery compartment. Any rubbing action may destroy the insulation and result in grounds.

c. It is essential that the battery be well blocked in the compartment to prevent excessive movement.

d. Clearance between battery and blocking at sides, back and front, should normally be about one-eighth of an inch.

e. Blocking for monobloc trays should be high enough to bear against reinforcing strips on the sides and ends of the trays. The end blocking should not be higher than 9 inches above the tray bottoms. The side blocking must engage both the upper and lower container ribs. Do not wedge.

### 116. Bolted Connections

a. Before connecting up the battery, clean the contact surfaces of the solid lead terminal posts with a wire brush. The lead coated copper lugs or intertray connectors must not be scraped or cleaned with a wire brush, as the thin lead coating may be completely removed.

b. Apply a thin coat of petrolatum or vaseline to all contact surfaces and connector bolts.

c. Tighten connector bolts securely by using two wrenches, not over 6 inches (preferably box type) one on each connector bolt nut. The use of two wrenches lessens the strain on the battery terminal posts.

d. After all connections have been securely tightened, they should be gone over and tightened a second time. Wipe off all connections with a clean cloth to remove the surplus grease.

e. Heavy currents are required to start a diesel engine. Tight and clean connections will help prevent starting failures.

f. Remove corrosion on connector bolts, lugs and cables by washing in a hot soda solution, consisting of one pound of commercial bicarbonate of soda to one gallon of water. Severe cases of corrosion are removed more quickly, and effectively, if the solution is near the boiling point.

g. Always wash the cleaned parts thoroughly in clean water and dry.

### 117. Voltage Regulator Adjustment

a. Since current from the battery starts the engine by using the main generator as a starting motor, this current, and any other current supplied by the battery must be restored to the battery in service, by the auxiliary generator.

b. When the main engine is running the auxiliary generator supplies the current needed for lights and other electrical equipment. The ammeter should indicate some charge into the battery, the amount depending on the state of charge of the battery. The charge rate will be higher when the battery is discharged, and very little when the battery is charged.

c. The voltage of this generator is controlled by a voltage regulator that should maintain a constant voltage across the battery throughout the normal range of speed and load of the generator.

d. An ideal setting of the voltage regulator will maintain the specific gravity of the electrolyte at about its fully charged value without using an excessive amount of water or heating up the battery.

e. Too high a setting of the voltage regulator will result in a water consumption of more than one-half inch a month and electrolyte temperature exceeding 15° above average outside air temperature. Excess charging, shortens battery life and necessitates more frequent addition of water.

f. Too low a setting of the voltage regulator will result in specific gravity readings becoming lower from week to week and a water consumption of less than one-fourth inch a month. Too little charging may cause a starting failure.

g. When a discharged battery is found, and if after checking the voltage regulator, it is found to be properly adjusted, check carefully for partially loose connections, corroded contact surfaces and frayed or damaged wires. Any of these conditions cause high resistance in the charging circuit. As a result the battery does not receive its proper charge rate.

h. A standard value cannot be given for setting the voltage regulator, that will cover all service conditions. Proper setting will depend upon the type of equipment, the working schedule of the diesel locomotive, and seasonal temperature changes.

i. Before making a voltage regulator setting, check the engine rpm at idling and running speeds, to make sure that the engine rpm is within the limits specified by manufacturer.

j. The coils of the voltage regulator must be at operating temperatures, normally reached after 1 to 2 hours operation. The regulator coils should be hot to the touch. If the regulator is adjusted while the coils are cold, the voltage will be different when the coils become hot.

k. For a trial setting adjust the voltage regulator to hold a constant voltage, at both idling and full throttle engine speeds, equal to approximately 2.32 volts per cell. For example, the voltage regulator setting for 32 cells would be 74 volts and for 56 cells, 130 volts.

l. Take all readings at the voltage regulator panel, with no loads in the panel circuit except the continuous loads. The record of this trial setting as found and as left should be entered on the card in the locomotive.

m. On subsequent inspections, if the specific gravity readings (corrected for temperature and level) tend to drop off, or consistently remain 15 to 25 points below the known fully charged specific gravity readings of the cells, the voltage regulator has been adjusted at too low a setting for the locomotive's working schedule.

n. To correct this, adjust the voltage regulator from 1/2 to 1 volt higher, and on subsequent routine inspections, observe the specific gravity reading (corrected for temperature and level) of the cell marked by the rotating vent plug in each half of the battery. It may be necessary to make more than one such increase in setting before the specific gravity readings reach the known fully charged value, with electrolyte temperature and water consumption normal. When this condition is found, from inspection to inspection, the voltage regulator setting may be considered satisfactory for the particular working schedule of the locomotive.

o. If, on routine inspections, specific gravity readings (corrected for temperature and level), are found to be at their known fully charged value; with electrolyte temperature and water consumption higher than normal, lower the setting of the regulator in 1/2 to 1 volt steps, until normal specific gravity temperature and water consumption are observed at subsequent routine inspections.

p. Make inspection to determine the effectiveness of a changed setting of the voltage regulator after two or three days of normal operating service.

q. Make voltage regulator settings, as found and as left, and battery specific gravity readings on battery card, every time a regulator adjustment is made.

r. When installing a new regulator with a new battery, check the engine rpm.

### **118. Operating Check of Voltage Regulator Performance Without Voltmeter**

When locomotive is equipped with an ammeter, a rough check can be made on the performance of the voltage regulator by the following method:

- a. Make certain that the battery is approximately fully charged and that the generator and voltage regulator are at operating temperature.
- b. Observe the charging rate indicated by the ammeter with the engine running at medium speed.
- c. Stop the engine and shut off the fuel pump.
- d. Roll the engine over two or three times, by use of the battery starter.
- e. Open the fuel pump and start engine.
- f. Observe charging rate with the engine running at medium speed.
- g. The charging rate should be higher than before, because of the battery being partially discharged because of rolling over and starting the engine.
- h. After a few minutes of running, the battery should again be fully charged and the charging rate should have decreased to about the same rate observed at the beginning of the test.
- i. If the charging rate does not taper off to approximately the same value, the voltage regulator may have too much frictional lag at the pivots of other points and it should be adjusted mechanically and the proper setting made with a voltmeter.

### **119. Adding Water**

- a. Add only approved or distilled water to the cells at sufficiently frequent intervals to keep the electrolyte level above the tops of the splash covers. When adding water, fill to one-eighth of an inch below the bottom of cover filling tubes, and no higher.
- b. Careless addition of water above the high level point results in subsequent overflow of electrolyte through the vent openings provided in the vent plugs, for normal gas escape.
- c. An overflow of electrolyte lowers the gravity, reduces battery capacity, rots wood trays and damages the battery compartment. It also causes corrosion and troublesome grounds in the electrical circuits. Eventually it will necessitate removal of the battery for gravity adjustment and repairs to damaged parts.
- d. The amount of water used is a good indication whether the battery is receiving the correct amount of charge. As a general rule, a battery in good condition,

using more than approximately one-half inch of water per month, is receiving too much charge.

- e. If it uses less than approximately one-fourth inch per month, it is not receiving sufficient charge for a locomotive in daily service.
- f. All cells should require the same amount of water. If one cell takes more water than the others, examine it for leakage.
- g. Always take hydrometer readings before adding water.
- h. The time of adding water is important in cold weather. When it is cold, add water just before the locomotive goes into service, so that the charging current will mix the water with the electrolyte. If water is added, and the battery left standing in freezing temperatures, it will freeze, just the same as it would outside of the battery, resulting in possible damages by breaking the hard rubber jars or containers.
- i. Approved water is that which has been analyzed periodically and found to be safe for storage battery use. If approved water is drawn from a tap, allow it to run a few moments before using. Water should not be transported or stored in any metallic vessel, except one made of lead. Glass, earthenware or rubber receptacles that have not been used for any other purpose, are satisfactory.

### **120. Cleaning**

- a. Keep the battery, its connections and surrounding external parts clean and dry.
- b. If dirt or acid soaked mud accumulates on top of the battery it is an unpleasant job to handle and will eventually cause trouble.
- c. Electrolyte spilled on the battery cell covers, trays, or battery compartment, never dries or evaporates. It rots the wood trays, causes grounds, and corrodes any metal parts that are subject to attack from sulphuric acid.
- d. If, during a monthly inspection the top of a battery is found to be damp with electrolyte, neutralize it by applying a solution of commercial bicarbonate of soda, consisting of one pound of soda to a gallon of water. For best results apply soda solution freely, preferably hot, with a paint brush. The brushing action tends to remove the oil film usually found on tops of batteries in diesel locomotives.

e. Keep vent plugs in place. Do not allow any of the soda solution to get into the cells. It will neutralize the electrolyte and lower cell capacity. Sufficient time must be permitted for neutralization. Wait until foaming stops on electrolyte soaked areas, especially on wood trays, and then immediately rinse off with water at moderate pressure, to remove the soda solution. If soda is allowed to dry on top of the battery, it produces a path for current leakage. Allow to air-dry.

f. During a regular monthly inspection, if the top of a battery is found to be dry but dusty, rinse off with water at a moderate pressure.

g. In freezing weather, after rinsing the top of a battery, if there is not sufficient time for air drying in the shop, use low pressure air to blow off the surplus water.

h. Do not use steam or high pressure air for cleaning or drying as both will remove the protective grease from the grease ring seal nut on the posts. This grease prevents electrolytic corrosion on the copper lugs, cables, and connector bolts attached to the posts. Steam also tends to remove the protective coating of paraffin and paint from the woodwork, and may damage the sealing between the jar and cover to the extent that resealing might be necessary to prevent loss of electrolyte.

i. Increase water pressure to wash out battery compartment and dirt from under battery trays. This helps to prevent grounds.

### 121. Vent Plugs, General

a. Keep the vent plugs securely in place at all times, except when taking hydrometer readings or adding water.

b. All vent plugs are provided with small openings for the escape of gas.

c. Clogged openings may cause sufficient gas pressure within the cell, to break the seal between the jar and cover.

d. If these openings are found clogged with dirt, when examined during any inspection, immerse in water and thoroughly clean.

e. It may be necessary to use a piece of wire to clear the openings.

f. Accumulated gum or grease deposits on the plugs can be removed by cleaning with carbon tetrachloride or cleaning fluid. Remove cleaning fluid with low pressure air.

g. A cracked vent plug, or one upon which the soft rubber gasket does not seal tightly, or from which the

hard rubber disk below the gas chamber has been lost, must not be used.

h. Vent plugs, when removed, should be placed bottom side up on the battery covers. When laid right side up, accumulated dirt may be introduced into the cell, contaminating the electrolyte, which may in turn shorten battery life.

i. Cell covers damp with electrolyte may be an indication of clogged vent openings. Damp covers may also be caused by poorly applied plugs, adding too much water or a break in the seal.

### 122. Vent Plugs, Rotating

a. Each time a hydrometer reading is taken, a small amount of electrolyte may be lost. If one cell is read continuously, its fully charged specific gravity will gradually be lowered, resulting in individual low cells.

b. To avoid an excessive loss from any one cell, use a different cell in each half of the battery every time a gravity reading is taken.

c. By the use of a special plug (white porcelain or painted), the change in cells can easily be marked and followed. Start with the positive terminal cell in each half of the battery, and follow the series circuits until the negative terminal cell is reached. The special plugs should then be returned to the positive terminal cells, and the same routine repeated.

d. Therefore, after each hydrometer reading change the white porcelain vent plug to the next cell, thus moving progressively through the battery circuit so that all cells will be read and recorded every four months.

#### HYDROMETER READING

Daily .....	32 cells .....	Check 1 cell in each half battery.
Daily .....	56 cells .....	Check 1 cell in each half battery.
Weekly .....	32 cells .....	Check 1 cell in each half battery.
Weekly .....	56 cells .....	Check 2 cells in each half battery.
Monthly.....	32 cells .....	Check 4 cells in each half battery.
Monthly.....	56 cells .....	Check 7 cells in each half battery.

e. The above procedure will indicate symptoms of developing trouble in individual cells so that necessary corrective action can be taken to avoid serious damage to the battery or failure to crank diesel engine.

### 123. Hydrometer Readings-Specific Gravity

a. There is a need for an understanding of the proper method of reading the hydrometer syringe. Unless a uniform method is used a wide variety

of readings may be obtained by different men taking hydrometer readings of the same electrolyte.

*b.* Draw off enough electrolyte to fill the barrel of the syringe to a level which will permit the hydrometer to float freely without touching the barrel at either top or bottom. Allow the rubber bulb to expand completely and hold syringe by the neck of the bulb.

*c.* Shake the syringe gently to be sure hydrometer is floating freely.

*d.* Hold the syringe at eye level.

*e.* The point at which the electrolyte level appears to intersect the stem of the hydrometer, will indicate the specific gravity readings to be recorded.

*f.* Empty the hydrometer syringe completely, making certain that the electrolyte is returned to the same cell from which it was taken.

*g.* A clean accurate hydrometer syringe must be used. It must be disassembled and washed thoroughly at least once a month. Avoid any dripping of electrolyte from the hydrometer syringe.

*h.* To insure accuracy when water is added, take hydrometer readings before adding water. Water is lighter than electrolyte and will float on top of the electrolyte when added. A day or two will be required for the water and electrolyte to mix thoroughly, after which hydrometer readings may be assumed to be accurate again.

*i.* The fully charged specific gravity varies in different types of batteries and is shown on the battery nameplate.

*j.* The discharged specific gravity (not shown on the battery nameplate) also varies with the battery type, but is usually around 130 to 140 points lower than the fully charged specific gravity.

*k.* The specific gravity or hydrometer reading of the electrolyte lowers on discharge and rises again on charge. Consequently, if we know the specific gravity temperature and height of electrolyte above the splash cover, we can estimate the approximate state of charge, provided that no electrolyte has been lost or added to the cells.

*l.* A specific gravity reading 100 points below the full charge value is a warning not only that the battery needs charging immediately, but that the charging equipment probably has failed in some way and should be checked.

*m.* The fully charged specific gravity of electrolyte in new batteries is adjusted within the limits shown on

the nameplate, and should not require adjusting during the life of the battery, unless electrolyte is actually lost or spilled. Replacement of spillage should only be made in regular battery shops.

#### **124. Hydrometer Readings-Effect of Temperature and Level**

*a.* Hydrometer or specific gravity readings of the electrolyte are affected by temperature. Correct hydrometer readings if the temperature of the electrolyte is very much above or below 77° F.

*b.* For each 3 degrees above 77° F. add one point (.001) to the hydrometer reading, or for every 15° F., add 5 points.

*c.* For each 3 degrees below 77° F. subtract one point from the hydrometer reading or for every 15° F., subtract 5 points.

*d.* Hydrometer on specific gravity readings are also affected by the electrolyte height. The full charge specific gravity is based on the electrolyte level being at the high limit of one-eighth inch below the bottom of the filling tube in the cover. If the electrolyte level is at the splash cover, the specific gravity readings are increased from 15 to 45 points, depending on the type of battery involved.

#### **125. Specific Gravity Reduction with Age**

*a.* A too frequent mistake is made in assuming that every battery, when charged, will reach the maximum specific gravity specified by the manufacturer.

*b.* A gradual reduction of fully charged specific gravity may be expected as the battery ages. This reduction should not exceed 15 to 20 points during the life of the battery, and should be taken into account when a battery is recharged.

*c.* Any greater reduction in fully charged specific gravity may indicate a loss of electrolyte. This may be the result of watering too high, which could cause the cells to overflow while on charge. Any electrolyte lost is replaced with water, and will result in a loss in fully charged specific gravity.

*d.* If no electrolyte is lost from a battery it should go through its entire life without the necessity of a gravity adjustment.

#### **126. Low Individual Cell Readings**

*a.* Low individual cell readings (voltage or gravity) may be the first indication of trouble.

b. Individual cells should be considered to be low when reading 40 points below the highest reading cell in specific gravity (corrected for temperature and electrolyte level), or 0.20 volts lower than the average cell when the battery is on charge.

c. If low cells are not due to leaky jars or containers, or improper regulator setting, and an equalizing charge fails to correct the trouble, trays containing low cells should be replaced with suitable spare trays.

d. Trays with low cells which are removed for shopping, should be tagged to indicate the low cells and if possible, the cause of the trouble.

e. Repaired trays, when returned, must be placed in their original position. This is to insure cell readings being in proper order throughout the life of the battery.

f. Battery record card should note trays sent in for repairs.

### **127. Temperature Hot Battery**

Under normal operating conditions the electrolyte temperature may run up to 15° F. higher than the average atmospheric temperature surrounding the battery compartment. A greater difference may result from the following causes:

a. A hot battery may be due to excessive overcharging or charging at too high a rate for too long a time. High charge rates are often due to the voltage regulator being set too high, to yard charge rates which are too high, or the battery may be in an unserviceable condition.

b. Poor ventilation may also cause excessive battery temperatures. Refer to paragraph 114.

c. When a battery is found to be operating at an excessive temperature every effort should be made to locate the cause and correct the condition immediately.

d. When the regulator is checked, record on the battery record card the date and setting as found and left.

### **128. Recharging**

a. The charging equipment on the locomotive is designed to keep the battery in a fully charged condition. Improper voltage regulator settings or failure of equipment may result in a partly or completely discharged battery. Recharging of the battery from an outside source or in the battery shop may then be necessary.

b. If battery is found discharged 100 points below full charge, a starting failure may result, and a charge should be given. The amount of charge need be only sufficient to get the locomotive in service. The cause for the discharged battery should be determined and corrected.

c. A recharge may be started at any rate in amperes, up to three times the normal finishing rate. This high rate of charge may be continued until the voltage of the battery reaches 2.40 volts per cell or approximately 76 volts for a 32-cell battery, or 134 volts for a 56-cell battery. The charge rate should then be lowered into the finishing rate, or to a rate below that, if necessary to keep the electrolyte temperature under 110° F., or not to exceed 15° above surrounding temperature. This method will safely complete the charge in a minimum length of time.

d. An equalizing charge is a continuation of a recharge, and should be given at the finishing rate or slightly lower. Temperature limits mentioned previously should be observed. The equalizing charge should be continued until all cells gas freely, and until the specific gravity and voltage of the lowest cells show no further increase over a period of four successive hourly readings.

e. A recharge may be given the battery only for a short while in order to start the engine. This is called a "boost charge." The auxiliary generator on the locomotive would be expected to complete the charge.

f. Batteries left on charge over night, with no attendant present, should be charged at from 1/4 to 1/2 of the finishing rate. This will prevent excessive temperature and possible damage to the battery.

### **129. Identification of Individual Cells and Trays**

a. In order to obtain dependable records, establish a definite method for identifying individual cells and trays. Readings will then be recorded in their proper order, and can be used as a reference throughout the life of the battery.

b. Make the positive terminal cell, connected to the positive side of the auxiliary generator circuit, number one.

c. Mark the tray containing this cell number one.

d. Number each subsequent tray in order, following the series circuit of the battery.

e. Mark the positive terminal cell of the second half of the battery with its proper number.

f. By numbering the trays in the above manner, the battery when removed from a locomotive for shopping can be reinstalled in any locomotive in the same order.

g. Indicate the location of the positive terminal cells in red paint on the inside of the battery compartment at points adjacent to these cells. For example: locomotive with a 32-cell battery, mark the compartment as follows:

- (1) Positive cell number 1 (marked +1) in first half of battery.
- (2) Positive cell number 17 (marked +17) in second half of battery.

### 130. Inspection--Record of Battery Performance

a. To keep track of the performance of the battery and its charging equipment, keep a diesel battery and voltage regulator inspection card in a holder located on each diesel locomotive, so that the desired information can be quickly recorded.

b. Each battery will be marked with an identifying number. If the battery is transferred from one locomotive to another, the battery record card must also be transferred. This will permit keeping a continuous record of the operation and performance of each battery.

c. A systematic inspection program, and a carefully kept running record of the operation, of the battery and its charging equipment, as found at each inspection, will help to accomplish better maintenance.

d. Symptoms of developing trouble can be detected by regular study of the battery record card and necessary corrective measures can be taken in time to prevent any severe trouble, which might otherwise result in a locomotive failure.

e. When a battery record card is filled up, replace it with a new card, and all pertinent information will be recorded on the new card including all readings made on the last inspection and recorded on the old card.

f. Place the old card on file at the assigned maintenance terminal.

g. Proper records will be a decided aid to the maintenance personnel in readily disclosing irregularities, so that such irregularities can be promptly corrected.

### 131. Routine Battery Inspection

Make the routine battery inspection at least once each week, immediately upon arrival of the locomotive at the inspection point.

a. *Hydrometer or specific gravity readings* (take before adding water).

- (1) Record hydrometer or specific gravity readings of cells marked or indicated by rotating vent plugs in each half of the battery together with the inspection date and initials of inspector.
- (2) If reading is 100 points or more below full charge value, "boost" charge battery. Refer to paragraph 128.

b. *Electrolyte Level (Take Before Adding Water).*

- (1) Record the electrolyte level or height above the splash cover (to nearest 1/5 inch) in cells marked by rotating vent plugs.
- (2) Water addition should be required only at time of monthly inspection. If, however, electrolyte level is close to splash cover, add water to all cells and check reason for need. Refer to paragraphs 117 and 118.
- (3) Enter record of any water addition on battery card.

c. *Temperature.*

- (1) Check temperature of cell by touching cover with hand. If it feels very warm, take thermometer reading of electrolyte.
- (2) When electrolyte temperature is above normal, find cause and correct it. Refer to paragraph 127.

d. *Rotating Vent Plugs.* Change the rotating vent plugs to the next cell in the series circuit in each half of the battery. When the last cell in each half of the battery is reached return rotating vent plug to the original cells started with. Refer to paragraph 122.

e. *Check by Touch, or Visually.*

- (1) Tray blocking. Refer to paragraph 115.
- (2) Inter-tray and terminal wiring and all bolted connections. Refer to paragraph 116.
- (3) Tightness and condition of vent plugs. Refer to paragraph 121.
- (4) Evidence of electrolyte leakage, as from broken container, cover, or loose or missing vent plug.

- (5) Cleanliness of battery. Refer to paragraph 120.

### 132. Monthly Battery Inspection

a. Monthly inspections are made to see that battery is being maintained in serviceable condition, and the charging equipment is properly adjusted to perform such servicing as may be required by the battery or charging equipment.

b. Make this inspection immediately upon the arrival of the locomotive at the inspection point. Take the following steps:

- (1) *Hydrometer or specific gravity readings--(take before adding water).* Record hydrometer or specific gravity readings of the cells marked or indicated by the rotating vent plugs in each half of the battery, together with the inspection date and initials of inspector.
- (2) *Electrolyte level--(take before adding water)*
  - (a) Record the electrolyte level or height above the splash cover (to nearest 1/8 inch in cells marked by rotating vent plug in each half of the battery.
  - (b) If level has lowered more than 1/2 inch since last monthly inspection, find reason and correct it. Refer to paragraphs 117 and 119.
- (3) *Temperature.* Check temperature of several cells by touch and if above normal, find causes and make corrections.

#### Note

**If cells seem warm by touch, take a thermometer reading of electrolyte.) Make sure the voltage regulator is not the cause. Refer to paragraphs 117 and 127.**

- (4) *Addition of water.* Add water to all cells and enter record of addition on battery card.
- (5) *Rotating vent plugs.* Advance the rotating vent plugs to the next cells in the series circuit. Refer to paragraph 122.
- (6) *Voltage regulator setting.* Record the voltage regulator setting AS FOUND and AS LEFT, together with the date and inspectors initials. Refer to paragraphs 117 and 127.
- (7) *Check by touch or visually.*
  - (a) Tray blocking.
  - (b) Inter-tray and terminal wiring, and all bolted connections.

- (c) Tightness and condition of vent plugs.
- (d) Evidence of electrolyte leakage from any source.
- (e) Cleanliness. Dampness found around vents or elsewhere on covers usually contains some acid. Neutralize and remove as instructed in paragraph 120.

### 133. Annual or Emergency Battery Inspection

a. Make a thorough battery inspection once a year, or at any time that severe trouble is indicated by poor performance.

b. This inspection is required to make certain that the battery has been maintained in a good, serviceable condition, and also to insure that it will deliver satisfactory service until the next annual inspection. Take the following steps:

- (1) *Hydrometer or specific gravity readings--(take before adding water).* Record the hydrometer or specific gravity readings of all cells together with the date and inspectors initials.
- (2) *Addition of water.* Add water to all cells and enter record of addition on battery card, with date and initials of inspector.
- (3) *Cell voltage readings.* Record the voltages of all cells, on charge either at the FINISHING rate or with the engine idling. Also record the amperes charging current.
- (4) *Comparative cell readings.*
  - (a) Record or check mark cell number, specific gravity and voltage readings of the highest and the lowest cell in the battery.
  - (b) For future comparison, record electrolyte heights above splash covers to nearest 1/8", electrolyte temperatures, and sediment depths in these two cells. Also record the temperature of the air around the locomotive.
  - (c) If the LOW READING cell is lower than it should be (voltage 0.20 volts below average and specific gravity 40 points below highest reading cell), locate the cause and correct it. See paragraph 126.

#### Note

**Do not move rotating vent plugs during this inspection.**

- (5) *Voltage regulator.* During the annual or emergency inspection, thoroughly

check the voltage regulator as described in paragraph 117. Adjust and recheck if necessary.

**Note**

**When installing a new battery at an annual or emergency inspection period, if possible, replace voltage regulator by spare shop overhauled and adjusted unit.**

- (6) *Cleanliness*. Thoroughly clean the battery and battery compartment. Refer to paragraph 120.

**134. Shopping Complete Battery or only One Tray**

a. When battery performance has not been satisfactory and the readings at the end of equalizing charge indicate evidence of trouble, make proper arrangements for a replacement battery.

b. If the readings indicate evidence of trouble in only a few cells, remove the trays containing these cells for shopping, as soon as proper spare trays are available for replacement. Refer to paragraph 135.

c. Remove trays for shopping when any cell reads 0.20 of a volt lower than the average cell on charge at proper finish rate, or when the specific gravity or hydrometer reading of any cell is 40 points or more lower than the highest reading cell, providing the difference in gravity is not caused by a difference in electrolyte height.

d. The battery will eventually wear out. This will be indicated by a very low and irregular hydrometer reading, which higher regulator settings or additional charging will not improve. This condition will be accompanied by a decided increase in the volume of water required.

e. Pre-planning for each replacement will prevent unforeseen difficulties and handicaps which result in confusion and often involve expensive delays.

f. Internal inspections and gravity adjustment should be made only in regular battery shops equipped to repair cells, and make capacity test to determine condition of battery for future service.

g. The results of proper handling of batteries in a regular battery shop will undoubtedly reduce the number of batteries removed from locomotives because of trouble in the battery.

h. The records normally kept in the battery shop, covering the condition of incomplete sets of batteries

removed from a locomotive for gravity adjustment, repairs, and discharge test, should be very valuable in estimating the capacity of remaining cells in the locomotive. This is especially true when a four cell tray, containing both high and low reading cells, has been shopped and undergone a properly conducted capacity test. If there are no more low reading cells in the battery, the remaining cells should be in equally as good condition, and capable of maintaining dependable performance under normal operating conditions, until the next annual inspection.

i. These records also indicate an advance warning of impending failures, so that a sufficient number of batteries may be kept in stock, or on order, to prevent locomotive failures, if unusual delays are encountered in obtaining desirable replacement batteries.

**135. Unbalanced Battery Loads**

a. The connection of any load across only a part of the battery is undesirable.

b. If lower than the total battery voltage is needed for any accessory equipment, use an adequate series resistor for reducing the total battery voltage to the desired value.

c. On locomotives in which the battery circuit is so arranged that part of the load is taken from each half of the battery, an unbalance is likely to occur which will permit one-half of the battery to become more discharged than the other half.

This could easily occur if higher wattage lamps than those specified are used.

d. Load balancing switches are usually provided so that loads may be alternated on the two sides of the battery. Proper operation of the load balancing switches will prevent one side of the battery from continuously discharging more than the other, should a load unbalance exist. In normal service and with proper operation of load balancing switches, the load unbalance should not cause the specific gravity of the two halves of the battery to differ more than 15 or 20 points between known cell gravities. The same side of the battery should not remain continuously low if satisfactory battery life is to be obtained.

e. The prolonged use of extension cords (with 32-volt lamps) on one-half of the battery or a grounded circuit will result in unbalanced condition of the battery.

# TRI-PLEX OIL SYSTEM (Full Flow Type)

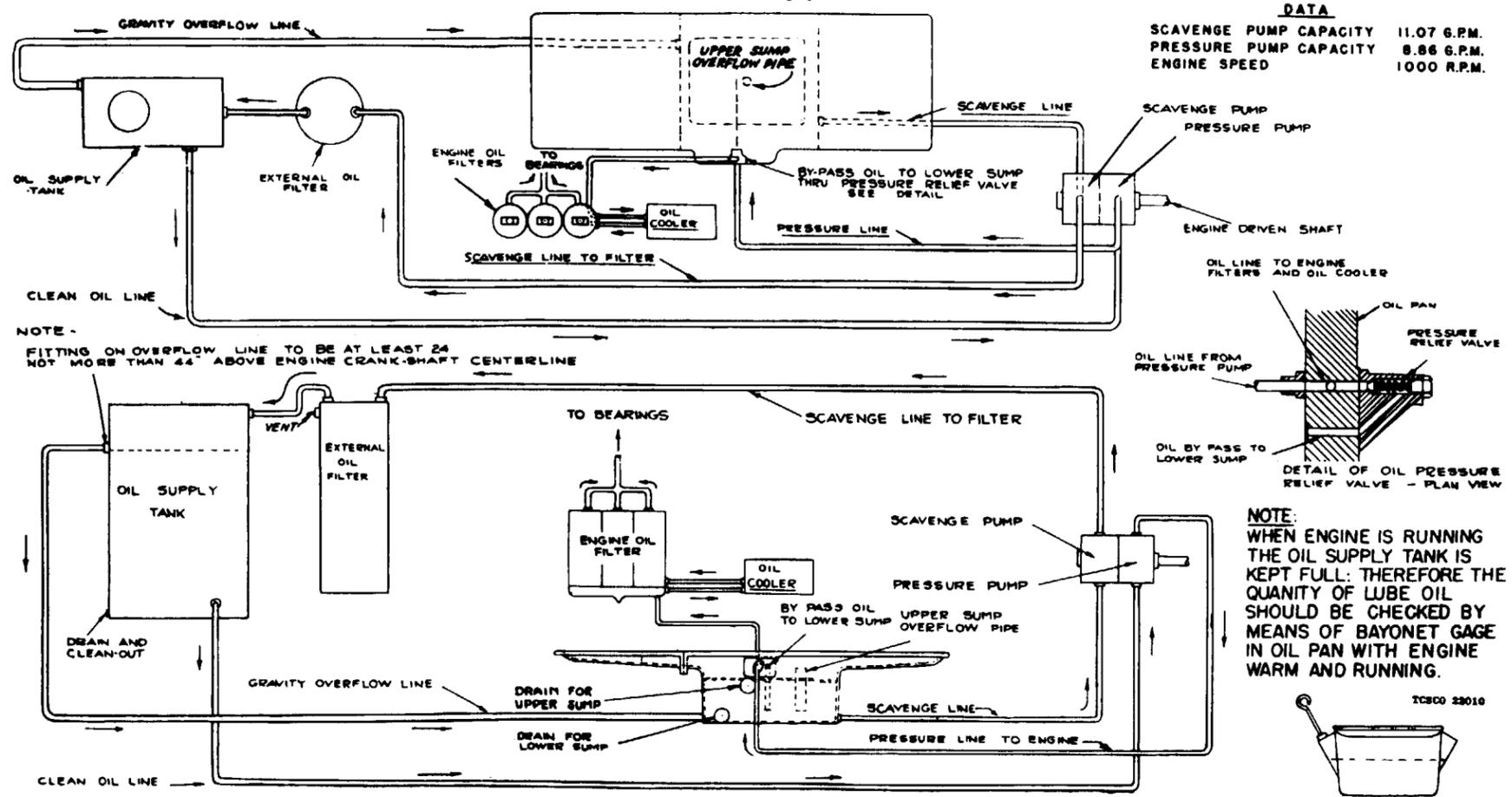


Figure 43. Lubrication oil piping diagram.

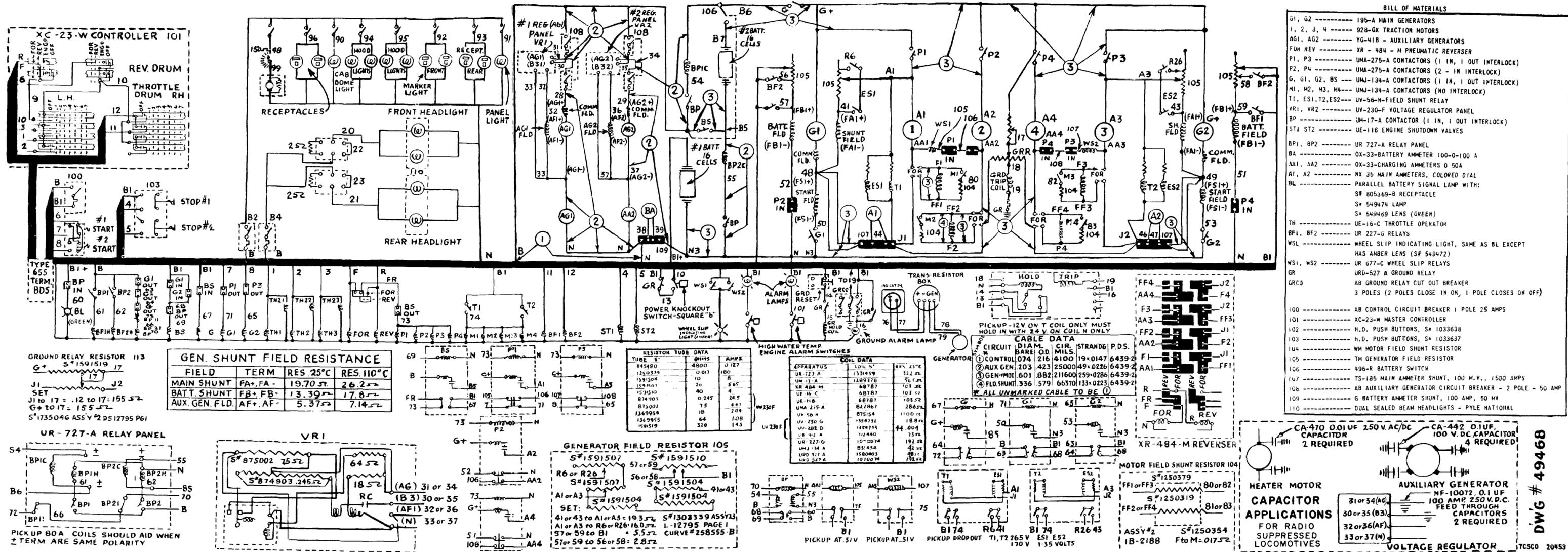


Figure 44. Locomotive wiring diagram.

DWG # 49468

### 136. Rules and Precautions

a. Do not work on battery or in battery compartment without first opening the main battery switch.

b. Keep all flames away from the battery.

c. Do not lay any tools on top of battery.

d. Do not tap or connect any load across a part of the battery for any purpose whatsoever. If lower than total battery voltage is needed for any accessory equipment, use an adequate series resistor for reducing the total battery voltage to the value desired.

e. Low electrolyte temperatures temporarily reduce the battery capacity. Restoration of normal temperatures restores the usual capacity.

f. Continued and frequent temperatures above 115° F. shorten battery life. Provide full ventilation in warm weather.

g. With proper operation, battery temperature should not exceed 15° F. more than temperature of outside air.

h. Do not permit oil to drip on the battery. It injures the sealing compound. Remove oil on the battery covers, trays, and compound by wiping with a cloth dampened with carbon tetrachloride. Do not pour this liquid on cover or compound, but use it only for dampening the cloth used in wiping off the oil.

i. If combustion does not take place promptly when cranking the engine do not needlessly hold in the starting button and continue to crank or roll the engine until the battery becomes exhausted.

j. If the battery cranks the engine and the engine fails to start, the fault lies outside of the battery. The failure to start may be due to a number of causes, either mechanical or electrical.

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[AG 300.7 (30 Sep 55)]

BY ORDER OF THE SECRETARY OF THE ARMY:

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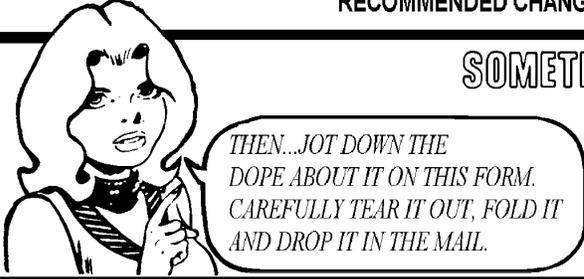
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For explanation of abbreviations used, see SR 320-50-1.

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## The Metric System and Equivalents

### Linear Measure

1 centimeter = 10 millimeters = .39 inch  
 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

### Weights

1 centigram = 10 milligrams = .15 grain  
 1 decigram = 10 centigrams = 1.54 grains  
 1 gram = 10 decigrams = .035 ounce  
 1 decagram = 10 grams = .35 ounce  
 1 hectogram = 10 decagrams = 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

### 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

### 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. feet  
 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
pound-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
----	---------------------------	-------------------------------	------------------------	----

