BALDWIN

OPERATOR'S MANUAL

DIESEL • ELECTRIC LOCOMOTIVES

THE PENNSYLVANIA RAILROAD COMPANY

THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, U. S. A.

BALDWIN

OPERATOR'S MANUAL

NO. DP-108

DIESEL-ELECTRIC

PASSENGER LOCOMOTIVE

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THE PENNSYLVANIA RAILROAD COMPANY

"A" Units: Nos. 5770-A to 5787-A Incl.
"B" Units: Even Nos. 5770-B to 5786-B Incl.

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THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA, PA., U.S.A.

INTRODUCTION

This manual contains instructions for the operation of the locomotive and the installed equipment. The instructions are simplified as much as possible, but complete with enough factual information for intelligent operation of the locomotive.

The manual is divided into sections containing separate classifications of information. The sections may be located by their page number, Page 101 being the first page of Section 1, Page 201 the first page of Section 2, and so forth. The contents of a section are tabulated on the first page of the section.

Maintenance of the Diesel engines is covered in the Diesel Engine Manual.

Maintenance of electrical and auxiliary equipment is covered in the Maintenance Bulletin Book.

It is recommended that engineers, fireman, hostlers, and other operating personnel become thoroughly familiar with this manual and that a copy be conveniently located for reference.

This manual is published by THE BALDWIN LOCOMOTIVE WORKS and contains the manufacturer's recommendations for the operation of the locomotive. Railroad personnel, however, should be cognizant of the possibility that the governing rules of the railroad may differ in some respects.

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GENERAL DESCRIPTION OF LOCOMOTIVE

This locomotive is a three-unit 6000 horsepower Diesel Electric type, composed of two "A" units and one "B" unit. All units have a standard 0-6-6-0 wheel arrangement. The "A" units each contain a cab with complete locomotive operating controls. The "B" unit is equipped with hostler's controls only. For various power demands, a locomotive can be made up by connecting units in "A-B-A", "A-B", or "A-A" combinations, or an "A" unit may be operated alone.

Each unit is powered by two six-cylinder, 1000 horsepower, four-cycle Baldwin Diesel engines. Each engine is supercharged by an Elliot-Buchi exhaust-gas turbocharger mounted on the main generator at the end of each engine. The exhaust gas is led to the turbocharger turbine through two exhaust manifold pipes, each of which collects exhaust gas from three of the engine cylinders.

Each engine is connected by a direct drive to a main generator which supplies D.C. electrical power to two traction motors. The main generators are separately excited from an exciter-generator which is belt driven from the main generator shaft. The traction motors are series wound with reversers in the field circuits for selecting the direction of locomotive travel. The electric transmission provides smooth, controlled acceleration and extremely close regulation of locomotive speed. The generators are also used in starting the Diesel engines, at which time a generator operates as a motor energized from storage batteries.

The engine cooling water is circulated through radiators located near the roof of the engine room. The radiator compartment is equipped with radiator shutters and variable speed motor-driven fans. The fan speed and the shutter position may be controlled manually or automatically. The engine lubricating oil is cooled in a heat exchanger, through which both the lubricating oil and the engine cooling water are circulated.

The running gear of each unit consists of two six-wheel trucks with traction motors connected to the front and rear axles of each truck.

A steam generator is installed in each unit to supply steam for train heating. Steam lines are also connected to the boiler water supply tank and the engine cooling water system to prevent freezing during winter operation.

The locomotive is equipped with standard road locomotive air brake equipment complete with overspeed and controlled emergency protection and automatic sanding during emergency applications. The locomotive braking system includes electro-pneumatic braking, but does not include electrical dynamic braking.

The locomotive power output is controlled by varying the Diesel engine speed from the throttle at the engineer's position. The locomotive speed depends upon its power output and the train load.

A general arrangement diagram will be found in Section 1 of this manual. The operating instructions which follow include more detailed descriptions of the equipment.

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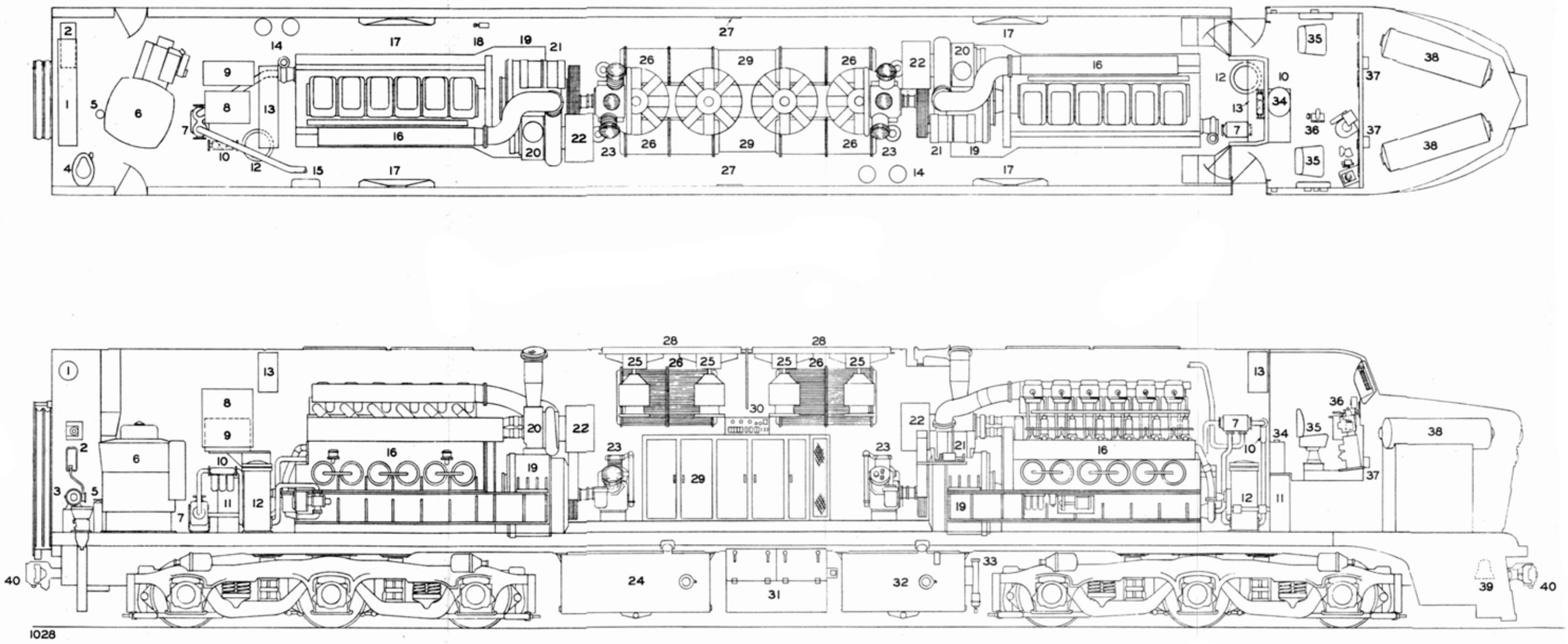

1. SANITARY WATER TANK
2. TRAIN COMMUNICATION EQUIPMENT
3. TRAIN COMMUNICATION MOTOR-GENERATOR
4. TOILET
5. WATER TREATMENT TANK
6. STEAM BOILER
7. LUBRICATING OIL HEAT EXCHANGER
8. TRAIN COMMUNICATION EQUIPMENT BOX
9. CAB SIGNAL EQUIPMENT BOX
10. LUBRICATING OIL STRAINER
11. TRACTION MOTOR BLOWER
12. LUBRICATING OIL FILTER
13. ENGINE WATER EXPANSION TANK
14. FIRE EXTINGUISHER GAS CYLINDERS
15. CABINET
16. DIESEL ENGINE
17. SAND RESERVOIR
18. HAND BRAKE
19. MAIN GENERATOR
20. TURBOCHARGER
21. EXCITER-AUXILIARY GENERATOR
22. ENGINE AIR INTAKE FILTER
23. AIR COMPRESSOR
24. BOILER WATER SUPPLY TANK
25. RADIATOR FAN
26. ENGINE WATER RADIATOR
27. ENGINE GAUGE PANEL
28. RADIATOR SHUTTERS
29. ELECTRICAL EQUIPMENT CABINET
30. ENGINE ROOM CONTROL PANEL
31. STORAGE BATTERY BOX
32. FUEL OIL SUPPLY TANK
33. AIR AFTERCOOLER
34. WATER COOLER
35. SEAT
36. LOCOMOTIVE CONTROLS
37. CAB HEATER
38. MAIN AIR RESERVOIR
39. BELL
40. COUPLER

ARRANGEMENT OF EQUIPMENT -- "A" UNIT
Figure 1

BALDWIN

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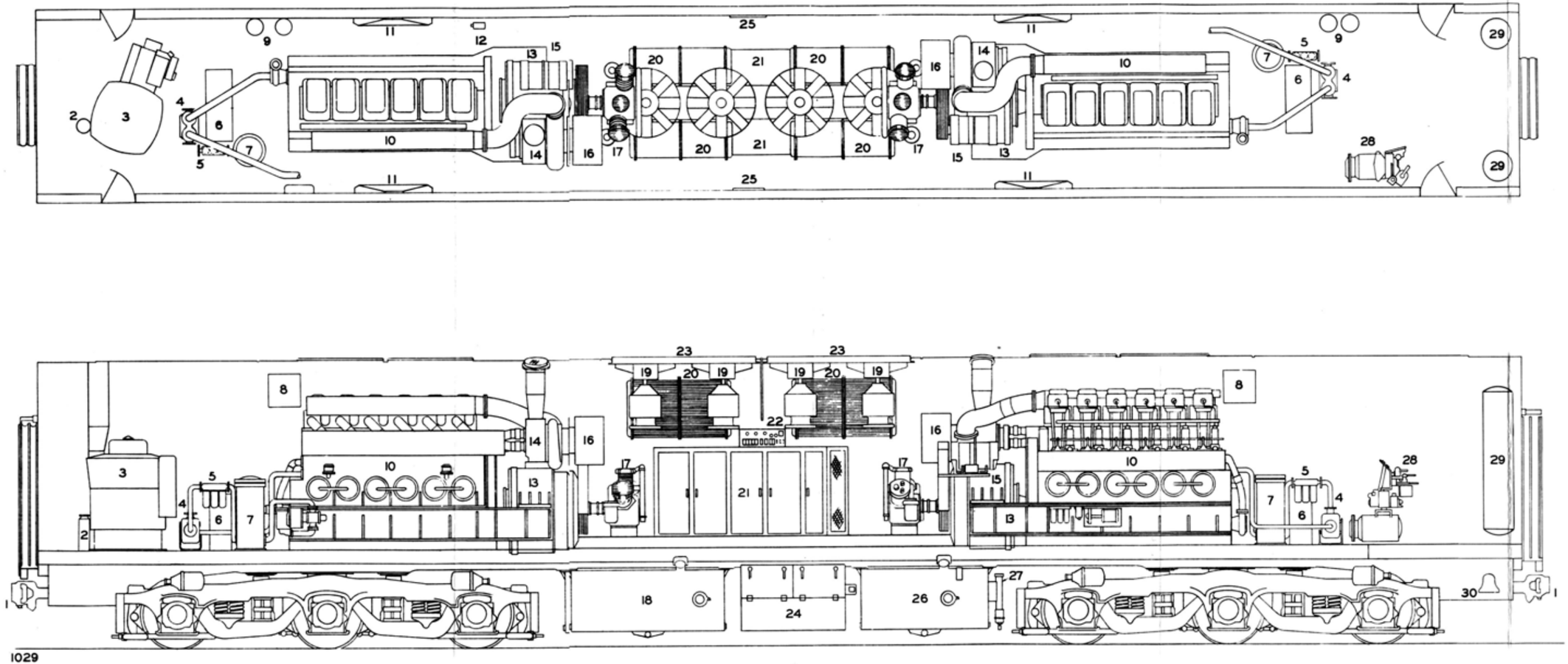

1. COUPLER
2. WATER TREATMENT TANK
3. STEAM BOILER
4. LUBRICATING OIL HEAT EXCHANGER
5. LUBRICATING OIL STRAINER
6. TRACTION MOTOR BLOWER
7. LUBRICATING OIL FILTER
8. ENGINE WATER EXPANSION TANK
9. FIRE EXTINGUISHER GAS CYLINDERS
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16. ENGINE AIR INTAKE FILTER
17. AIR COMPRESSOR
18. BOILER WATER SUPPLY TANK
19. FAN
20. RADIATOR
21. ELECTRICAL EQUIPMENT CABINET
22. ENGINE ROOM CONTROL PANEL
23. RADIATOR SHUTTERS
24. STORAGE BATTERY BOX
25. ENGINE GAUGE PANEL
26. FUEL OIL SUPPLY TANK
27. AIR AFTERCOOLER
28. HOSTLER'S CONTROLS
29. MAIN AIR RESERVOIR
30. BELL

ARRANGEMENT OF EQUIPMENT -- "B" UNIT
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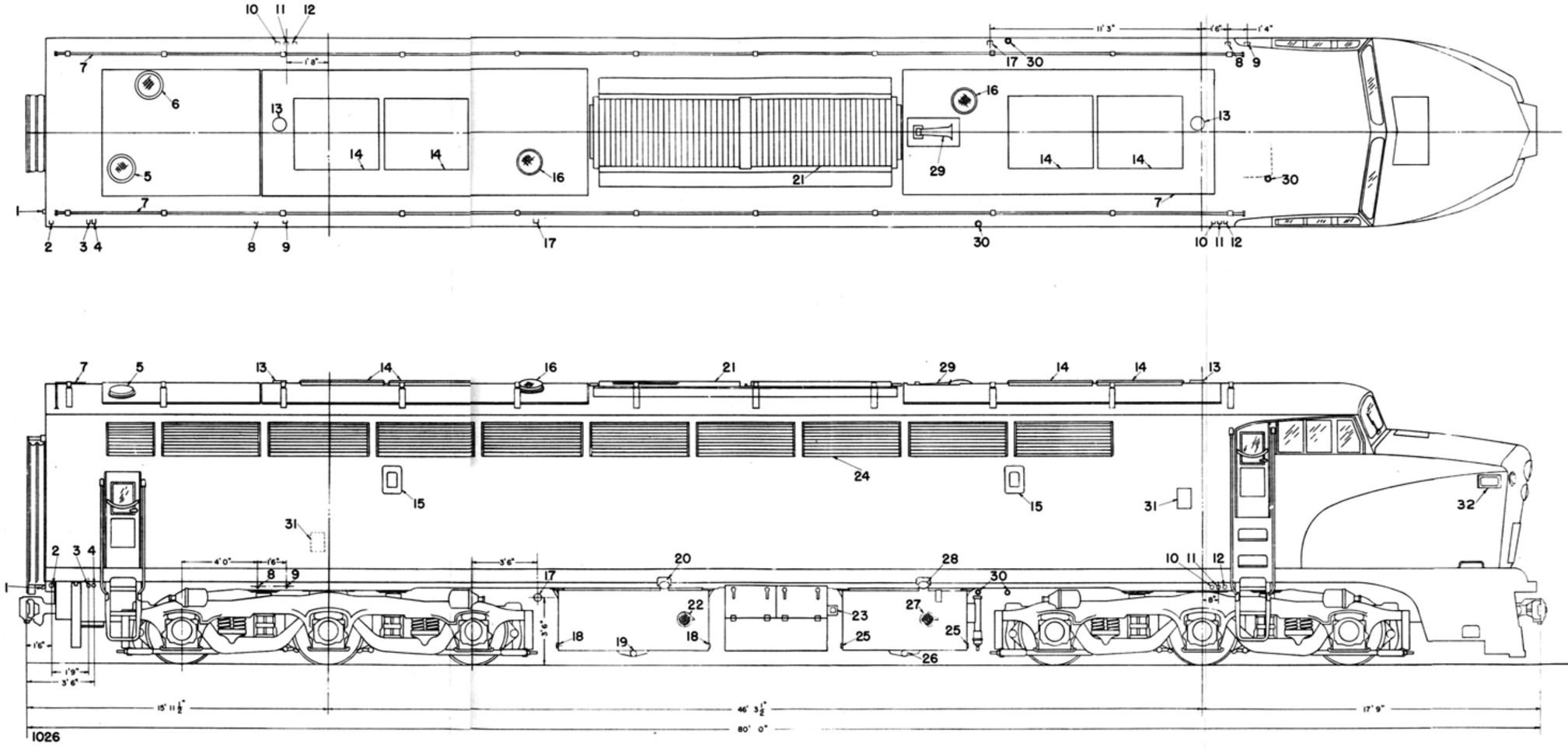
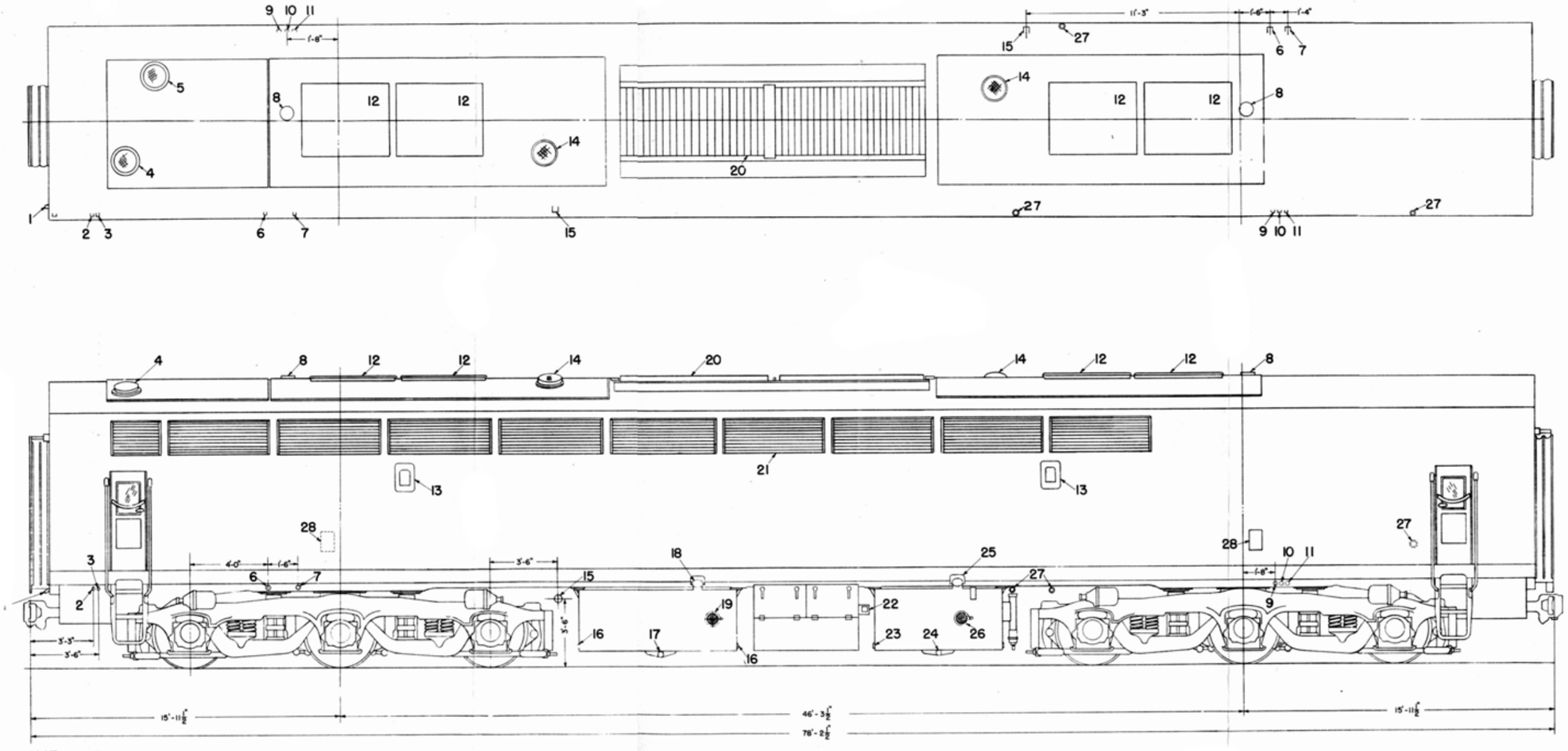
1. STANDBY LIGHTING RECEPTACLE
2. SANITARY WATER TANK FILL
3. BOILER WASHOUT CONNECTION
4. SEPARATOR WASHOUT CONNECTION
5. BOILER EXHAUST OUTLET
6. BOILER AIR INTAKE
7. TRAIN COMMUNICATION SYSTEM AERIAL
8. LUBRICATING OIL FILTER DRAIN
9. ENGINE WATER F..L
10. ENGINE WATER FILL
11. ENGINE WATER DRAIN
12. WATER EXPANSION TANK VENT
13. TOP ENGINE WATER FILL
14. ROOF HATCHES
15. SAND BOX FILL (BOTH SIDES)
16. ENGINE EXHAUST OUTLET
17. ENGINE LUBRICATING OIL DRAIN
18. BOILER WATER TANK DRAIN (BOTH SIDES)
19. BOILER WATER TANK SUMP DRAIN
20. BOILER WATER TANK FILL
21. RADIATOR SHUTTERS
22. BOILER WATER LEVEL GAUGE
23. BATTERY CHARGING RECEPTACLE
24. ENGINE ROOM AIR INTAKE OPENINGS
25. FUEL TANK DRAIN (BOTH SIDES)
26. FUEL TANK SUMP DRAIN (BOTH SIDES)
27. FUEL LEVEL GAUGE
28. FUEL TANK FILL
29. HORN
30. EMERGENCY FUEL SHUT-OFF VALVE PULL RING
31. ENGINE LUBRICATING OIL FILL ACCESS OPENING
32. NUMBER LIGHT
33. MARKER LIGHT
34. MARS SIGNAL LIGHT
35. HEADLIGHT



EXTERIOR OF "A" UNIT -- FILLS AND DRAINS
Figure 3



1. STANDBY LIGHTING RECEPTACLE
2. BOILER WASHOUT CONNECTION
3. BOILER SEPARATOR WASHOUT CONNECTION
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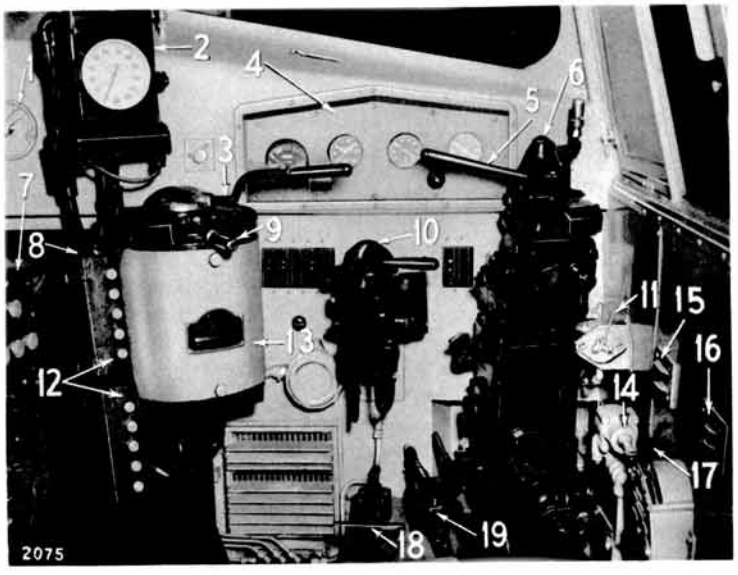
27. EMERGENCY FUEL SHUT-OFF VALVE PULL RINGS
28. ENGINE LUBRICATING OIL FILL ACCESS OPENING

EXTERIOR OF "B" UNIT -- FILLS AND DRAINS
Figure 4

INSTRUMENTS, CONTROLS AND OPERATION

CONTENTS



CONTROLS AND INSTRUMENTS
ENGINEER'S POSITION
Figure 1

1. Rotair Valve Handle
2. Speed Indicator and Recorder
3. Throttle Lever
4. Gauge Panel (See Figure 2)
5. Automatic Brake Valve Lever
6. Automatic Brake Pedestal
7. Train Communication Control Station
8. Control Switch Station Lock
9. Reverse Lever
10. Independent Brake Valve
11. Bell Ringer Valve
12. Control Switch Station
13. Master Controller
14. Air Signal Valve
15. Headlight Switch
16. Cab Light Switch
17. Mars Headlight Switch
18. Deadman Pedal
19. Cab Signal Acknowledging Switch

(See Figure 2 for controls and instruments on panel)

INSTRUMENTS AND CONTROLS

INTRODUCTION

The necessary locomotive operating controls and instruments are located conveniently near the engineer's and fireman's positions in "A" unit cabs. The "A" units contain identical control equipment. The "B" unit is equipped with hostler's controls only.

Instruments and controls for the Diesel engines and other engine room equipment are mounted on the engine room control panels, in the electrical equipment cabinets, and at other locations in the engine room.

Steam boiler controls are located at the fireman's position.

When units are being operated "in multiple" (two or more units being operated together), all functions which are controlled from the engineer's position are controlled from that position in one "A" unit only, such control being effective on all other units in the combination. The "A" unit at which control is established is termed "the controlling 'A' unit" throughout this manual. The other "A" unit in the combination is termed "the controlled 'A' unit". Engine room controls are operated from each unit during multiple operation, in the same manner as in single unit operation.

The term "power unit" refers to one Diesel engine, together with its generator, traction motors, and all auxiliary and power transmission equipment. In each locomotive unit, the forward power unit is the No. 1 Power Unit; the other power unit is the No. 2 Power Unit.

ENGINEER'S CONTROLS AND INSTRUMENTS

"A" UNIT CABS

The location of control equipment at the engineer's position is shown in Figure 1. The use of each control is indicated below.

MASTER CONTROLLER

The master controller contains the throttle and reverse levers. The throttle is used to control the speed of the locomotive by setting the engine governors pneumatically for a Diesel engine speed corresponding to the throttle position. In the "OFF" position, the throttle also opens the power switches, disconnecting the traction motors from the main generators.

The reverse lever has three positions, forward (FOR), reverse (REV), and "OFF", and is used to select the direction of locomotive travel. This is accomplished by means of the reverser, a traction motor field-reversing switch in the electrical equipment cabinet. With the reverse lever in the "OFF" position, the engine speed may be increased without movement of the locomotive.

AUTOMATIC BRAKE VALVE

The automatic brake valve lever is located near the top of the brake pedestal in front of the engineer's position. This lever is used to apply the brakes on the entire train.

INDEPENDENT BRAKE VALVE

The independent brake valve lever is used to apply the brakes on the locomotive only.

DEADMAN PEDAL

The deadman foot pedal is a safety device which must be depressed at all times when the locomotive is in operation. A release of the deadman pedal causes a warning whistle to sound for approximately 5 seconds after which the brakes are automatically applied and the engines brought to idling speed. If the deadman pedal is depressed within the warning period, however, no action takes place.

To release the controls for normal operation after a deadman pedal application, depress the deadman pedal, place the throttle lever in the "OFF" position, and place the automatic brake valve lever in the "LAP" position until the brakes release.

CONTROL SWITCH STATION

The control switch station is mounted on the left side of the master controller and contains the following pushbutton switches (listed from top to bottom):

1. Control Switch
2. Overspeed Valve Switch
3. Cab Signal Switch
4. Defroster Switch
5. Attendant Signal Switch
6. Marker Light Switch
7. Rear Headlight Switch
8. Gauge Light Switch
9. Number Light Switch
10. Emergency Shut-Down Switch

A key-operated lock is installed in the top of the control switch station. When locked, the control switch cannot be actuated, preventing control of the locomotive from that unit. Thus, when operating units in multiple, unlock the control switch station in the controlling "A" unit, and lock it in all other units.

The Control, Overspeed, and Cab Signal switches are gang-operated; they must open or close together.

ROTAIR VALVE

The Rotair valve is a selector valve used to isolate the independent brake valve on controlled "A" units or to select passenger or freight type air brake service. Three positions may be selected, "FRGT", "PASS", and "LAP". Place the pointer in the "LAP" position on controlled "A" units to isolate the automatic brake valve. In controlling "A" units, the pointer is ordinarily placed in the "PASS" position for passenger or short trains, and in the "FRGT" position for long freight trains. See Section 6.

SANDER VALVE

The sander valve is operated by depressing the sanding bail at the top of the automatic brake pedestal with the automatic brake valve lever. When the sander valve is operated, sand is applied to the wheels from all sand nozzles on the sides of the wheels in the direction of locomotive travel. Use sand only under the most unfavorable track conditions and as sparingly

as possible. Excessive sanding is very injurious to the traction motors and running gear.

Sand is automatically applied in the same manner during an emergency brake application.

BELL RINGER AND AIR HORN

The bell ringer and air horn valves are located at the engineer's position. See Figure 1.

OVERSPEED WHISTLE AND BRAKE APPLICATION

The overspeed alarm and overspeed brake application are arranged to operate at two separate pre-determined locomotive speeds. At one speed, the overspeed whistle will sound. If the locomotive speed is allowed to increase, an automatic brake application will occur at a second specific speed.

WHEEL SLIP INDICATORS

When any pair of driving wheels slip, a buzzer will sound and a signal light will light in the cab. At the same time, the speed of the engine supplying power to the slipping wheels will be automatically reduced until slipping stops, then increased to the original speed. If the buzzer sounds again, reduce the throttle to prevent further slippage. Do not apply sand.

SPEEDOMETER

The speedometer is located at the engineer's position. It indicates and records the locomotive speed.

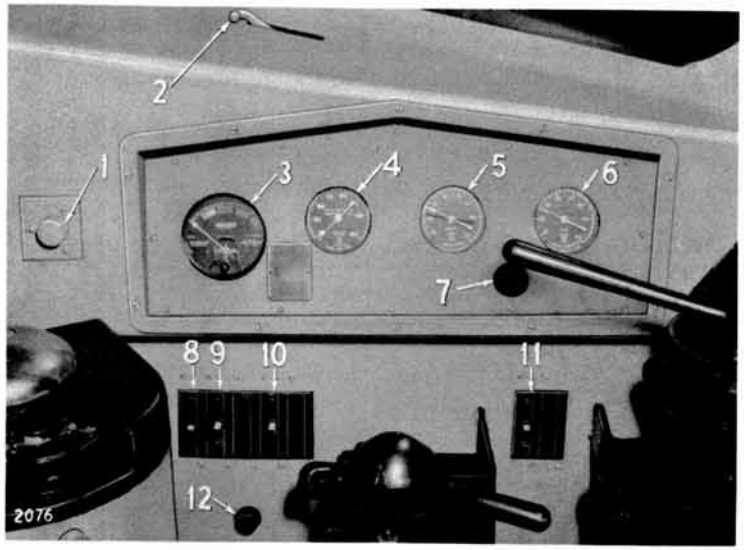
HEADLIGHT AND SIGNAL LIGHT SWITCHES

A three-way toggle switch (OFF, DIM, BRIGHT) beneath the engineer's side window controls the headlight. A rear headlight is installed on each "A" unit. The rear headlight switch is mounted on the control switch station.

The "Mars" signal light controls (if installed) are located beneath the engineer's side window.

WINDSHIELD WIPERS

The control knob for the windshield wipers is lo-



INSTRUMENT PANEL
ENGINEER'S POSITION
Figure 2

1. Windshield Wiper Control Knob
2. Manual Windshield Wiper Lever
3. Load Ammeter
4. Straight Air Pipe Pressure Gauge
5. Brake Pipe and Cylinder Air Pressure Gauge
6. Main and Equalizing Air Reservoir Pressure Gauges
7. Gauge Light Rheostat Control Switch
8. Nose Light Switch
9. Engineer's Heater Switch
10. Electro-Pneumatic Brake Switch
11. Overspeed Governor Switch
12. Heater Rheostat Control Knob

cated on the front panel of the cab at the engineer's position. Manual operating levers project from the front cab panel directly below each windshield.

ELECTRO-PNEUMATIC BRAKE SWITCH

This switch is mounted on the front panel of the cab at the engineer's position and is used to cut the electro-pneumatic brake equipment in or out.

SPEED GOVERNOR SWITCH

This switch is also mounted on the front panel of the cab at the engineer's position and is used to cut the speed governor brake pressure controls in or out.

CAB SIGNAL

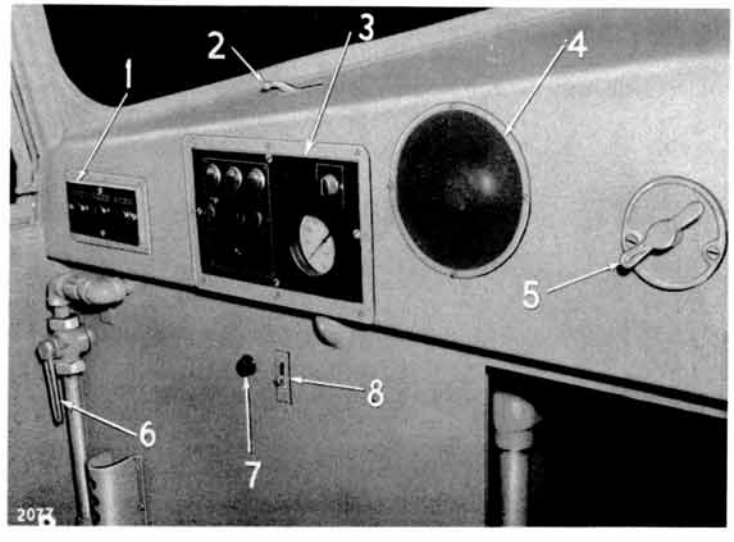
The acknowledging switch of the code cab signal system is located on the floor of the cab at the engineer's position. See Figure 1. A warning whistle in the cab is arranged to sound before a train control actuation takes place.

TRAIN COMMUNICATION CONTROLS

The train communication control stand with a handset talking instrument is located at the left of the engineer's position. This equipment provides a means of conversation between trains, between trains and stations, and between points on one train. See Section 9 for operating details.

FIREMAN'S CONTROLS AND INSTRUMENTS - "A" UNIT CABS

Controls and instruments as shown in Figure 3 are located at the fireman's position on the left side of each "A" unit cab.



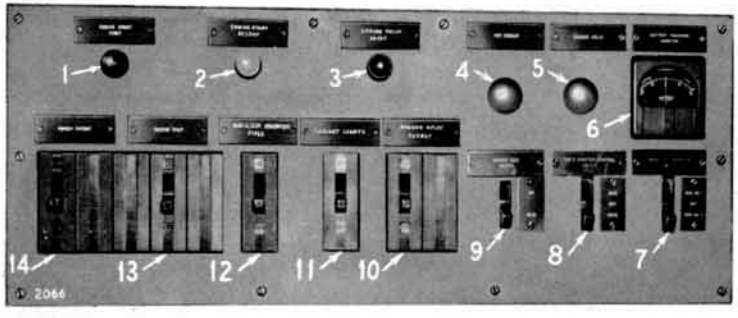
CONTROLS AND INSTRUMENTS
FIREMAN'S POSITION
Figure 3

1. Fire Warning and Indicator Lights
2. Manual Windshield Wiper Lever
3. Fireman's Instrument Panel
   (See Page 802)
4. Train Communication Speaker
5. Rotair Valve Handle
6. Fireman's Emergency Brake Valve

ENGINE ROOM CONTROLS AND INSTRUMENTS

"A" AND "B" UNITS

The engine room controls and instruments are mounted on panels on top of the electrical equipment cabinets on each side of the center section of "A" and "B" units. Controls for Engine No. 1 (the forward engine) are located on the right-hand side of the locomotive; controls for Engine No. 2 are located on the left-hand side. The various controls are shown in Figure 4. The use of these controls is outlined under "OPERATION" in this section, and their function is explained in Section 4.



ENGINE ROOM CONTROL PANEL
Figure 4

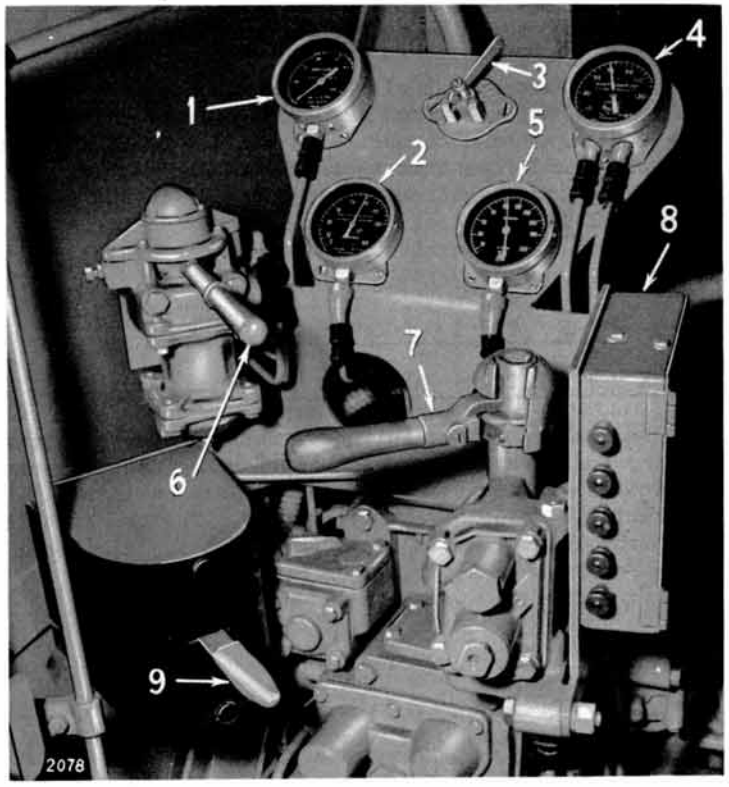
1. Engine Start--First Button
2. Engine Start--Second Button
3. Ground Relay Re-Set Button
4. Hot Engine Warning Light
5. Ground Relay Warning Light
6. Battery Charging Ammeter (No. 1 Power Units Only)
7. Ammeter Transfer Switch (No. 1 Power Units Only)
8. Fan & Shutter Control Switch
9. Engine Idle Switch
10. Ground Relay Cutout Switch
11. Electrical Equipment Cabinet Lights
12. Auxiliary Generator Switch
13. Engine Stop Switch
14. Power Cutout Switch

HOSTLER'S CONTROLS AND INSTRUMENTS - "B" UNIT

The necessary controls and instruments for independent operation of the "B" unit are located in the forward, right-hand corner of the unit. These controls are more simplified than those at the engineer's position, but the function of each control is the same as that of the comparable control at the engineer's position in the "A" units. The hostler's controls are shown in Figure 5.

ELECTRICAL EQUIPMENT CABINETS - "A" AND "B" UNITS

The battery cutout switches, control disconnecting switch, and other manual controls for use under special conditions are located in the electrical cabinets in the center section of the locomotive. The use of this equipment is outlined under "OPERATION" in this section; for further details, see Section 4.



CONTROLS AND INSTRUMENTS
HOSTLER'S POSITION
Figure 5

1. Straight Air Pipe Pressure Gauge
2. Control Air Pressure Gauge
3. Bell Ringer Valve
4. Brake Pipe and Cylinder Air Pressure Gauge
5. Main Air Reservoir Pressure Gauge
6. Brake Valve Lever
7. Throttle Lever
8. Control Switch Station
9. Reverse Lever

LOCOMOTIVE OPERATION

Operate the locomotive in accordance with the following instructions. For locating the controls and equipment mentioned, refer to the General Arrangement Drawing on Page 103 and other illustrations in this section of the manual.

I. PRELIMINARY

A. Inter-Unit Connections

Make certain that all necessary connections are properly made between the units. These connections include:

1. Train line jumper and electro-pneumatic brake jumper.
2. Main reservoir pipe.
3. Straight air pipe.
4. Actuating pipe.
5. Application and release pipe.
6. Controlled emergency pipe.
7. Throttle pipe.
8. Brake pipe.
9. Signal pipe.

B. Cab Lights

The "A" unit cab lights may be turned on by means of the toggle switches located near each cab entrance door and beneath each side window of the cab.

C. Engine Room Lights

The engine room lights may be turned on by means of the toggle switches located in the frame of each entrance door on the locomotive.

II. INSPECTION BEFORE STARTING

A. Check the following supplies:

1. Fuel oil
2. Engine crankcase and engine governor oil levels
3. Air compressor crankcase oil levels
4. Engine cooling water level
5. Boiler water supply tank level
6. Sand

B. Drain the condensate from the main air reservoirs.

C. Disconnect the storage battery from any outside charging unit before starting the engines.

III. STARTING THE DIESEL ENGINES

A. At the master controller in the cab of the controlling "A" unit:

1. Place the throttle lever in the "OFF" position. Place the reverse lever in the "OFF" position.
2. Unlock the control switch station in the controlling "A" unit. Check that the control switch station in all controlled units is locked.
3. Close the control pushbutton switch. This is the uppermost pushbutton on the control switch station.

B. At each engine room control panel (See Figure 4):

1. Place the Fan & Shutter Control Switch in the "AUTO" position.
2. Place the Auxiliary Generator Switch in the "OFF" position.
3. Place the Engine Stop Switch in the "ON" position. (An alarm bell will then sound continuously until the engine starting button is pressed.)
4. Press the Engine Start--First Button.

This should crank the engine fast enough to start it. Hold the starting button depressed until the engine fires and the lubricating oil pressure exceeds 20 psi; then release the starting button. If the starting button is released before the oil pressure exceeds 20 psi, the engine will be stopped automatically by the low lubricating oil pressure shutdown system.

If the engine does not turn fast enough to start, press the Engine Start--Second Button to increasing the cranking speed. Hold the first starting button in contact continuously while pressing the second starting button. An engine cannot be started by pressing the second starting button alone.

CAUTION:

If the engine does not start within ten seconds of cranking, release the starting button and determine the difficulty. See "Operating Difficulties" at the end of this section.

After the engine is started:

5. Place the Engine Idle Switch in the "ON" position.
6. Place the Power Cutout Switch in the "ON" position.
7. After both engines in the unit are started, place the Auxiliary Generator Switch in the "ON" position, and note that a current is indicated on the Battery Charging Ammeter. This current should be from 5 to 50 amperes at starting, diminishing to zero as the batteries become fully charged.

IV. STARTING AND MOVING THE LOCOMOTIVE

A. Before starting the locomotive, make the following inspection:

1. Check the main air reservoir pressure. It should be 140 psi before starting.
2. Check the control air pressure gauge. It should be 70 psi before starting.
3. Check the application and release of the brakes with both the automatic and independent brake valves.
4. Check the fuel oil and engine lubricating oil pressures.
5. Check the engine cooling water temperature.
6. Test the operation of the bell ringer and horn.
7. Release all hand brakes.
8. Check that the traction motor cutout switches are closed.
9. Check that the traction motor blowers are operating. The locomotive must not be used to pull a train unless the blowers are operating.
10. Check the operation of the radiator fans and shutters. The shutter position and fan operation should correspond to the engine cooling water temperature as indicated in the table in Section 3 under "Temperature Control".

B. To move the locomotive:

1. Insert the reverse lever into the master controller of the controlling unit and place it in the "FOR" or "REV" position corresponding to the direction of movement desired.
2. Depress the Deadman Pedal. Release the air brakes.
3. Move the throttle slowly away from the "OFF" position to the first notch and hold it there until the load ammeter on the engineer's instrument panel indicates that current is flowing through the traction motors. About 4 seconds will elapse before a current will be indicated.
4. Stretch the train, starting smoothly by using the least necessary throttle advance. Then advance the throttle to the position required for the desired acceleration. Advance the throttle slowly (20 to 25 seconds to full throttle) without jarring, and without exceeding the load limits tabulated in Paragraph V below. Avoid wheel slip due to excessive acceleration. When the desired train speed has been attained, retard the throttle as much as necessary to maintain that speed.
5. Wheel slip will be indicated by the wheel slip buzzer. When any pair of driving wheels slip, the speed of the engine supplying power to those wheels will be decreased momentarily, then increased to the original speed. If the buzzer sounds again, retard the throttle until wheel slip stops. Do not apply sand while the wheels are slipping. Sanding is a preventative, not a corrective measure.
6. The traction motors are connected for one-step automatic field shunting which occurs as the locomotive speed increases. This change takes place at approximately 55 miles per hour and is accompanied by a sudden increase in the load ammeter reading.
7. When reversing the direction of locomotive movement, bring the locomotive to a complete stop with the throttle lever in the idle position before changing the reverse lever position.

C. To start and move the "B" unit independently, follow the procedure outlined above for the controlling "A" unit.

V. ELECTRICAL LOAD LIMITS

The main power circuits, which consist of the main generators, traction motors, and connecting wiring, must be protected against overheating by observing load (current) limitations. Overheating of the wiring chars the insulation; even should no failure occur at the time of overheating, the resulting deterioration is likely to cause a failure at some future time.

The continuous rating of each main generator is 1800 amperes. The locomotive may be safely operated for an indefinite period of time at loads which produce 1800 amperes or less current in the main power circuits. The load ammeter on the engineer's instrument panel in each "A" unit indicates the main power circuit current in the No. 1 (forward) power unit which, under normal conditions, is approximately the same as the current in all other main power circuits in the locomotive. Any load current exceeding 1800 amperes constitutes an overload.

It may frequently be desired to accelerate the locomotive at a rate which overloads the electrical equipment. The equipment can be overloaded in this manner without overheating the wiring, provided that the equipment is cool at starting and that the overloading is held within definite time limits. Safe overloading, under these conditions, will depend upon the amount of excess current and the time interval during which it is sustained. Overloading must be held within the limits tabulated below to prevent overheating of the wiring.

Generator Amperes	Time Limit
1800	No Limit
2000	40 Minutes
2200	20 Minutes
2600	10 Minutes
3000	6 Minutes
3600	4 Minutes

Whenever any one of the overload limits shown above is reached, retard the throttle immediately until the load current is 1800 amperes or less. The limits listed above DO NOT apply to equipment which is warm before the overload is started.

Safe electrical overloading limits at times when the electrical equipment is warm will depend upon the temperature of the wiring at the time that overloading is started. The locomotive operator, however, has no means of determining the wiring temperature. When the electrical equipment is warm, therefore, avoid overloading entirely, or observe special overload limits computed by the railroad for the specific operating conditions (tonnage, acceleration, grade, section of run, etc.) involved. (Such computations must be based upon the heating and cooling rates of the electrical equipment and should be compiled for operation of the locomotive with all posible combinations of power units.)

VI. INSPECTION DURING OPERATION

The gauges to be checked in performing the following inspections are located on the sides of the engine room control panel.

A. Check the engine water temperature; it should be between 151° and 158° at all times. If the automatic controls fail to maintain this temperature, the fans and shutters must be operated manually. See Page 304.

B. Check the lubricating oil pressure; it should be approximately 65 psi when the engine is running at 625 RPM. Investigate any significant deviation from this pressure promptly. See Page 309.

C. Check the engine fuel oil pressure; it should be 25 psi. Investigate any loss in fuel pressure promptly. See Page 313.

VII. TO STOP THE LOCOMOTIVE

A. Normal Stop

1. Move the throttle lever to the first running position and hold it there until the load ammeter indicates that the current has dropped. Then move the throttle lever to the "OFF" position.
2. Apply the brakes in a regular service application.

NOTE: To stop trains smoothly, keep them stretched by a light application of the train brakes, then retard the throttle as indicated above, moving the lever gradually toward the first running position.

B. Emergency Stop

1. Move the automatic brake valve to the emergency application position.
2. Move the throttle lever to the "OFF" position.

VIII. TO STOP AN ENGINE

At the engine control panel:

A. Place the Engine Idle Switch in the "OFF" position.

B. Place the Engine Stop Switch in the "OFF" position.

C. Place the Auxiliary Generator Switch in the "OFF" position.

IX. PROCEDURE WHEN LEAVING LOCOMOTIVE

A. When leaving the locomotive with the engines running:

1. Check that the brakes are properly set.
2. Remove the reverse lever from the master controller in the "A" unit cabs.

B. To stop the engines and leave the locomotive:

1. Stop all auxiliary electrical equipment, such as the steam boilers and the 1500 watt motor-generator sets.
2. Stop all engines as outlined in Paragraph VIII above.
3. Place the Power Cutout Switch on each engine room control panel in the "OFF" position.
4. Lock the control switch stations.
5. Apply the air brakes with the independent brake valve and close the brake pipe cutout valve on the automatic brake pedestal.
6. Set the hand brakes.

7. In freezing weather, protect the engine cooling water from freezing as outlined in Section 3.

C. To leave the locomotive for a considerable period of time:

1. Proceed as in Paragraph B above, and in addition:
2. Open the battery cutout switch in each electrical equipment cabinet.
3. Open the control disconnecting switch in each No. 1 equipment cabinet.
4. Turn out all lights.

X. SPECIAL OPERATING PROCEDURES

A. To Isolate a Power Unit with Locomotive Running

If trouble develops in any part of a power unit while the locomotive is in operation, that power unit may be taken out of service without disturbing the operation of the other power units. A power unit may be isolated by either of the following procedures.

1. If the engine is to be left running while the power unit is isolated, place the Engine Idle Switch in the "IDLE" position. This will idle the engine and disconnect the traction motors from the main generator at the power switches. The fans will continue to operate, and the steam boiler will also continue to operate even though connected to the isolated power unit through the boiler transfer switch.

2. If the engine of the isolated power unit is to be stopped, place the Power Cutout Switch in the "OFF" position. This will idle the engine, disconnect the traction motors from the main generators at the power switches, and disconnect the main generator field windings. The fans will stop, and the steam boiler will stop if connected to the isolated power unit. (To connect the boiler to the other power unit, use the boiler transfer switch in the No. 1 electrical equipment cabinet.

To stop the engine, after the power unit has been isolated as in Paragraph 1 or 2 above, place the Engin Stop Switch and the Auxiliary Generator Switch in the "OFF" position.

B. To Place an Isolated Power Unit Back into Service with Locomotive Running

1. Place the Engine Stop Switch in the "ON" position.
2. Check that the Engine Idle Switch is in the "IDLE" position.
3. Start the engine as outlined in Paragraph III above.
4. Place the Auxiliary Generator Switch in the "ON" position.
5. Place the Engine Idle Switch in the "ON" position.

C. To Isolate a Traction Motor with Locomotive Running

If a traction motor fails enroute, it may be isolated and the other traction motor of the same power unit kept in operation by the following procedure.

1. Place the Engine Idle Switch in the "IDLE" position. This will disconnect both traction motors from the generator.
2. Open the traction motor cutout switch in the electrical equipment cabinet for the motor being isolated. (Do not operate these switches while the motors are connected to the generator.)
3. Place the Engine Idle Switch back in the "ON" position.

CAUTION:

The load ammeter at the engineer's position indicates the load current of the No. 1 power unit only. Accordingly, if one traction motor is isolated in the No. 1 (forward) power unit of the controlling "A" unit, the load ammeter readings will be one-half as great as they would otherwise be. In this case, the continuous rated load current (1800 amperes) of all other generators in the locomotive will have been reached when the

load ammeter reads 900 amperes. Similarly, all of the limiting current values tabulated in Paragraph V above will be indicated by load ammeter readings one-half as great as shown.

If the isolated traction motor is in any other power unit, the load ammeter readings and proper load limits will be no different than for normal operation as covered in Paragraph V.

D. To Vary Engine Speed without Moving Locomotive

To operate the engines at greater than idling speed for purposes of pumping air at a high rate, checking engine speed range, conducting an engine load test, or similar purposes, proceed as follows:

1. With the engines running and the control pushbutton switch closed, place the reverse lever on the master controller in the "OFF" position.
2. Advance the throttle lever until the desired engine speed is obtained.

E. To Stop All Engines in an Emergency

To stop all engines in any emergency, close the Emergency Shut-Down pushbutton switch on the control switch station in any unit. In multiple-operating units, this switch is operative on all control switch stations, whether locked or unlocked, and any one switch may be used to stop all engines in the combination.

F. To Operate the Emergency Fuel Shut-Off Valves

If a fire occurs on or near the locomotive, or if the locomotive is endangered by fire due to any other accident, close the emergency fuel shut-off valves immediately.

These valves are located in the three suction lines from the fuel tank. All three valves are closed simultaneously by pulling any one of three pull rings on each unit. To close the valves, pull the ring in the cab or either of the rings adjacent to the fuel tank on each side of the locomotive. The pull ring on the inside of the "B" unit is located at the hostler's position.

To be opened, the valves must be re-set manually. After they have been operated, it will usually be necessary to bleed the air from the fuel systems before starting.

G. Fire Alarm and Extinguisher Operation

The fire alarm system is actuated by thermostats mounted in the engine room. When the temperature at any thermostat becomes high enough to actuate the alarm system, a bell will ring in each "A" unit cab and an indicator light will turn on at the fireman's position. Three lights on each panel, marked "This A Unit", "B Unit", and "Other A Unit", indicate the location of the fire.

A carbon dioxide fire hose with a nozzle is located near the ends of each unit. To release the carbon dioxide, open the cylinder valves by pulling a release cord anywhere inside the locomotive or at any exterior pull box next to the entrance doors. The nozzles can then be operated by squeezing the trigger on the nozzle.

H. To Change Control from One "A" Unit to the Other

In the "A" unit cab which has been controlling:

1. Make a 20 pound brake pipe reduction with the automatic brake valve, then move the automatic brake valve handle to the "LAP" position.
2. Move the independent brake valve handle to the release position and observe that the brakes are still applied.
3. Close the brake pipe cut-out cock.
4. Place the Rotair valve handle in the "LAP" position.
5. Move the automatic brake valve handle to the running position and remove both brake valve handles.
6. Remove the reverse lever from the master controller.
7. Lock the control switch station and remove the key.

In the "A" unit cab which will be controlling:

1. Insert the brake valve handles, place the Rotair valve in the "PASS" position, and move the independent brake valve handle to the application position.

2. Open the brake pipe cut-out cock, then move the automatic brake valve handle first to the emergency position, then back to "LAP".
3. Depress the independent brake valve handle in full application position for about 8 seconds. Move the automatic brake valve handle to running or release position.
4. Place the Rotair valve handle in "PASS" or "FRGT" position for service desired, depress deadman pedal, check reservoir pressures, and test braking.
5. Insert the reverse lever and place it in the "OFF" position.
6. Unlock the control switch station.

J. To Tow the Locomotive

To prepare the locomotive for towing, set the controls as follows in the controlling "A" unit:

1. Place the reverse lever in the "OFF" position and remove the lever. Place the throttle lever in the idle position.
2. Lock the control switch station and remove the key.
3. Place the automatic and independent brake valve handles in the running position. Close the double heading cock.
4. Place the Rotair valve handle in the "LAP" position.

XI. MISCELLANEOUS OPERATING INSTRUCTIONS

A. If the Engine Overspeed Stop Trips:

Re-set the overspeed stop manually. See Page 302.

B. If Locomotive Units Uncouple:

If the main reservoir connection is broken between the units, set the hand brakes immediately; the loss in air pressure may make the air brakes inoperative. Close the main reservoir cut-off valve in each unit as soon as possible; these valves may be opened when the units are re-coupled.

C. If the Alarm Bell Sounds:

1. Inspect the Boiler Off Light at the fireman's position. If the light is off, proceed as in 2, below.

If the light is on, the boiler has stopped; check the fuses in the boiler wiring circuits. If the boiler will not start, it will require a thorough inspection and possible repair.

2. Inspect the Ground Relay Light and the Hot Engine Light on each engine room control panel.

If any Ground Relay Light is on, press the adjacent Ground Relay Re-set Button; if the ground was only momentary, the relay will remain closed. If the relay trips and the light turns on again, the Ground Relay Cutout Switch on the control panel may be placed in the "OFF" position and the locomotive operated. This must be considered emergency operation, however; rules of the railroad for such operation should be followed.

If any Hot Engine Light is on, the corresponding engine will be stopped due to overheating. See "Engine Overheats" in Paragraph XIII below.

3. If none of the indicator lights are on, one of the engines will be stopped due to the action of one of the automatic shut-down devices. At the engine room control panel of the stopped engine, inspect the Engine Stop Switch. This is a breaker-type switch and may be tripped out of the "ON" position. If so, place the switch back in the "ON" position. This should permit the engine to be started in the normal manner.

If, on inspection, the Engine Stop Switch is found in the "ON" position, the engine has been stopped by the low lubricating oil pressure shut-down system. See Page 309.

XII. OPERATING PRECAUTIONS

A. Use of the Deadman Pedal

DO NOT use the deadman pedal for normal stopping of the locomotive. This safety device is for emergency use only, in case of incapacity of the engineer. The sudden power shut-down resulting from a deadman pedal stop may damage the electrical equipment.

B. Running through Water

Use care in running through water to avoid splashing water on the traction motors. In case of unavoidable operation on water-covered track, operate at reduced speed. Do not attempt to operate on track where the water level is more than three inches above the top of the rails.

C. Operating over Cross-Overs

When approaching a cross-over, reduce speed at approximately a car-length ahead of the cross-over. This measure will reduce shock on traction gear teeth and reduce commutator pitting which might otherwise result.

D. Use of the Reverse Lever

Whenever there is a possibility of movement of the locomotive by an outside force, such as in double-heading or when drifting from its own weight on a grade, make certain that the reverse lever is either in the "OFF" position or in the position corresponding to the direction of movement. This precaution is necessary to prevent an accidental application of power to the traction motors at a time when the wheels are turning in one direction and the reverse lever position corresponds to the opposite direction. Such a circumstance would be likely to damage the electrical equipment.

XIII. OPERATING DIFFICULTIES AND CAUSES

A. An Engine Fails to Turn When Starting Is Attempted

1. Control disconnecting switch open.
2. Battery cutout switch open.
3. Starting circuit contactors stuck open.
4. Engine Stop Switch open.

B. At Starting, an Engine Turns but Will Not Fire or Run After the Starting Button is Released

1. Fuel tank empty.
2. Fuel pump transfer switch open or thrown in position for pumping fuel to the other engine in the unit.

3. Emergency fuel shut-off valves tripped.
4. Blocked fuel filter or strainer.
5. Fuel system not primed properly.
6. Fuel supply pump not functioning properly.
7. Engine overspeed stop tripped.
8. Emergency engine shut-down switch closed.
9. Insufficient lubricating oil pressure to keep low pressure shut-down system from operating.
10. Engine shut-down cylinder or engine shut-down valve not functioning properly.
11. Insufficient oil supply in the engine governor.

C. Engine Speed Will Not Increase When Throttle is Advanced

1. Engine Idle Switch in the "IDLE" position.
2. Power Cutout Switch in the "OFF" position.
3. Main control fuse or control pushbutton fuse blown.
4. Starting contactor stuck in closed position.
5. Throttle magnet valve not operating properly.
6. Insufficient control air pressure (Check pressure gauge in the nose compartment of the locomotive.)
7. Engine governor not operating properly.

D. An Engine Overheats

1. Insufficient water supply.
2. Automatic fan and shutter controls not operating properly (Place the Fan & Shutter Control Switch in the "MAN" position and operate the shutters manually until repairs can be made.)
3. Engine overloaded.
4. Radiator fan motor fuses blown.
5. Water pump not functioning properly.

E. An Engine Stops

1. Fuel tank empty.
2. Engine overspeed stop tripped.
3. Emergency fuel shut-off valve tripped.
4. Fuel supply pump not functioning properly.
5. Blocked fuel strainer or filter.

6. One of the following automatic shut-down devices has operated:

   a. Low lubricating oil pressure switch.
   b. Hot water temperature switch.
   c. Engine Stop Switch (breaker type).

7. Emergency Shut-Down pushbutton switch closed.

F. The Locomotive Does Not Move When the Throttle Is Opened

1. Reverse lever in "OFF" position.
2. Power Cutout Switches in "OFF" position.
3. Engine Idle Switches in "IDLE" position.
4. Traction motor cutout switches open.
5. Power knockout switch fails to close.
6. Main control fuse or control pushbutton fuse blown.
7. Auxiliary Generator Switch (breaker type) tripped.

DIESEL ENGINE

CONTENTS

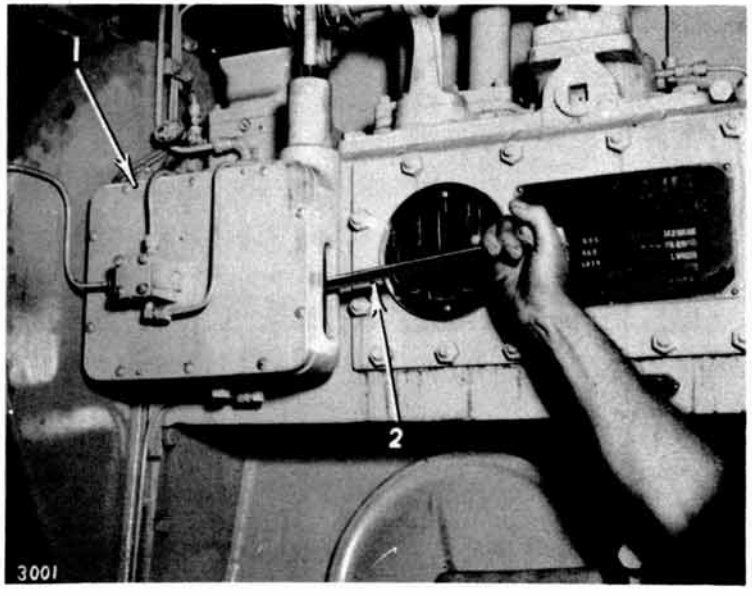
NOTE: For complete descriptive and maintenance information covering the Diesel engines, see the Diesel Engine Manual.

ENGINE OVERSPEED CONTROL

The engine is protected against excessive speed by the overspeed stop located on the front of the camshaft casing at the generator end of the engine. See Figure 1. The overspeed stop is a spring-loaded tripping device which is set to trip at a pre-determined camshaft speed. When it trips, a plunger connected to the fuel control shaft turns the shaft to the "No Fuel" position, stopping the engine.

TO RE-SET THE OVERSPEED STOP

When the overspeed stop trips, it may be re-set by engaging the tripping lever with a screw driver or small bar inserted through the slot in the overspeed stop housing and prying the lever downward until the mechanism becomes re-engaged. If the overspeed control stops the engine repeatedly, it will be necessary to check the operation of the engine.



OVERSPEED STOP
Figure 1

1. Overspeed Stop
2. Small Bar or Screwdriver (Pull Downward to Re-Set)

ENGINE COOLING SYSTEM

The engines are water-cooled by a separate system for each engine. The water is circulated through the system by an engine-driven centrifugal pump. The pump discharges into the engine header from which it is distributed through the engine system. The water then passes into the engine discharge water manifold at the top of the engine from which it is piped to the cooling radiators. From the radiators, the water passes to the heat exchanger where the lubricating oil is cooled, then back to the water pump to complete its circuit through the system. Expansion tanks are connected to the suction side of each pump. These tanks allow for water expansion and hold a supply for replacement of losses. A water level gauge is mounted on each tank. See Figure 3.

TEMPERATURE CONTROL

The engine water is cooled at the radiators by the circulation of air which enters the engine room through inlets on the side of the locomotive, is forced through the radiators by motor-driven fans, and is discharged through outlets in the roof of the locomotive. The water temperature is controlled by regulating the fan speed and the position of the shutters in the cooling air discharge openings. The fans and shutters are automatically controlled during normal operation, but may be manually controlled for emergency purposes.

For normal operation, keep the Fan and Shutter Control Switches on each engine room control panel in the automatic (AUTO.) position. The automatic temperature controls will then function as follows:

1. A temperature sensitive bulb is installed in the water line leading to the engine. This bulb is connected to, and controls, the Grad-U-Stat, an air pressure varying device in the fan and shutter control air lines. See Figure 2.

2. The varying air pressure in the Grad-U-Stat is transmitted to a pair of air operated electric switches. One of these switches is connected in a circuit with a magnetic shutter valve which controls the flow of air to the shutter operating cylinder, determining the shutter

position. Both of the air operated switches are connected into the fan motor circuits to obtain two fan speeds.

3. The possible steps in automatic operation take place as indicated below.

INCREASING WATER TEMPERATURE

Operation	Inlet Water Temperature (°F.)
Fans are stopped. Shutters are closed.	Up to 154°
Fans operate at low speed. Shutters open.	154°
Fans operate at high speed. Shutters are open.	158°

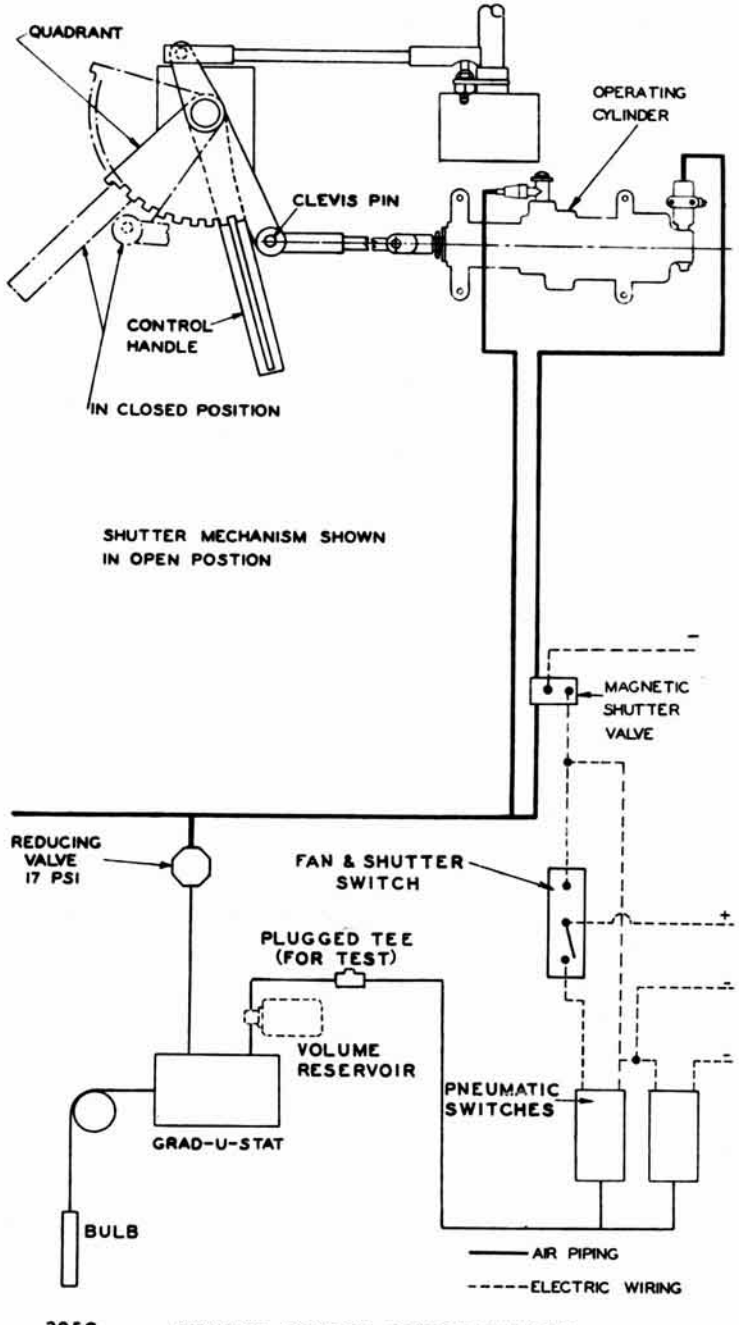
DECREASING WATER TEMPERATURE

Operation	Inlet Water Temperature (°F.)
Fans operate at high speed. Shutters are open.	Down to 155°
Fans operate at low speed. Shutters are open.	155°
Fans stop. Shutters close.	151°

When the automatic temperature controls do not function properly, the fans and shutters can be manually controlled in the following manner.

1. With the Fan and Shutter Control Switch in the manual (MAN.) position, the fans will operate at low speed and the shutters can be set manually to any desired position. The shutter control handles are located at each end of the radiator section.

2. With the Fan and Shutter Control Switch in the "OFF" position, the fans are stopped and the shutters closed.



3052 SHUTTER CONTROL SYSTEM DIAGRAM
Figure 2

A separate water temperature switch set at 190° F. will act on the engine shut-down valve to stop the engine if the engine water reaches that temperature. This switch is shown in Figure 5.

FILLING THE COOLING SYSTEM

The cooling system can be filled with water at the filling connections at each side of the locomotive and at the filling connections on the roof of the locomotive over each expansion tank. Use the side filler connections whenever possible; use of the top filler connection when the expansion tank is empty has a tendency to produce air pockets in the system.

Normally, water should be added to the system only when the engine is cold and stopped. If it becomes necessary to add water when the engine is warm (above 120° F.), add the water very slowly or heat it before adding. In an emergency, the engine cooling system can be filled from the boiler water supply, by opening Valve No. 2 as shown Figure 4.

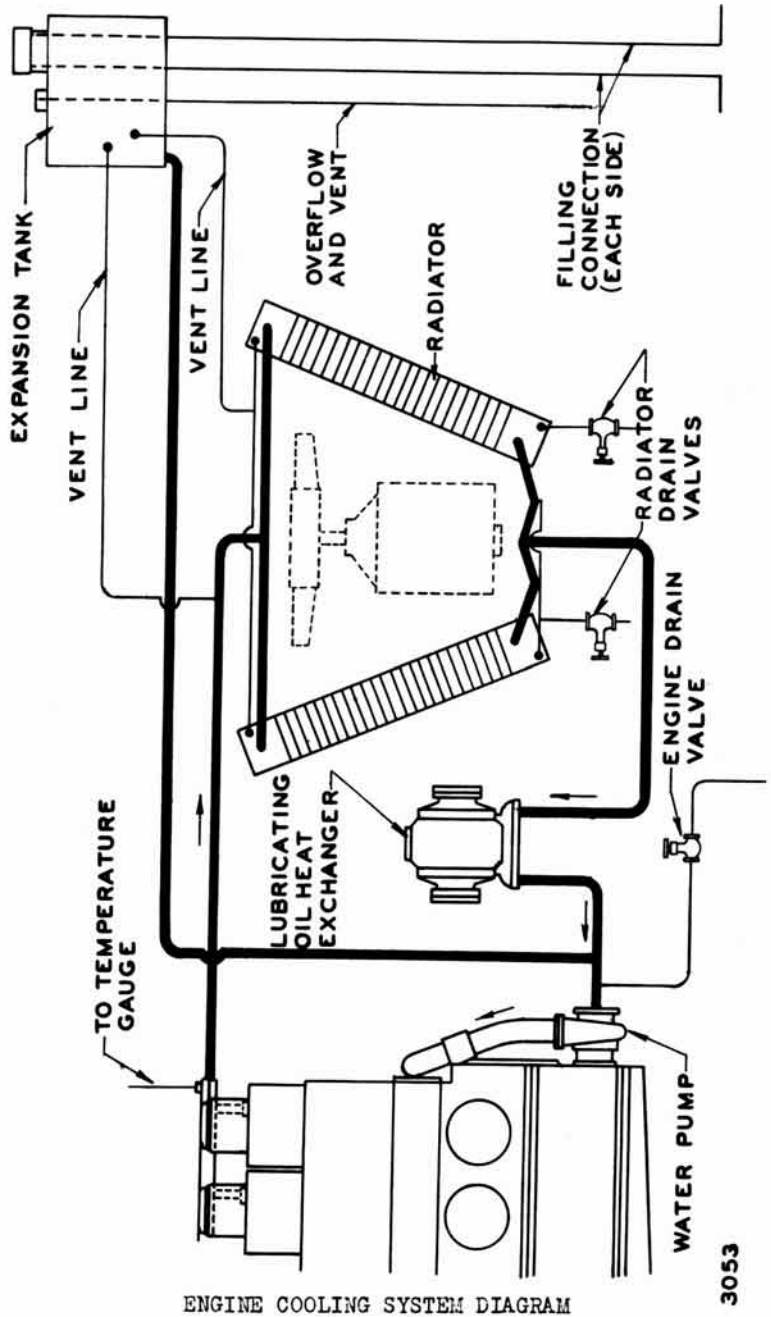
The water placed in the cooling system should be distilled or chemically treated. For complete information, see the Diesel Engine Manual.

PREVENTION OF FREEZING OF WATER SUPPLY

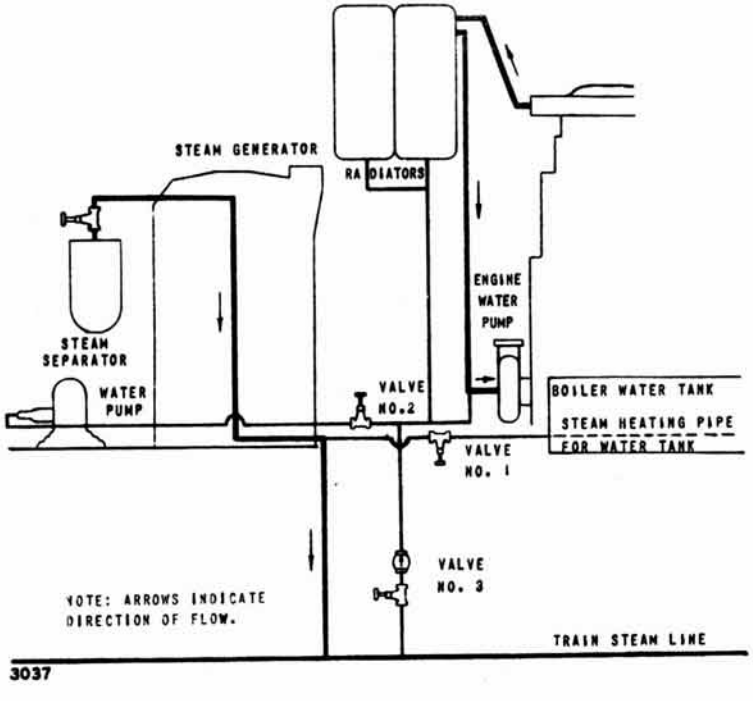
Steam lines are installed to provide steam heating of the engine cooling system and the boiler water supply tank to prevent freezing during winter operation.

When the locomotive is standing idle under freezing conditions, supply steam to the locomotive steam line from an outside source. Then open Valve No. 3, Figure 4, admitting steam to the engine cooling system. When the locomotive is standing idle or in operation during freezing weather, open Valve No. 1 to admit steam to the heating pipes in the boiler water tank.

It is necessary to drain the boiler coils, steam separator, and water treatment tank to prevent freezing. Instructions for draining may be found in Section 8.



ENGINE COOLING SYSTEM DIAGRAM
Figure 3



BOILER-TO-ENGINE PIPING DIAGRAM
Figure 4

ENGINE LUBRICATING

OIL SYSTEM

Each engine has an independent lubricating oil system. See Figure 6. The oil is drawn from the sump formed by the engine bedplate through a check valve and a suction strainer by an engine driven pump. The oil is discharged from the pump into an absorbent-type filter. It then passes in succession through a strainer and a heat exchanger, then enters the lubricating oil header in the engine. The lubricating oil is distributed by the header to the moving parts of the engine from which it drains back into the sump completing its circuit. The pump discharge relief valve shown in Figure 6 is set at 125 psi; the heat exchanger by-pass relief valve is set at 25 psi.

The lubricating oil is cooled in the heat exchanger by transfer of heat to the engine cooling water. The pressure strainer is of the metal-edge type; the handles should be turned a few revolutions after each four hours of operation. The elements in the filter should be changed in accordance with the schedule shown on the Maintenance Chart for this locomotive.

FILLING THE LUBRICATING OIL SYSTEM

The lubricating oil system is filled at the filler connection on the valve-gear side of the engine. An oil level gauge is located adjacent to the filling connection. Maintain an oil level between the high and low marks on the gauge at all times. Do not check the oil level until at least five minutes after the engine has been stopped.

LUBRICATING OIL PRESSURE

Normal lubricating oil pressure at the oil header is 65 psi at an engine speed of 625 RPM. Any significant deviation from this value should be investigated. Low lubricating oil pressure may result from one or more of the following conditions.

1. Clogged strainers or filters.
2. Low oil level.
3. Abnormal oil viscosity.

4. Faulty operation of the oil pump.

5. Faulty operation of the pump discharge relief valve.

6. Leakage in the oil piping.

LOW LUBRICATING OIL PRESSURE SHUT-DOWN

An automatic system is installed on each engine to stop the engine if the lubricating oil becomes excessively low. See Figure 5. A small oil line is extended from the lubricating oil header to a lubricating oil pressure switch. This switch is connected in series with the water temperature switch. When the oil pressure drops below 20 psi, the switch breaks the electrical circuit to the engine shut-down valve. The engine shut-down valve then releases the fuel oil pressure from the engine shut-down cylinder which turns the fuel control shaft to the "NO FUEL" position, stopping the engine. The fuel oil at the engine shut-down valve and the engine shut-down cylinder is utilized as a hydraulic actuating medium only.

TURBOCHARGER LUBRICATING OIL PRESSURE

Turbocharger lubricating oil pressure is indicated on the gauge panel mounted on the side of the engine room opposite each engine room control panel. The oil pressure should be not less than 20 psi and this pressure must be reached within 12 to 15 seconds after the turbocharger begins to rotate.

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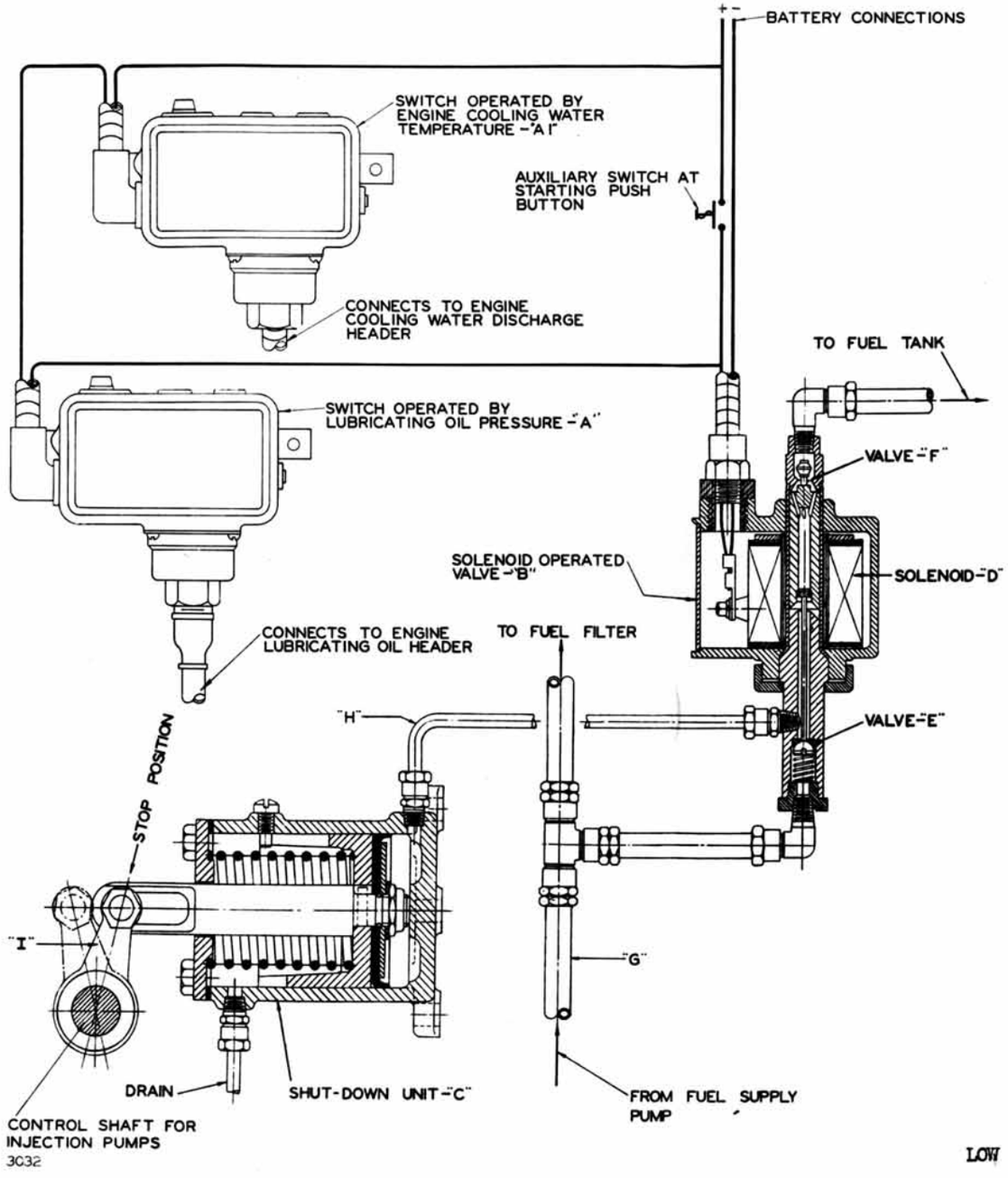
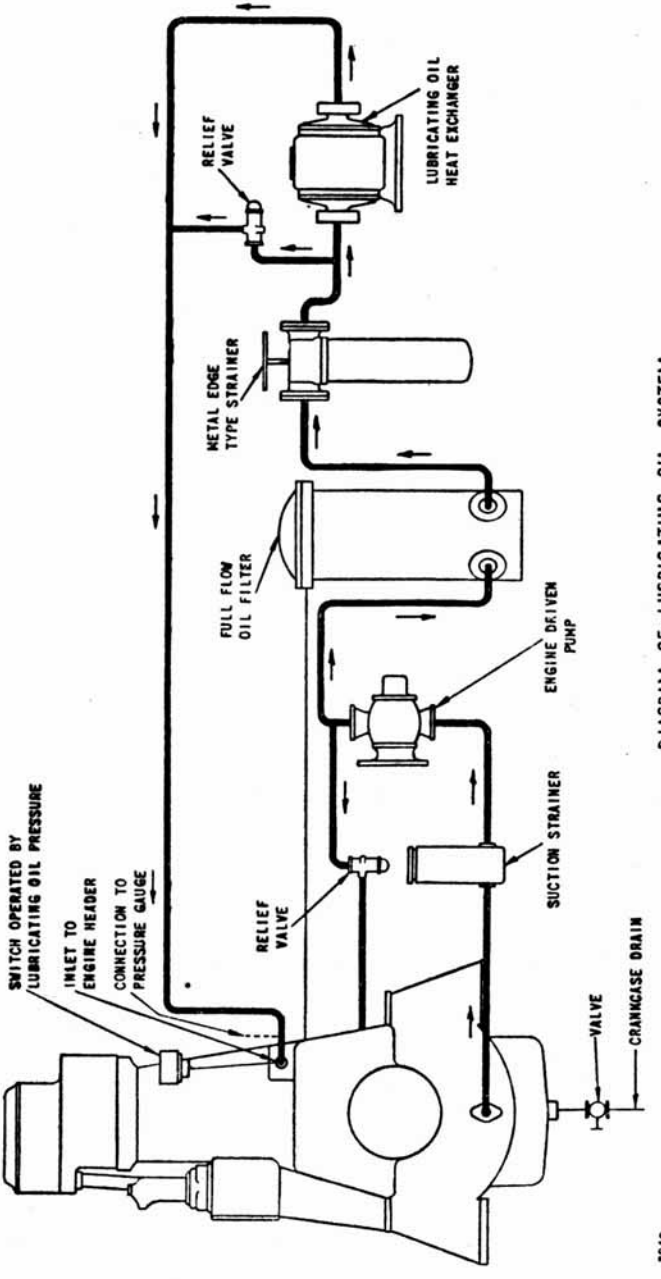


LOW LUBRICATING OIL PRESSURE SHUT-DOWN
Figure 5



ENGINE LUBRICATING OIL SYSTEM DIAGRAM
Figure 6

ENGINE FUEL OIL SYSTEM

The fuel oil is drawn from the fuel tank through a suction strainer by a motor-driven transfer pump. See Figure 7. The pump discharges through a filter into the fuel oil header which supplies the fuel injection pumps. A fuel injection pump is located adjacent to each cylinder and pumps a controlled volume of fuel through the fuel injectors into the cylinder once each cycle. Relief valves at the fuel transfer pump and at the end of the fuel oil header release excess pressure by expelling fuel into a return line to the fuel tank. An engine stop valve is connected to the fuel oil line. This valve utilizes the fuel oil pressure to actuate the engine shut-down cylinder (See Figure 5) for emergency purposes, and is controlled by electric switches.

FILLING THE FUEL TANK

The fuel tank can be filled at the filling connections on each side of the locomotive. A fuel gauge is installed in the side of the fuel tank.

EMERGENCY FUEL SHUT-OFF VALVES

An emergency fuel shut-off valve is located in each suction fuel line from the fuel oil tank. These valves are located outside of the engine room directly above the fuel oil tank, one on the right-hand and two on the left-hand side of the locomotive. The valves on each unit may be tripped, shutting off the fuel, by pulling any one of three pull rings on the unit. The pull rings are attached to the emergency shut-off valves by cables, and all three valves are tripped simultaneously by pulling any ring. A pull ring is located on the outside of each unit adjacent to each side of the fuel tank. The third pull ring in each unit is located in the cab, in the "A" units, and at the hostler's position in the "B" unit.

To open the valves after an emergency shut-off, they must be re-set manually.

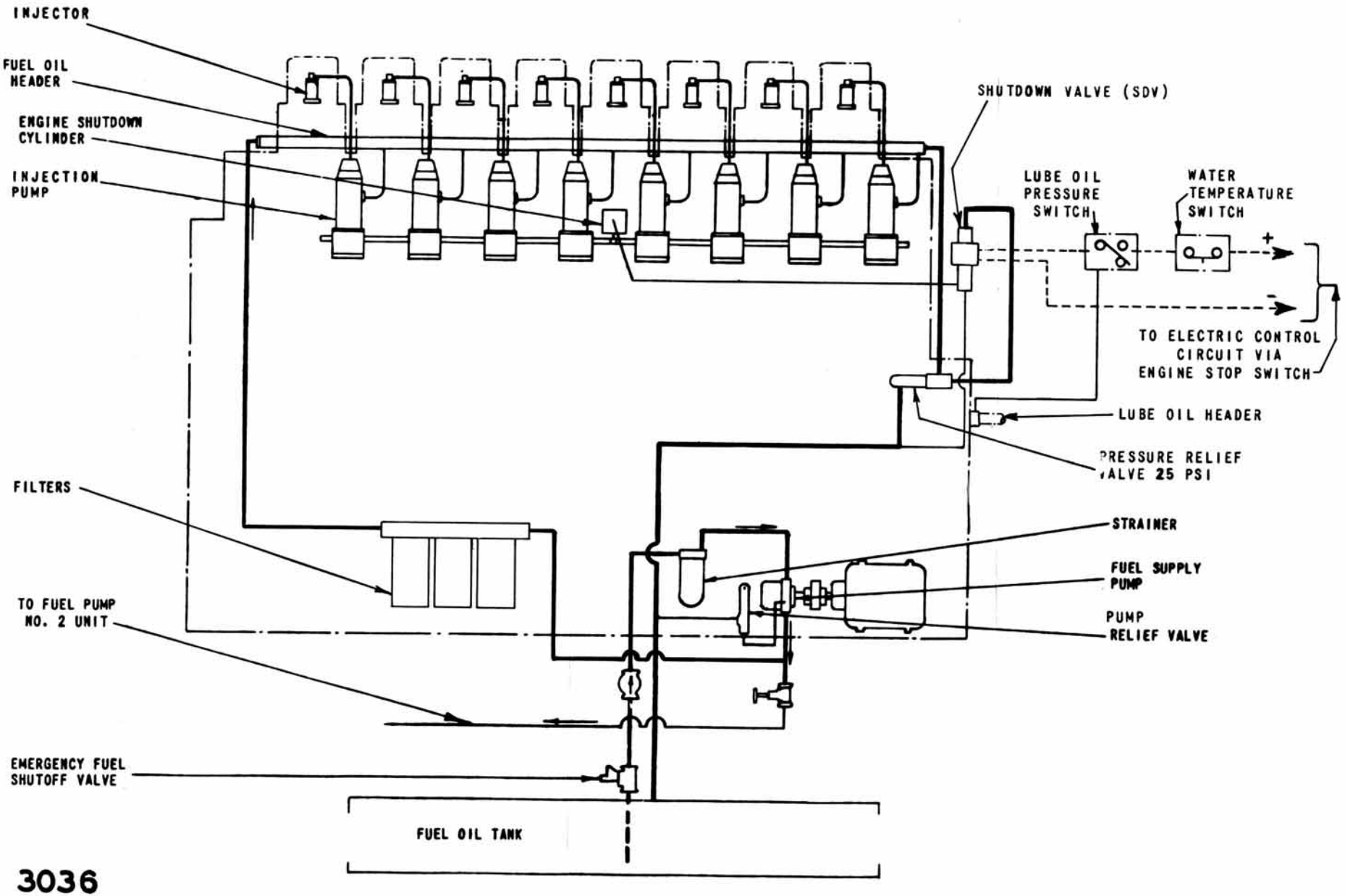
FILTERS AND STRAINERS

The filter on the pressure side of the fuel transfer pump is of the three-unit absorbent type. The filter elements must be changed periodically.

LOW FUEL OIL PRESSURE

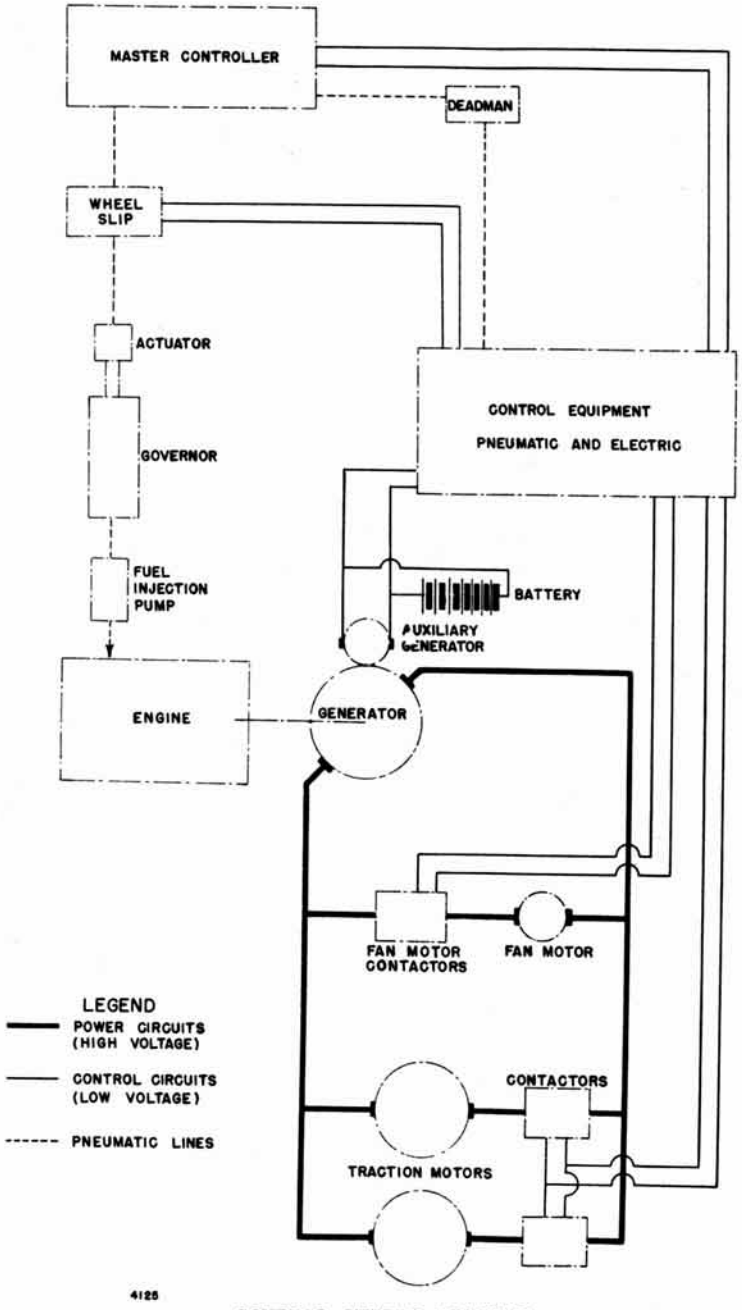
Low fuel oil pressure may be caused by one or more of the following conditions.

1. Blocked strainers or filters.
2. Fuel pump failure.
3. Fuel pump motor failure.
4. Leakage from the fuel oil piping.
5. Incorrect setting of relief valves.



ENGINE FUEL OIL SYSTEM DIAGRAM
Figure 7

E.L E C T R I C A L E Q U I P M E N T



CONTROL SYSTEM DIAGRAM
Figure 1

E L E C T R I C A L E Q U I P M E N T

I N T R O D U C T I O N

This section describes the function and operation of the various pieces of electrical equipment and their relationships in the various circuits. The electrical equipment of the locomotive consists of the following main elements.

a. Main Generator - driven by a Diesel engine.

b. Traction Motors - geared to the driving axles.

c. Power Control Equipment

d. Auxiliary Equipment and Controls

e. Lights, Heating, and Miscellaneous Equipment

The Control System Diagram in Fig. 1 shows the basic relationship of the principal electrical equipment, together with a schematic layout of the related pneumatic control lines. The Master Controller in the upper portion functions (a) pneumatically through the governor and fuel injection pump to control the engine speed and power (via the dotted line), and (b) electrically through the control circuits to the traction motor contactors and fan motor contactors. (See legend on Fig. 1 to identify power and control circuits). The engine driven generator supplies the power circuits, while the auxiliary generator charges the battery and furnishes a regulated low voltage power supply to the control circuits. The battery is shown in normal operating connection. Special starting circuits from the battery are explained later. Many details of the circuits are purposely omitted to facilitate understanding.

There are two power units on each locomotive unit. A power unit consists of one engine, one generator, two traction motors and certain auxiliary equipment, all of which are entirely independent of any other power unit, except that all are controlled by one master controller. Some equipment has suitably interlocked connection to either unit. "A" and "B" locomotive units are alike except for minor details in lighting, heating, sanding and power control.

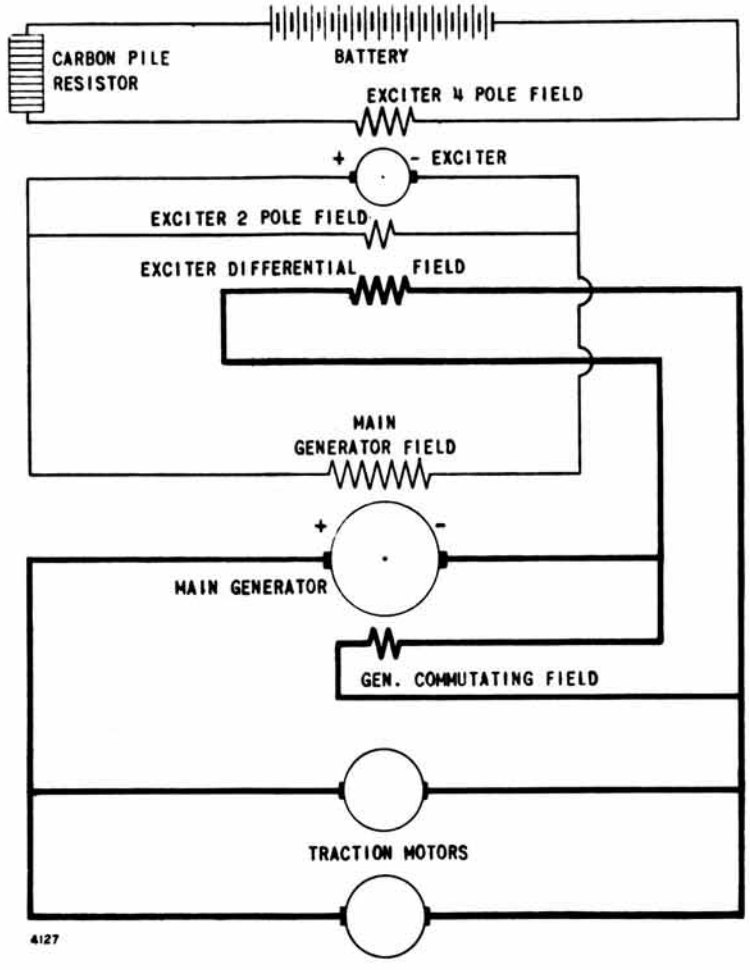
GENERAL PRINCIPLES

OF OPERATION

Each Diesel engine drives a generator which in turn powers the traction motors over various heavy duty high voltage circuits. A simplified schematic diagram of these connections is shown in Fig. 2. In starting, a high tractive effort and torque are necessary. The motor torque is proportional to the amperage, therefore a high current is required. Since there is no counter electro-motive force at stand still, and the motor's internal resistance is low, the current is high at low generator voltage and low generator speed. As the locomotive speed increases, the combined motor resistance and counter electro-motive force increases, and the generator voltage must be increased by increasing its speed, if high current is to be maintained. The speed of the engine-generator is pneumatically controlled by the throttle lever and governor. The amperage drops rapidly after the initial acceleration. The voltage increases to a maximum of about 750 volts as the generator speeds up. The exciter fields are so arranged that, at any engine speed, the maximum power input to (or output from) the generator is nearly constant. Under such conditions, the product of tractive effort x speed is constant for all speeds, and the product of generator voltage x amperes is constant for all amperages.

A low voltage circuit, 75 volts, is provided for as much of the auxiliary equipment and control apparatus as can possibly be removed from the high voltage circuits. This circuit is supplied by an auxiliary generator which also charges a battery for supplying the circuit when the power unit is not running.

Controls - Controls fall into two main classes, manual and automatic. In general, the manual controls are those required in starting a power unit, operating the locomotive, and emergency operation, isolation, or shutdown of portions of the locomotive while continuing operation with the remaining equipment. Automatic controls are protective or interlocking in nature or relieve the crew of incidental operating details necessary for efficient operating such as (a) field shunting of the traction motors and fan motors, or (b) the Carbonstat regulation of the exciter field for smooth acceleration. Some of the protective devices



SIMPLIFIED SCHEMATIC WIRING DIAGRAM
Figure 2

function regularly in normal operation, while others function only when abnormal conditions arise. In many instances the proper attention to gauge readings, such as those for lube oil pressure and cooling water temperature, will reveal the trouble in advance, but should the crew fail to detect such conditions, the protective devices will function. An alarm system warns the crew of abnormal conditions. Some abnormal conditions may be rectified enroute, while others re-

quire servicing at terminal points. These details are discussed later in this section under "Alarm" and "Ground Relay".

A series of wiring diagrams in simplified form illustrates the various circuits which are described in this section. When examining the diagrams, it must be kept in mind that all switches and relay contacts and interlock contacts are shown in their normal shut down position. For example, a relay whose contacts open when the coil is energized is shown with closed contacts, and one whose contacts close when the coil is energized is shown with open contacts.

Interlocks - Interlocks, which are auxiliary switches actuated by an element in a controlling circuit or mechanism, are designated by the symbol of the controlling element coupled to an "in" or "out" designation if the controlling element is electrical. An "in" interlock completes a circuit when the main circuit contacts are closed. An "out" interlock completes a circuit when the main circuit contacts are open. (In other words, except for spring loaded equipment, an "in" interlock completes an auxiliary circuit when current is flowing through the controlling circuit).

Contactors - All contactors are normally open unless drawn with an arrow running diagonally through the contacts. In many instances, a diagram shows contacts without the corresponding actuating coil, or vice versa, because the relay functions in two different circuits. For simplicity in the diagrams, the corresponding connection usually is not shown, altho suitable cross reference is usually made in the text.

Electro-Pneumatic Valves - An electro-pneumatic valve consists of an electro-magnetic coil which actuates valves in the air lines. The coils are part of the electrical circuits and are shown in the wiring diagrams, but reference must be made to the Air Piping Diagram in Section 6, for the pneumatic portion of such equipment as, for example, the Compressor Valve, Throttle Valve, Sander Valves, Overspeed Valve, Power Switches and Reverser.

FUSES

FUSES

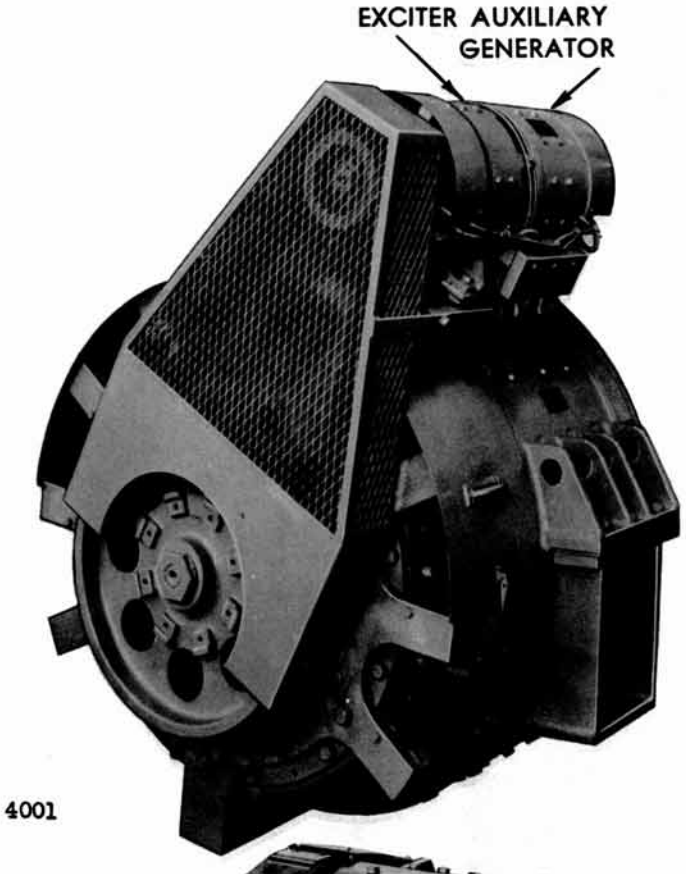
There are a total of 23 fuses on each "A" unit. "B" units are similar except there are no Cab Signal fuses and there are fewer circuits at the Control Push Button Station. (See Section 2 for list of push buttons). A fuse tester is mounted on the left end of the No. 1 Equipment Cabinet. Observe safety precautions before replacing fuses. See Trouble Shooting at end of this section.

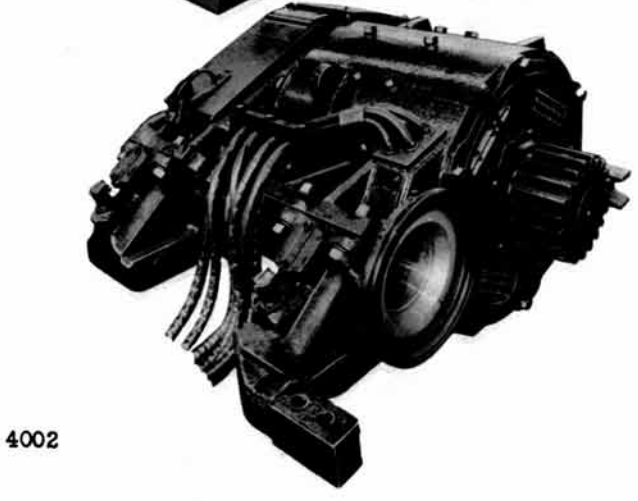
TABLE OF FUSES

Quantity	Circuit	Location	Rating (Amp.)
1	Control (Main)	#1 Equipment Cabinet	70
2	Fan Motor	Equipment Cabinets	175
2	Fan and Shutter Control	Equipment Cabinets	15
2	Auxiliary Generator	Equipment Cabinets	175
2	Train Telephone, Cab Signal and Headlight	#2 Equipment Cabinet	70
4	Steam Generator (Control and Ignition)	Steam Generator	10
1	Control	Control Push Button Box	15
1	Overspeed	Control Push Button Box	15
1	Cab Signal Control	Control Push Button Box	15
1	Emergency Engine Shut Down	Control Push Button Box	15
1	Attendant	Control Push Button Box	15
1	Marker Lights	Control Push Button Box	15
1	Back-Up Light	Control Push Button Box	15
1	Gauge Lights	Control Push Button Box	15
1	Number Lights	Control Push Button Box	15
1	Defroster	Control Push Button Box	15

NOTE:

Do not replace a fuse with one of a higher amperage rating. If a fuse burns out immediately after replacement, do not replace it a second time until the trouble has been located and rectified or isolated from the circuit.





MAIN GENERATOR AND TRACTION MOTOR
Figure 3

PROPULSION EQUIPMENT

MAIN GENERATOR

The main generator, shown in the top portion of Fig. 3 is a 12-pole d.c. self-ventilated single bearing generator directly connected to the Diesel engine by a coupling. It furnishes power over a wide range of speeds up to 625 r.p.m. and rotates in a counter-clockwise direction when viewed from the commutator end. It supplies power to the traction motors, and radiator fan motors.

AUXILIARY GENERATOR AND EXCITER

The auxiliary generator and exciter unit on the main generator frame (Fig. 3) is belt driven by the main generator.

The auxiliary generator is about 10 Kw. capacity. It charges the battery, supplies power to the fuel pump motors and heater fans and energizes the control relays. It is regulated for constant voltage by a vibrating type voltage regulator. The auxiliary generator circuit is protected by a 175 ampere fuse which is mounted in the equipment cabinet.

The exciter supplies the main generator fields, and is specially wound to maintain power output as nearly constant as possible. To avoid overloading the engine, the strength of the main generator field must be varied so that the generator voltage is decreased as the current demand is increased. To do this the exciter has three seperate field windings, as follows:

(a) A 2-pole shunt field energized by exciter current.

(b) A 4-pole field energized by the auxiliary generator and regulated by a Carbonstat.

(c) A reversed (differential) field energized by main generator current.

The connections for these fields are shown in the Schematic Wiring Diagram in Fig. 2. When current from the main generator to the traction motors is high, the reversed field opposes the other exciter fields which

weakens the main generator fields and reduces the voltage and current supplied to the traction motors. The exciter is designed so that its inherent differential characteristics automatically decrease the field strength, and hence the voltage, of the generator as the current demand increases.

TRACTION MOTORS

The traction motor, shown in the lower portion of Fig. 3 is a direct-current, series-wound 6 pole motor mounted on, and geared directly to, each driving axle. Two motors are connected to each main generator as shown on the Simplified Schematic Wiring Diagram in Fig. 2. The motor connection remains the same for all running conditions. The field connections are reversed to reverse the direction of rotation of the motors. They are force-ventilated by separate mechanically driven blowers through ducts in the locomotive underframe feeding into openings in the top of the motors.

EQUIPMENT CABINETS

Two equipment cabinets, located between the engines on both "A" and "B" units, contain most of the electrical equipment on the locomotive. Figures 4 and 5 show the arrangement of equipment in these cabinets. In general, each power unit has its own cabinet, and the two cabinets are similar to each other except for certain items which serve both units. An engine control panel is on top of each cabinet. These panels are shown in detail in Section 2.

SAFETY NOTICE

High voltages are used on much of the equipment in the cabinets. Cabinet doors should be kept closed as much as possible. No attempt should be made by unqualified personnel to open the doors or make adjustments to the equipment.

The crew should also be familiar with all switches which should NOT be opened under load. Such instructions are given in the following text wherever applicable. Disregard of such instruction may cause arcing which may damage equipment or cause personal injury.

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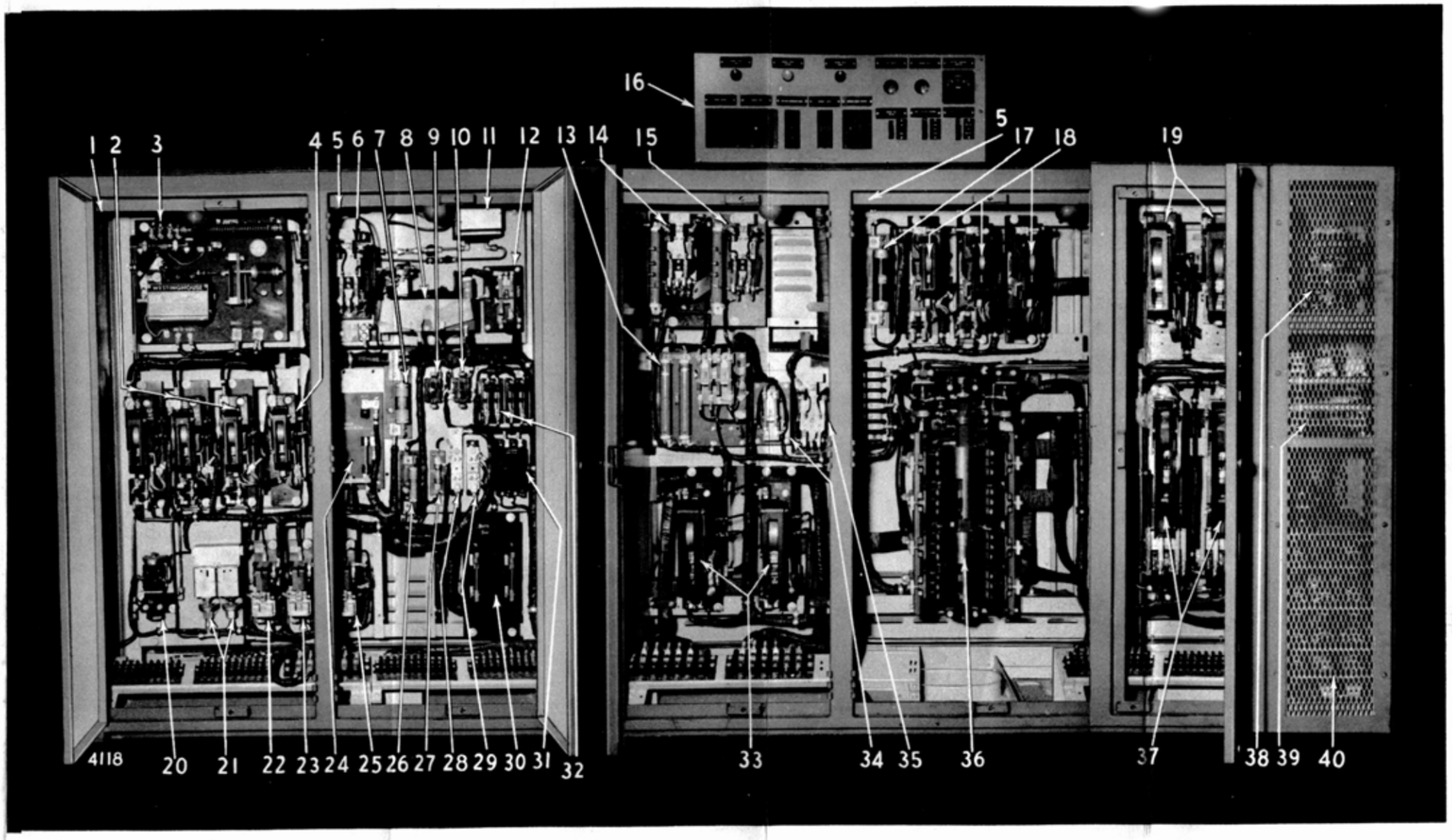
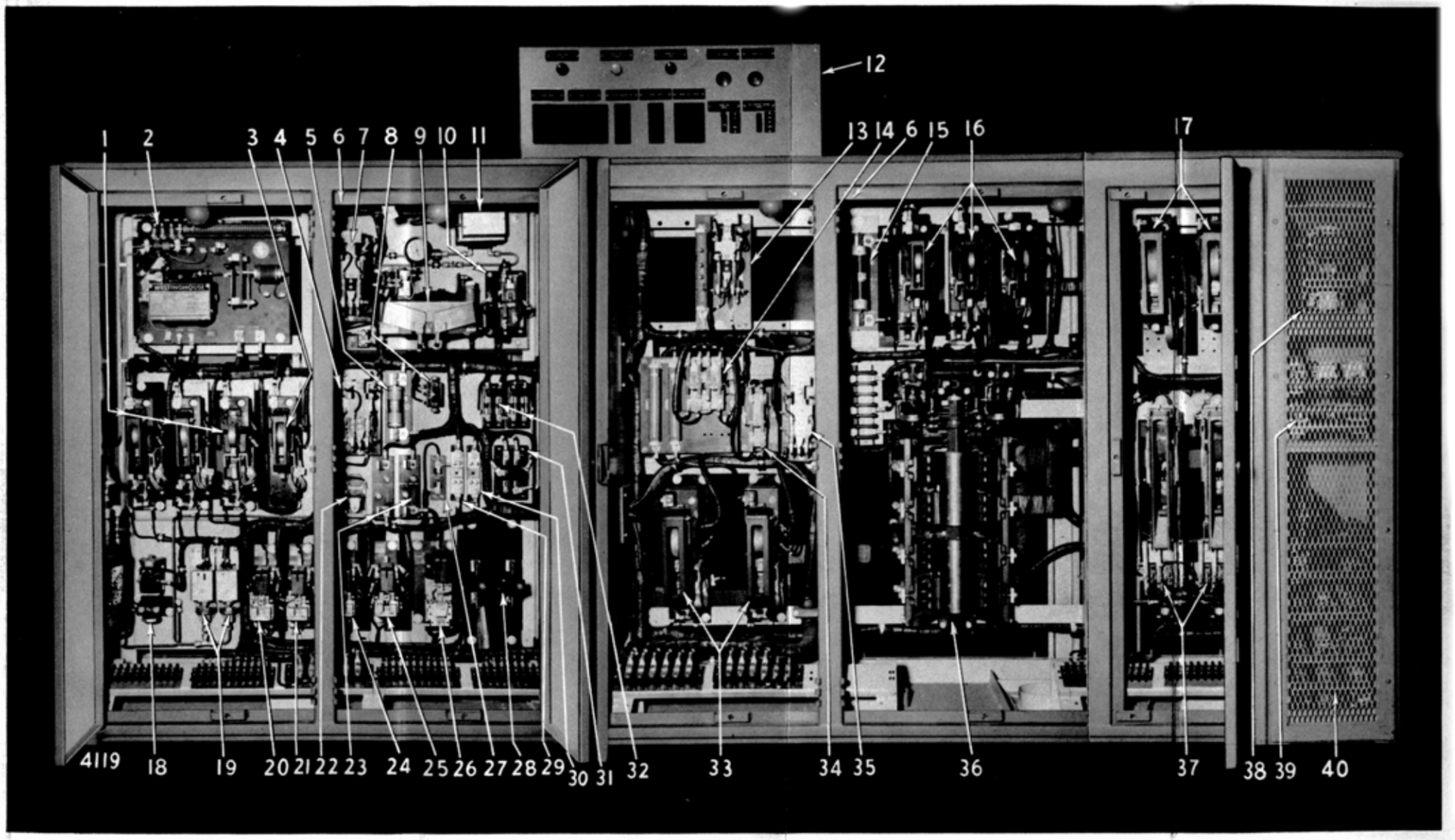
1. Fuse Tester (not visible)
2. Starting Field Contactors (GF10, GF11, GF12)
3. Voltage Regulator (VR1)
4. Reverse Current Contactor (A1)
5. Thermoswitch, Fire Alarm (behind frame)
6. Starting Protective Relay (PT1)
7. Auxiliary Generator Fuse
8. Reverse Current Relay (RC1)
9. Fuel Pump Switch
10. Standby Lighting Transfer Switch
11. Grad-u-stat
12. Engine Alarm Relay (SG1)
13. Ground Relay (GR1)
14. Traction Motor Field Shunt Relay (FS)
15. Fan Motor Field Shunt Relay (R1)
16. Engine Control Panel
17. Fan Motor Fuse
18. Fan Motor Contactors (F1, F3, F5)
19. Traction Motor Field Shunt Contactors (M1, M2)
20. Shutter Control Valve (SV1)
21. Temperature Control Switches (TS1, TS3)
22. Power Control Contactor (FR1)
23. Exciter Field Contactor (EF1)
24. Boiler Transfer Switch
25. Boiler Alarm Relay (BOR)
26. Main Control Fuse (70 Amp.)
27. Fan Control Fuse
28. Shunt (Auxiliary Generator)
29. Battery Ammeter Shunt
30. Battery Switch
31. Engine Room Light Switch
32. Traction Motor Cutout Switches (TMCO1, TMCO2)
33. Starting Armature Contactors (G1, G3)
34. Wheel Slip Relay (WS1)
35. Fan Motor Starting Relay (CF1)
36. Reversor
37. Power Switches (P1, P2)
38. Resistors, (Traction Motor Field Shunt)
39. Resistors, (Fan Circuits)
40. Resistors, (Auxiliary Generator)



NO. 1 ELECTRICAL EQUIPMENT CABINET
Figure 4

1. Starting Field Contactors, (GF20, GF21, GF2
2. Voltage Regulator (VR2)
3. Reverse Current Contactor (A2) 2)
4. Control Relay (COR)
5. Auxiliary Generator Fuse
6. Thermoswitch, Fire Alarm (behind frame)
7. Starting Protective Relay (PT2)
8. Fuel Pump Switch
9. Reverse Current Relay (RC2)
10. Engine Alarm Relay (SG2)
11. Grad-u-stat
12. Engine Control Panel
13. Fan Motor Field Shunt Relay (R2)
14. Ground Relay (GR2)
15. Fan Motor Fuse
16. Fan Motor Contactors (F2, F4, F6)
17. Traction Motor Field Shunt Contactors (M3,
18. Shutter Valve (SV2)
19. Temperature Control Switches (TS2, TS4) M4)
20. Power Control Contactor (FR2)
21. Exciter Field Contactor (EF2)
22. Fire Alarm Relay (FAR)
23. M-G Set Fuse Base
24. Control Contactor (CR)
25. Energizing Shutdown Contactor (ESX)
26. Emergency Shutdown Contactor (ES)
27. Fan Control Fuse Base
28. Battery Switch
29. Shunt (Auxiliary Generator)
30. Battery Ammeter Shunt
31. M-G Set Transfer Switch
32. Traction Motor Cutout Switches (TMCO3, TMCO
33. Starting Armature Contactors (G2, G4)
34. Wheel Slip Relay (WS2) 4)
35. Fan Motor Starting Relay (CF2)
36. Reverser
37. Power Switches (P3, P4)
38. Resistors (Traction Motor Field Shunt)
39. Resistors (Fan Circuits)
40. Resistors (Auxiliary Generator)



NO. 2 ELECTRICAL EQUIPMENT CABINET
Figure 5

MAIN POWER CIRCUITS

The Power Circuits as shown in Fig. 6 show the connections between the main generator and the traction motors for power unit No. 1. (The circuits are duplicated for power unit No. 2 except that one Field Shunt Relay serves both units). This is similar to the heavy duty portion of the Schematic Diagram in Fig. 2, except that the connections of the traction motor fields, field shunts, reversers, pneumatic power switch, field shunt relays, fan motors, wheel slip relays and load ammeter are also shown. The generator is connected to the two traction motors permanently connected in parallel with each other. The current, after passing thru the traction motor armatures, the reverser and fields, goes through the main generator commutating field windings and the exciter differential field windings back to the negative side of the main generator armature.

PNEUMATIC POWER SWITCHES

Traction motor power switches, P1 and P2 (shown in Fig. 6), are electro-pneumatically operated by coils P1 and P2 (shown on Fig. 7) and connect the traction motors to the generators. When they are closed, current flows through the power circuit. Manually operated knife switches (TMCO) are connected in series with the coils P1 and P2 which, if opened, prevent the electro-pneumatic power switches from closing. These switches are located in the equipment cabinet.

REVERSERS

The reversers control the direction of rotation of the traction motors by reversing the direction of current through the field windings, thereby reversing the direction of locomotive travel. The dotted lines in Fig. 6 show the alternate field connections made by heavy duty contacts bearing on the reverser drum. A pneumatically operated cylinder rotates the drum to change connections. The cylinder is controlled by magnet valves which are connected to a small reverser drum in the master controller (see Fig. 7).

TRACTION MOTOR FIELD SHUNTS

The traction motor fields are shunted to provide a bypass for a portion of the field current after the

locomotive speed has reached a point where full Diesel engine power output under normal field strength is not absorbed. The field is automatically weakened by field shunt relay FS, thus increasing speed and making use of practically full output of the motive power unit. This relay, connected across the generator, is set to close at 600 volts. Both power units are controlled by one field shunt relay which when closed energizes all field shunting contactors M1, M2, M3, M4. Their action is further described in the text for Main Control Circuits and illustrated in Fig. 7. The field shunt resistors are located in the electrical equipment cabinet.

WHEEL SLIP RELAYS

The wheel slip relays and resistors are connected across each set of traction motors. They operate relays which automatically reduce power when the wheels slip. This is described and illustrated under Auxiliary Control Circuits.

Also, if one pair of wheels is locked due to mechanical or electrical failure, the wheel slip buzzer will sound continuously as soon as sufficient speed has been attained to establish a voltage differential from the normally operating traction motors.

RADIATOR FAN MOTORS

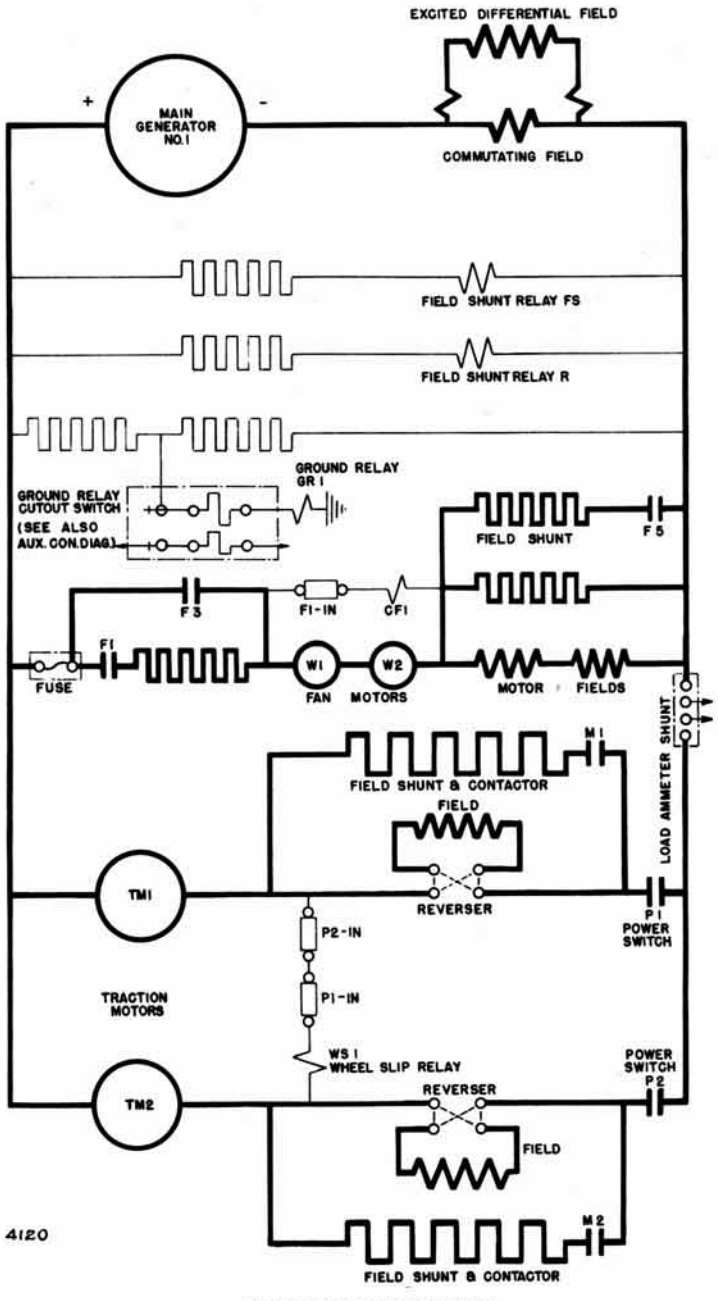
Two fan motors for each unit are connected in series across the main generator, and operate when the unit operates. They are series wound motors located near the roof of the radiator compartment. A 175 ampere fuse in the equipment cabinet protects this circuit.

FAN MOTOR FIELD SHUNTS

A shunt is provided around the fields of the fan motors to maintain high fan speed at low generator voltages if the water temperature is high enough to close the water temperature control switches which control the field shunting circuit. (See Fan Control Circuit in Fig. 8).

FAN MOTOR FIELD SHUNT RELAYS

Relay R1 on unit 1, and R2 on unit 2, are set to



MAIN POWER CIRCUITS
Figure 6

pick up at 490 volts thus opening the field shunting circuit on the fan motors. These relays function through the Fan Control Circuits shown in Fig. 8, to protect the fan motors against excessive speed if the main generator voltage is high.

FAN MOTOR CONTACTORS, SPEED CONTROL

Contactors F are controlled by pneumatically operated temperature control switches TS (Fig. 8), to increase or decrease radiator fan speed and maintain correct water temperature. Fans operate at two speeds. The circuit for each speed is as follows:

Low Speed - The fan motors are started through contactor F1 and a starting resistance. As soon as the voltage-drop across the fan motors is sufficient to make relay CF1 pick up, (about 80 volts), F3 closes and shunts out the starting resistance.

High Speed - Contactor F5 closes, F3 remaining closed, which shunts the fan motor fields, providing R1 is closed. (See also Fan and Shutter Switch and Temperature Control Switch in Auxiliary Control Circuit).

GROUND RELAY

If any portion of the high voltage circuit becomes grounded, current flows through the ground relay GR which sounds all alarm bells and lights a light on the engine control panel of the faulty unit. Details of the alarm circuit are shown and discussed later under Auxiliary Control Circuits.

LOAD AMMETER

The ammeter is located on the engineer's instrument panel in the cab and is connected in the circuit to show total generator current, which is the sum of the currents in the two parallel traction motor circuits. (See Locomotive Operating Section for load limits). The shunt for this ammeter is located in the equipment cabinet. The ammeter is connected to the No. 1 power unit only.

MAIN CONTROL CIRCUIT

The main control circuit consists of the master controller with a speed drum and a reverser drum and various contactors, relays and magnetic coils for the control of power to the traction motors. The control circuit is a low voltage circuit energized by the auxiliary generator at 75 volts. The starting circuit is independent of the circuit shown in Fig. 7 and is discussed under Battery Circuits. A control chart opposite Fig. 7 shows the position of the principal automatic relays and valves in the power and starting circuits for each of the principal operating positions.

CONTROL SWITCH AND MASTER CONTROLLER VALVE

The control switch on the panel at the engineer's position must be closed to establish power control by the master controller at that location. Contactor CR and valve MCV are thus energized, which connects the controller to the control circuit. A bus wire B+ is also energized. When several units are operated in multiple, wire B+ energizes relay COR in the control circuits for all other units, thus opening contacts COR in those control circuits. This provides interlocking protection against operation from any other controller. The CR-out interlock eliminates coil COR from the control circuit in the controlling locomotive unit, and contacts COR in this circuit remain closed. Therefore, this is the only Master Controller which will function, since no other control contactor (CR) or valve (MCV) can be energized.

MASTER CONTROLLER

The Master Controller regulates the speed and determines the direction of travel through a throttle lever and reverser lever respectively.

Throttle Lever - The throttle lever controls the application of power to the traction motors by regulating (pneumatically) the fuel supply and hence the output of the Diesel engines.

It has five notches throughout its angular travel. The first notch is "off" position in which the motors are disconnected. The second notch connects the motors across the generator with the latter delivering very low voltage for soft starting. Added movement of the

throttle lever gradually builds up the generator voltage to its full value. At the high speed end of the throttle travel, three notches are provided for running positions.

The throttle lever actuates, by means of a cam, a pressure regulating unit which is located in the lower left hand portion of the controller. Movement of the throttle lever increases or decreases the air pressure in the throttle pipe line in direct response to the magnitude of this movement. This varying air pressure operates an actuator which regulates the speed control shaft of the engine governor.

Reverse Lever - The reverse lever controls the direction of motion of the locomotive by reversing the traction motor fields. It rotates the reverser drum in the master controller (Fig.7) which closes contacts to energize reverser valves FOR and REV, according to the setting of the lever. The action of these valves is described in the next main paragraph. The lever can be placed in three positions as follows:
1. Off 2. Forward 3. Reverse

In the "off" position the engines can be speeded up by means of the throttle lever to maximum speed without moving the locomotive. This permits rapid pumping of air by the air compressor if necessary.

In the "Reverse" or "Forward" position, a movement of the throttle handle results in a corresponding locomotive movement.

The reverse lever is mechanically interlocked with the throttle lever. This prevents moving the reverse lever if the throttle lever is not in the "off" position.

REVERSER MAGNET VALVES

The reverser magnet valves, which are connected to the Master Controller as outlined above, are built into the Reverser to control its operating cylinder. When the reverse lever is in Forward position, valve FOR is energized, and when in Reverse position, valve REV is energized. The reverser is thereby moved so that the traction motor fields are connected for rotation corresponding to the setting of the reverse lever. The Reverser was described in the text for Fig. 6.

TRACTION MOTOR FIELD SHUNT RELAYS AND CONTACTORS

As the locomotive speed increases, a step of automatic field shunting occurs. Relay FS (Fig. 7) closes contactors M1 and M2 on the No. 1 power unit and M3 and M4 on the No. 2 power unit, which decreases the traction motor fields when armature current drops to a preset value. This occurs at a speed of approximately 54 miles per hour. A sudden increase in current is shown on the ammeter as the locomotive accelerates past this speed.

GENERATOR AND EXCITER FIELD CONTACTORS

Electro-magnetic contactors, GF11 and EF1, in the exciter circuit, must be closed to complete field circuits for the main generator and exciter (see Fig. 9). These contactors close when current flows through the corresponding coils in Fig. 7. When the engine is idling, or the generator isolated, the circuit through FR1-Out, P1-Out, P2-Out, provides current for the field relays GF11 and EF1 in order to maintain power supply to the fan motors. When the reverser is thrown to a Forward or Reverse position, the respective interlocks on the reverser close (FOR-1 or REV-1). Contactor FR1 is then energized (closed), which closes the Power Switches P1 and P2, and the field relays GF11 and EF1 are energized through interlocks P1-in and P2-in instead of P1-out, and P2-out, which are now open.

Start Button #1 is a double contact push button with one contact normally closed as shown in Fig. 7, and one contact normally open as shown in Fig. 8 and 9. The normally closed contact opens during starting to de-energize GF and EF, thus disconnecting the exciter and its field.

TRACTION MOTOR CUTOUT SWITCHES

Coils P1 and P2 (Fig. 7) operate electro-pneumatic power switches P1 and P2 (Fig. 6) which was discussed in the Main Power Circuits. Double-pole Traction Motor Cutout Switches (TMCO) are connected in series with these coils, and may be manually opened to de-energize coils P1 and P2 which opens the corresponding power circuit. The second pole of the TMCO switch is in the exciter field circuit (Fig. 9). When opened it adds resistance to this circuit to reduce the field, and hence the generator output, when full power is not

needed due to the corresponding traction motor being disconnected. Therefore, it is not necessary to operate at reduced throttle when motors are cut out. These switches should not be operated while power is applied.

POWER CUTOUT SWITCH

Each power unit has a power cutout switch on the engine control panel which when opened, completely disconnects the fields and power circuits of the unit. The fans will also stop.

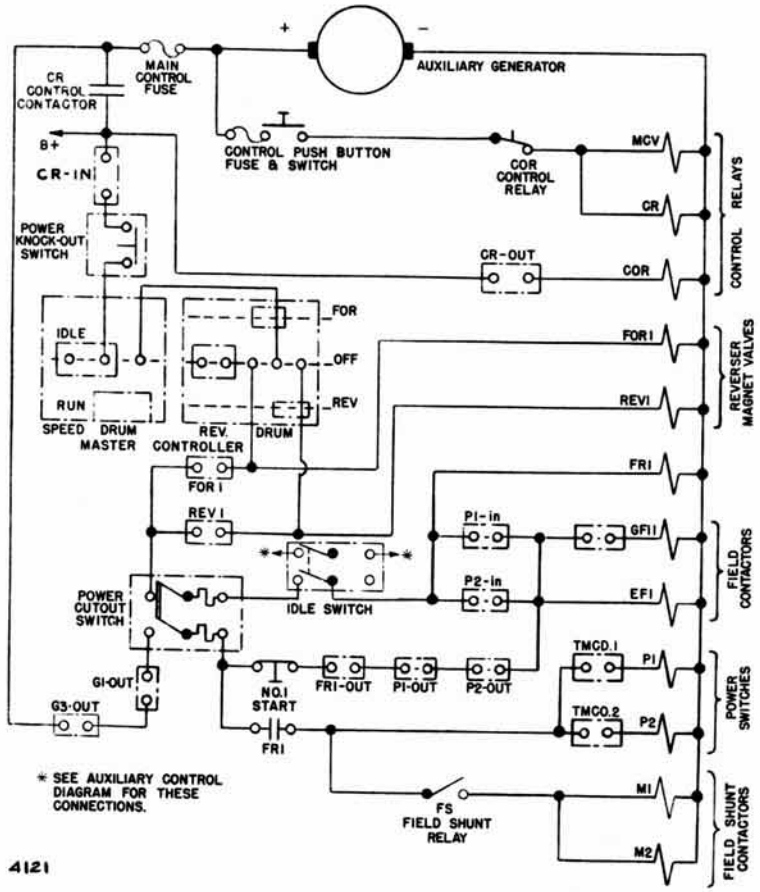
POWER KNOCKOUT SWITCH

This is a pneumatically operated switch which opens the control circuit between the auxiliary generator and the master controller. It opens when an emergency brake application is made, or when the Deadman Control is released. It shuts off power from the generator and brings the engine down to idling speed. This action is the same as if the throttle on the master controller were shifted to "off" position. The switch is located in the nose at the front of "A" unit. (There

CONTROL CHART
Position of Apparatus in Figures 7 and 9

Operation	Manual Controls: Cab: Reverse Lever	Throttle Lever	Control Button	Engine Panel: Power Cutout Switch	Engine Stop Switch	Aux. Generator Switch	Idling Switch (O-On)	Start Button No. 1	Start Button No. 2	Automatic Equipment: CR, MCV, SDV	G1, G3, GF12	GF10	EF1, GF11	FR1, P1, P2	FS, M1, M2, (M3, M4)	TV
LOCOMOTIVE SHUTDOWN		I														
ENGINE START, STEP 1		I	0	0	0		0	0		0	0	0				
ENGINE START, STEP 2		I	0	0	0		0	0	0	0	0					
ENGINE IDLE (normal operation)		I	0	0	0	0	0			0			0			
ENGINE RUN		R	0	0	0	0	0			0			0			
LOCOMOTIVE RUN	X	R	0	0	0	0	0			0			0	0		
LOCOMOTIVE RUN, FIELD SHUNTED	X	R	0	0	0	0	0			0			0	0	0	
ENGINE IDLE (isolated)	X	IR	0	0	0	0				0			0			0

0 - Closed or engaged position. Equipment is open or disengaged when not shown closed.
X - Forward or Reverse I - Idle R - Run



MAIN CONTROL CIRCUITS
Figure 7

is none on "B" units). It closes automatically when the brake lever or deadman pedal are returned to normal operating condition.

DEADMAN CONTROL

The deadman control pedal is a pneumatic device which performs three functions if released while the locomotive is running:

1. Pneumatically opens the power knockout switch in the electric control circuit. The engine idles.
2. Reduces pressure to the emergency cutoff valve in the controller which reduces the fuel supply just as though the throttle were set back.
3. Applies the brakes.

The only electrical action is that associated with the power knock-out switch. The Control System Diagram in Fig. 1 shows the basic line of action for functions 1 and 2 above. See Section 6, for the air piping.

IDLING SWITCH

Manually operated two-pole idling switch on the engine control panel for each power unit disconnects the load and idles the engine when thrown to the "idle" position. In this position, contactor FR is de-energized, which opens the traction motor circuits, and throttle unloading valve TV is energized (Fig. 8) which reduces the engine speed to idling by its pneumatic action on the governor and fuel supply. The generator fields remain excited to provide power for the fans, since the series of out-interlocks, fed by the other pole of the power cutout switch, in Fig. 7, close.

AUXILIARY CONTROL CIRCUITS

The controls for the Fuel Supply Pump, Radiator Shutters and Fans, Sanders, Engine Shutdown, and miscellaneous equipment such as the Alarm are shown in Figure 8.

FAN AND SHUTTER SWITCH

The fan and shutter switch is a small double-pole double-throw manually operated switch located on the engine control panel and connected as shown in Fig. 8. The switch has three positions, as follows:

Off - Fans will not operate. Shutters are closed.

Manual - Fans operate at low speed. Shutters may be adjusted by hand. This provides emergency manual control if automatic control fails.

Automatic - Fan speed automatically regulated thru temperature control switches.

TEMPERATURE CONTROL SWITCHES

A variable air pressure valve called a Grad-u-stat, sensitive to radiator water temperatures, operates the pneumatic temperature switches (TS), which control the speed of the fan motors by varying their fields. These switches operate successively at predetermined pressures (Temperatures) to energize relays F1, F3 and F5, in unit 1 (F2, F4 and F6 in unit 2), and change the field circuits in the manner previously described under Fan Motor Contactors. They are located in the electrical equipment cabinet..

SHUTTER VALVE

An electro-pneumatic shutter valve SV1 (SV2 in unit 2) is connected to the auxiliary generator voltage. When the fans are running, the shutter valve is energized and acts pneumatically on the operating cylinder to open the shutters. The valve for each unit is located near the temperature switches described in the preceeding paragraph.

See Section 3 for further details on Engine Cooling System.

FUEL SUPPLY PUMP

A motor driven fuel supply pump for each power unit operates at constant speed to supply fuel oil to the engine fuel injection pumps. They receive power through a manually operated single-pole, double-throw transfer switch located in each electrical equipment cabinet. These switches are normally kept closed, connecting the No. 1 pump motor to the No. 1 control circuit, and the No. 2 pump motor to the No. 2 control circuit. The transfer switch, plus a similar transfer feature in the fuel line, provide complete flexibility of these pumps between the two units if required, but they should be restored to their normal connection as soon as the emergency is over. These motors are fed through the normally closed emergency engine shutdown contactor ES.

EMERGENCY SHUTDOWN CONTACTOR

Closing the manually operated emergency engine shutdown pushbutton, on the engineer's control panel, energizes (opens) emergency shutdown contactor ES, opening the circuit to the fuel supply pump motors on all units. The circuit from the center pole of the engine stop switch is also broken at the same time by the ESX-out interlock. The shutdown valve in this circuit is de-energized. The fuel supply is therefore cut off at both the shutdown valve and at the supply pumps.

ENGINE SHUTDOWN VALVE

Solenoid operated shutdown valves SDV1 (SDV2 on unit 2) must be energized to maintain fuel supply. A circuit through the starting button energizes this valve when starting the engine. As soon as oil pressure builds up, the lube oil pressure switch closes and keeps the valve energized. When the engine is operating, it shuts down if SDV1 is de-energized by opening the Engine Stop Switch, the Water Temperature Switch, the Lube Oil Pressure Switch, or the ES Contactor. It is mounted on a panel at the pump end of the Diesel engine. Other details of the valve are illustrated in the shutdown diagram in Section 3.

LUBE OIL PRESSURE SWITCH

The Lube Oil Pressure Switch automatically opens

when lubricating oil pressure drops below a predetermined value. It acts on the Shutdown Valve as just described and is mounted on the same panel.

WATER TEMPERATURE SWITCH

The water temperature switch automatically opens when water temperature is too high. It lights the hot engine warning light on the engine control panel and acts on the Shutdown Valve as just described. It is mounted on the panel near the Shutdown Valve.

ENGINE STOP SWITCH

The engine Stop Switch is connected in series with the Fuel Supply Pump motors and the Shutdown Valve. It is a triple-pole toggle switch on the engine control panel, and stops the engine by cutting off the fuel supply in the manner just described. The switch also feeds the starting contactors and must be closed in order to start the engine.

GROUND RELAY

The coil of the Ground Relay is shown in the high voltage Main Power Circuit discussed earlier. It may be energized by some transient condition in which case it may be reset by pushing the Ground Relay Reset Button on the engine control panel and normal operation resumed. A single ground is from either the positive or negative line to the grounded frame, and the electrical circuits are not seriously affected until a double grounded condition produces a short circuit. If there is no short circuit, a ground relay cut-out switch on engine control panel may be manually opened to de-energize the relay and permit the limited use of the power unit until a railroad terminal is reached. The power unit should be isolated if there are major faults which cannot be rectified. Grounds may be caused by excessive dirt, oil, water, or faulty and sluggish interlocking.

ALARM

An alarm system, consisting of bells and indicating lights, gives warning when an engine shutdown or a ground develops. The ground indication is received through the Ground Relay as just described. Engine shutdown indication is received through alarm relay

SG1 which is in parallel with shutdown valve SDV1 and gives an indication when fuel is cut off due to hot engine, low lube oil pressure, or open ES contactor. Only a hot engine gives a light indication if the engine shuts down. Both the hot engine light and ground light are on the engine control panel.

An Attendant Call pushbutton and Boiler Out Relay BOR are also connected to the bells. See BOR in Sect 8.

To trace trouble check fan motor fuses, or fan and shutter control fuse if engine is hot, or attempt to operate fans in the manual position of the Fan and Shutter Switch, check lube oil supply if lube oil pressure switch has tripped, or investigate the emergency fuel shut-off valve, the engine overspeed stop or other operating difficulties listed in Section 2.

WHEEL SLIP RELAY

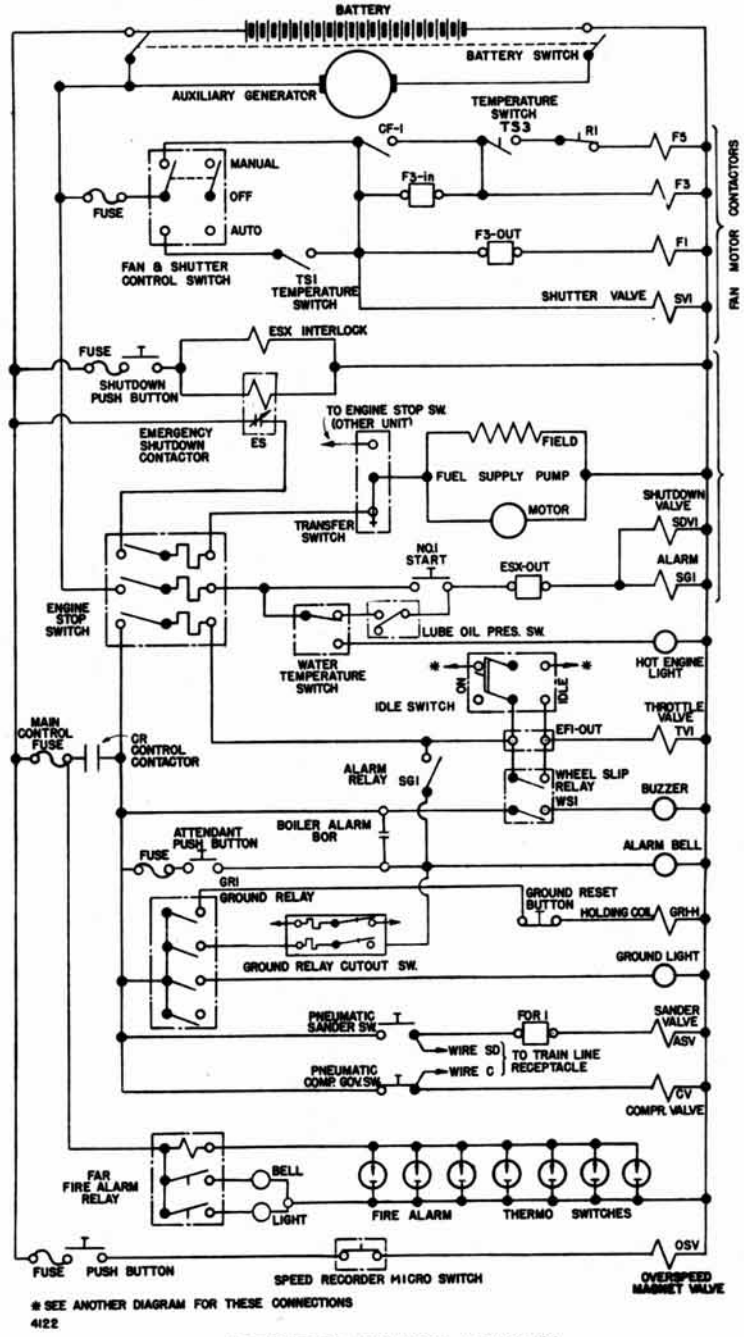
The wheel slip relay automatically limits the speed at which the driving wheels will spin when wheel-to-rail adhesion is exceeded. It is connected between the two parallel traction motor circuits (Fig. 6), and normally carries little or no current. If a pair of driving wheels starts slipping, the resulting difference in voltage in the two motor circuits causes the wheel slip relay to pick up. The contacts in Fig. 8 close, which sounds the wheel slip buzzer and actuates the throttle unloading valve.

THROTTLE VALVE

The throttle unloading valve TV1 reduces the pneumatic pressure on the governor, resulting in a decreased fuel supply. If actuated by the wheel slip relay, pressure (and fuel) automatically returns to the original value when the wheels stop slipping. Therefore, if the wheels start slipping repeatedly the engineer should reduce the throttle setting. The throttle valve is mounted on the generator end of the engine frame.

SANDER

Sander valve ASV is energized through an interlock which permits sanding on the leading wheels only. The interlock is fed through a pneumatically operated sander switch in the nose of "A" units which is closed by



AUXILIARY CONTROL CIRCUIT
Figure 8

a hand valve in the engineer's cab. (See Diagram, Section 6, for pneumatic details). It also closes automatically during an emergency brake application. There is no sander switch on "B" units, but interlocked valves FSV and RSV (forward and reverse) are fed through a trainline wire from the "A" units.

COMPRESSOR GOVERNOR SWITCH

A pneumatically operated compressor governor switch closes at low pressure on the main air reservoir and opens when the pressure builds up sufficiently. When closed, valve CV is energized, which permits the compressor intake valve to seat so the compressor pumps air. It is connected to wires B+ and C in the trainline circuit for multiple unit operation. The valve and switch are on the left hand rack in the nose of "A" units and on the wall near the hostler's controls on "B" units.

FIRE ALARM

A fire alarm bell and a fire alarm light in the cab give warning whenever various thermo-switches located through the locomotives are closed by excess heat thus energizing the fire-alarm relay. These thermo-switches are located as follows:

(a) Two in each electrical equipment cabinet
(b) One over each Diesel engine (generator end)
(c) One over the steam generator

SPEED CONTROL

The Speed Recorder Micro-Switch in the Speed Recorder located in the engineer's cab opens if the train speed becomes excessive. This de-energizes the Overspeed Magnet Valve which sounds the overspeed whistle and changes the pressure in the Overspeed Reservoir (see Piping Diagram, Section 6). If the engineer does not reduce the speed within a short time-delay interval provided by the reservoir, the brakes are automatically applied.

SPEED GOVERNOR CONTROL

The speed governor switch supplies battery power to the speed governor circuits which control braking pressures in conformity with speed. It is located in the cab in front of the engineer's position. The circuits are independent from the circuits described here.

BATTERY CIRCUITS

BATTERY

Each locomotive unit is equipped with a 32-cell 75 volt storage battery. It is mounted underneath the frame, between the Fuel Tank and Water Tank, See diagram showing arrangement of equipment, Section 1.

BATTERY CUTOUT SWITCH

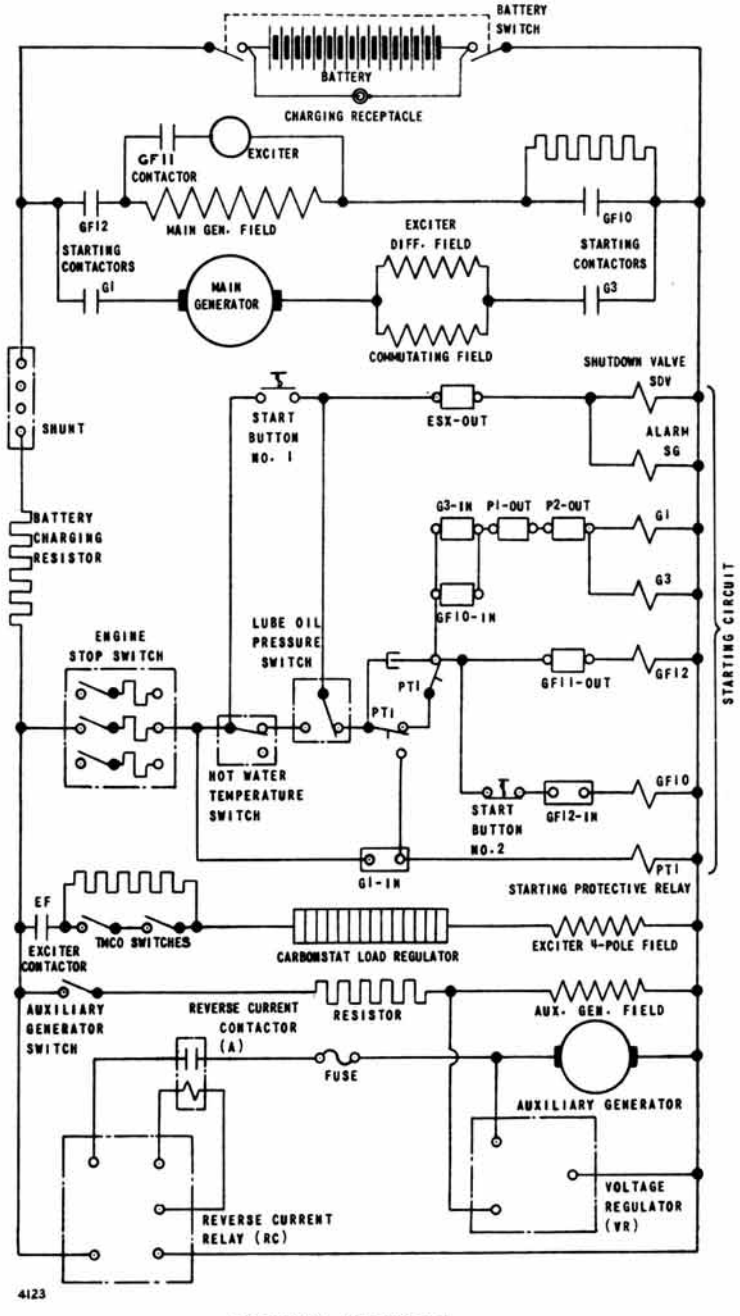
A manually operated, double-pole, single throw knife switch in each equipment cabinet disconnects the battery from the respective auxiliary generator. When open, the starting circuit, fan and shutter control and steam boiler are inoperative.

BATTERY AMMETER

An ammeter, located on the end of the engine control panel, provides an indication of battery charge and discharge current. It should be observed at least once every three hours. With the engine running, it should indicate either zero or varying charge readings, depending upon the charged condition of the battery. Continuous discharge of 10 to 15 amperes will not open the reverse current contactor but will drain the battery, and probably requires an adjustment of the voltage regulator. Excessive continuous charge (about 50 amperes) likewise calls for regulator adjustment. Such readings when observed should be reported at the end of the run. A transfer switch below the ammeter connects the ammeter to either the No. 1 or No. 2 auxiliary generator circuit. The ammeter shunts are lobated in the equipment cabinet.

STARTING CONTACTORS

Start Button #1 is mounted on the engine control panel, and controls the Electro-Magnetic Starting Contactors. When the button is held in, the starting contactors GF10 and GF12 in the generator field circuit and the starting contactors G1 and G3 in the generator armature circuit are closed. The current from the battery then flows to the main generator which now acts as a motor and cranks the Diesel engine. When the engine turns over, Start Button No. 2 should be pressed, opening contactor GF10 which weakens the generator field and increases the speed of the generator to the



BATTERY CIRCUITS
Figure 9

engine firing speed. The starting contactors are located in the Electrical Equipment Cabinet.

Armature contactors G1 and G3 are interlocked to prevent them from closing until the field contactors GF10 and GF12 are closed. If this were not done, the aramture would short circuit the battery. A starting protective relay (PT) picks up as soon as normal battery voltage is exceeded. This de-energizes (opens) G1 and G3 which disconnects the main generator as soon as the engine fires and prevents it from feeding the battery. When lube oil pressure has built up to 20 pounds, the Lube Oil Pressure Switch automatically changes to its normal operating position which keeps SDV (in the fuel supply line) energized regardless of the position of the Start Button. The Start Buttons may then be released. (Note: Start Button #1 has a second set of normally closed contacts which are opened during starting to disconnect the exciter and its field, page 421).

AUXILIARY GENERATOR SWITCH

The auxiliary generator switch must be closed to excite the field and enable the auxiliary generator to supply its normal load. It is open during starting, to reduce the load on the battery. It is a manually operated toggle switch located on the engine control panel.

CARBONSTAT LOAD REGULATOR

The exciter 4-pole field is energized by the auxiliary generator through Contactor EF1 which automatically closes immediately after starting. A Carbonstat (LR) is connected in series in this circuit. This is a hydraulically operated resistance changing device mounted on the engine chain drive casing consisting of a carbon pile resistor held under pressure by a spring. The spring is sensitive to changes in the governor and also, by pneumatic connection, to changes in the throttle mechanism. As the pressure changes, the resistance is varied which changes the current through the exciter field. This prevents overloading or underloading of the electrical equipment and also provides smooth acceleration when starting.

BATTERY CHARGING

The battery is automatically charged by the aux-

iliary generator which is controlled by a vibrating type voltage regulator so that the voltage is substantially constant at the various operating speeds of the Diesel engine. The reverse current relay automatically connects the battery and the auxiliary generator after the engine starts. This equipment is described in the following paragraphs. The battery may also be charged from terminal or shop circuits through the outside battery charging receptacle at the battery box.

VOLTAGE REGULATOR

The voltage regulator holds the auxiliary generator voltage constant over the normal operating speed range of the Diesel engine. A voltage relay element varies the auxiliary generator shunt field current to hold constant voltage regardless of engine speed and auxiliary load. A current limiting element prevents prolonged overload on the auxiliary generator. Under such conditions, the regulated voltage is reduced by the deflection of a bi-metallic heater element which compresses a carbon pile resistor connected to the voltage element. The intermittent operation or vibration of the moving contacts causes a light sparking which is audible at close proximity. The rheostat in the regulator is adjusted to give proper generator voltage and should not be changed by unauthorized personnel.

REVERSE CURRENT RELAY AND CONTACTOR

The reverse current relay has two automatic functions. It connects the auxiliary generator to the battery through contactor A when the generator voltage is sufficiently high to charge the battery, and protects against a reverse flow of current from the battery, when the generator voltage is too low, by opening the circuit.

Connections are made by means of voltage coils which close contacts in the circuit to contactor A when the generator voltage is about 1 volt above battery voltage. After the contactor closes, this voltage no longer affects the relay. It is therefore necessary to open the circuit by means of another coil which measures the current in the circuit between the auxiliary generator and battery. This coil opens contactor A when the reverse current reaches a magnitude of about 20 to 25 amperes. Both the relay and contactor are located in the electrical equipment cabinet.

LIGHTING AND MISCELLANEOUS

The following lights and heaters in "A" units are connected to the auxiliary generator and battery. Cab Heater Fans function directly from the Auxiliary Generator through fan switches with speed control rheostats. Engine room, nose and cab lights are connected directly to the battery when the stand-by lighting switch connects with locomotive circuits. The remaining equipment listed below is fed from the battery through a control disconnecting switch.

Headlight

Gauge Light

Marker Lights

Back-up Light

Number Lights

Equipment Cabinet Lights

Nose Light

Cab Lights

Engine Room Lights (and Trouble Light Receptacles)

Cab Signal and Train Communication

Defroster Fans

Cab Heater Fans

The "B" unit is equipped with Headlights, Engine Room Lights, Cabinet Lights, and Marker Lights only. See Table of Fuses for all fuse data, and Breaker Type Switches for possible sources of open circuit. Figure 10 shows the connections for "A" units.

All switches controlling the foregoing circuits are located in the cab except as follows:-

Battery Switch - in equipment cabinet.

Cabinet Lights - on engine control panel.

Main Light Switch - in #1 equipment cabinet.

Standby Lighting Transfer Switch - in #1 equipment cabinet.

M-G Transfer Switch - in #2 equipment cabinet.

Steam Generator Transfer Switch - in #2 equipment cabinet.

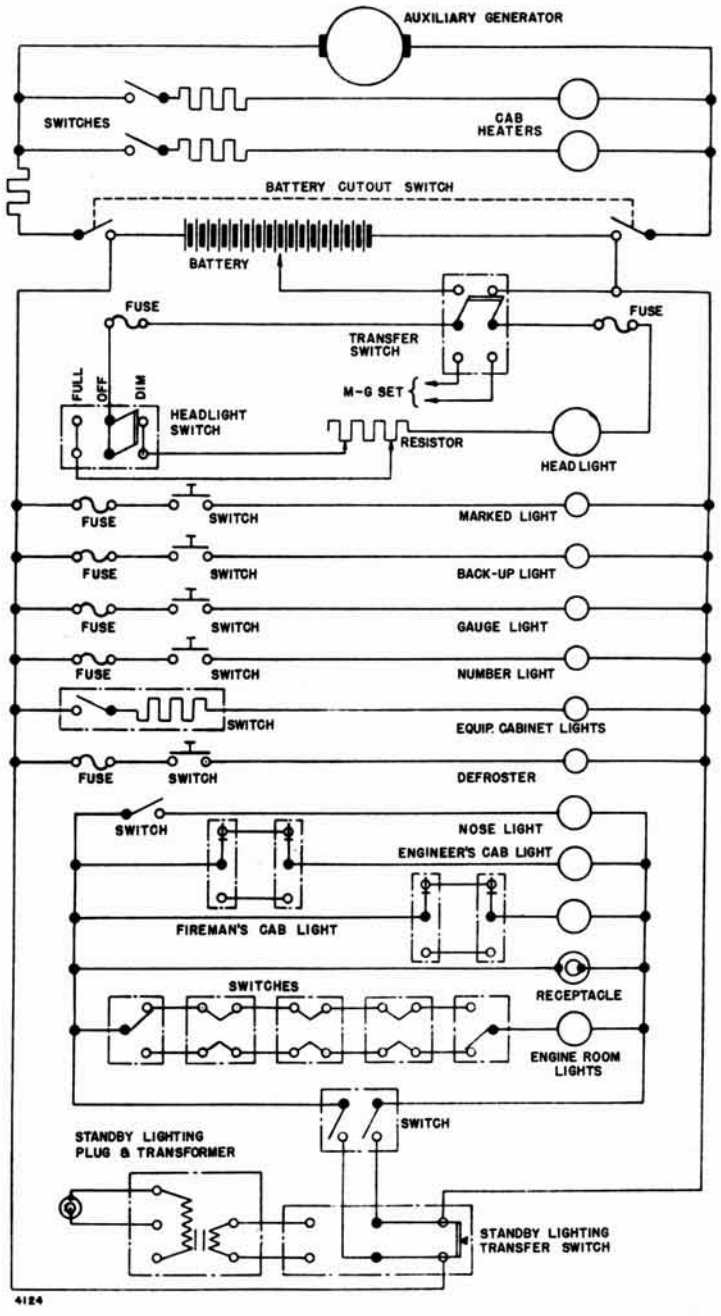
A motor-generator set on "A" units only also operates directly from the battery (regardless of the position of battery cutout switch) to supply 32-volt power for train communication (see Section 9), Cab Signals, and Headlights. If this set doesn't function a transfer switch connects this equipment to the midpoint of the battery as an alternate source of power. The M-G set gives a more satisfactory voltage output than the battery and should be used when possible.

Headlight is connected to a 32-volt supply, controlled by a three position switch in the cab. A resistor in series with the "dim" position of the switch dims the headlight. (Note: If there is a Mars Headlight, it is fed from the auxiliary generator at 75-volts. A small M-G set in the lower left air brake rack in the nose, provides 12 volt power for the circuit. This has no connection with the foregoing M-G set. The operating lever is in the cab below the engineer's arm rest).

Standby-Lighting is provided to the engine room, nose, and cab lights through a transfer switch and transformer which may be connected to outside 115 volt 60 cycle a-c power at the right rear corner.

Electro-pneumatic brakes are connected with full battery voltage through manually operated 2-pole breaker switches in the cab. The control push button switch must also be closed.

Steam generator for heating the train is powered by 75-volt auxiliary generator current. It is remotely controlled from the cab. A boiler transfer switch in the #2 equipment cabinet affords connection to either power unit. It should always be connected to an operating unit. If it is connected to a shut down unit, it will continue to receive power, but at reduced voltage. Therefore, check position of transfer switch when a unit is shut down. The electrical circuit and detailed operating instructions are given in Section 8.



LIGHTING CIRCUITS
Figure 10

TROUBLE SHOOTING

BREAKER TYPE SWITCHES

Some manually operated switches open automatically when overloaded, and should be checked if the circuits involved are not functioning. They must be moved to full "off" position before being reclosed. The following breaker-type switches are located in their respective circuits.

Engine Stop Switches
Power Cutout Switches
Auxiliary Generator Field Switches
Equipment Cabinet Lights Switches
Engine Room Lights Main Switch
M-G Set Switch
Ground Relay Cutout Switches
Heater Fan Switches
Electro-Pneumatic Brake Switches

FUSES

Fuse failures in the Steam Generator Control Circuits, and in all Control Pushbutton Circuits except the top one, are apparent and easily traced. See Fuse Data on page 407.

For any other fuse failure while Diesel engine is running, OPEN THE POWER CUTOUT SWITCH BEFORE ENTERING EQUIPMENT CABINET, to eliminate high voltages. Some of the 75 volt circuits will still be energized but they are not a hazard. The effect of other fuse failure follows.

Main Control Fuse - If this fuse fails, all control circuits on the locomotive unit (two power units) will be out of order except the Master Controller Cutout Valve MCV. Electric power is lost because the power switches and generator field contactors open but fuel supply will not be interrupted, and the Diesel engine will not stop unless the sudden loss in load causes the overspeed trip to function. If the fuse burns out in the controlling "A" unit, all units in multiple will stop because all control circuits are lost, and the alarm will not ring. If the fuse burns out in a trailing "A" or "B" unit in multiple, only the faulty unit is effected, and the alarm bell will ring. If the control disconnecting switch is open the same symptoms appear.

Control Pushbutton Fuse - If this fuse burns out on the "A" unit, the locomotive cannot be moved. If the same fuse is burned out on any trailing locomotive connected in multiple, all units will operate normally, but the locomotive whose fuse is out cannot become the controlling unit. The action is the same as in the preceeding paragraph except no alarm will ring and MCV is not energized.

This fuse also feeds the fire alarm relay and switches (but the pushbutton switch does not effect the fire alarm). Therefore, a good fuse should always be in this circuit in all trailing cabs.

Auxiliary Generator Fuse - If the fuse burns out, the generator will not charge the battery. A discharge current will be indicated by the battery ammoter since the battery will supply the control circuits. It is important that the recommended 3-hour checking schedule be adhered to in an endeavor to prevent excessive drain on the battery. Open the auxiliary generator switch while replacing this fuse.

Fan and Shutter Control Fuse - Each power unit is separately fused. If the fuse burns out, the fan contactors open, the fans stop, and when the radiator water heats sufficiently to trip the water temperature switch, the engine is stopped.

Fan Motors - If this fuse burns out, the action is the same as in the preceeding paragraph except that the fan contactor F3 (F4 in unit 2) will remain closed if the water temperature is high enough to require cooling (or if the Fan and Shutter Switch is in the "Manual" position).

Motor-Generator Fuses - These fuses feed the Cab Signal, Train Communication and Headlight circuits, all all of which are affected simultaneously if a fuse fails. They are on the output side of the motor-generator and do not effect the operation of the M-G set. The foregoing circuits are affected regardless of the position of the M-G set Transfer Switch. If the M-G set itself stops, check the breaker type switch located near the left rear corner of the locomotive.

ALARM

Alarm sounds for Boiler Off, Ground Relay, Hot Engine (see Indicator Lights) or Engine Stop. See p. 427.

ELECTRICAL INDEX

A I R S Y S T E M

CONTENTS

AIR SYSTEM

GENERAL DESCRIPTION

Compressed air is used on the locomotive for actuation of the air brakes, throttle, radiator shutters, sanders, window wipers, signal horns, and miscellaneous equipment. In addition, compressed air from the locomotive is supplied to the entire train for brake operation. Each unit of the locomotive has a complete air system which may be used independently. When units are used together, however, their air systems are joined together at connections at the ends of the units.

Each Diesel engine drives an air compressor which draws air from the interior of the engine room and pumps it into the air reservoirs. The air actuators throughout the locomotive are connected, through suitable cut-off or pressure-varying valves, to the air reservoirs. Schematic diagrams of the air systems for "A" and "B" locomotive units will be found at the end of this section. The air equipment mentioned in the text below is shown on these diagrams.

AIR COMPRESSOR AND MAIN RESERVOIR SYSTEM

The air compressors are of the two-stage type. The low-pressure cylinders of the compressors pump air through an intercooler to the high-pressure cylinder. The high-pressure cylinder then pumps the air into lines leading to the main reservoirs. The compressors are fitted with load-and-unload arrangements for maintaining the desired reservoir pressure. The compressor is controlled by an air compressor governor connected to the main reservoir system in each locomotive unit. This governor causes the compressors in the unit to load and unload at 125 psi and 140 psi reservoir pressures, respectively. When the compressors are "loaded", they pump air normally; when they are "unloaded", the moving parts reciprocate normally, but valves are opened to prevent the pumping of air.

The air from the compressors passes first into a sump reservoir and then into the two main reservoirs. An aftercooler is located in the line between the first and second main reservoir. Automatic drain valves at the sump reservoir and at the aftercooler drain the condensed moisture from the air. Safety valves are located adjacent to each air compressor and at the

entrance to the second main reservoir to prevent overloading of the system.

When two or more locomotive units are operated together, connect the main reservoir systems at the end connections and open the main reservoir cut-off valves between the units. In the event of an engine or compressor failure in one unit, full reservoir pressure will be maintained by compressors in the other units.

AIR BRAKE SYSTEM

The locomotive brakes are actuated by the brake cylinders located on each side of the trucks. The brake cylinders are connected through suitable control equipment to the main air reservoir system. Brake application for the entire train is also controlled from the locomotive. The principal control equipment is listed below:

1. DAE-24-H Automatic Brake Valve. This valve is a part of the brake pedestal located at the engineer's position in "A" units only. It is used to control the application of brakes in both the locomotive and the train.

2. S-40-D Independent Brake Valve. This valve is located adjacent to the brake pedestal at the engineer's position of "A" units only and is used to control the locomotive brakes independently from the automatic brake valve.

3. SA-2 Hostler's Brake Valve. This valve is located at the control position of "B" units only and is used to control the brakes of a "B" unit when operated independently.

4. K-2 Rotair Valve. This valve is located at the engineer's position in "A" unit cabs and is a selector valve for cutting out the independent brake valve or the controlled emergency application equipment.

Other items of air brake equipment which function automatically are the following. The D-24 control valve is a part of the automatic brake pedestal. The H-24-A Relayair valve regulates the emergency safety control and overspeed brake applications. The H-5-A relay valve is operated from the control valve and is

used in regulating automatic sanding and overspeed brake application. The FA-4 magnet valve is also used in controlling emergency or service brake applications caused by overspeed. The Type C deadman foot valve is a safety device which must be depressed to prevent a safety control brake application. The B-1 controller is an electro-pneumatic device which relays the self-lapping action of the brake valve to the brake cylinders. The FMS-186 relay valve fixes the proportions between the control pipe pressure and the brake cylinder pressure.

The principal air brake pipes, as shown on the schematic diagrams, have functions as follows:

1. The Straight Air Pipe runs the length of the train and connects the control valves, 21-B magnet valves, and the master controllers for synchronization of the electro-pneumatic brake.

2. The Actuating Pipe is trainlined to all units from the S-40 independent brake valve through the Rotair valve on the controlling unit to all D-24 control valves. It transmits air pressure for releasing automatic applications on the locomotive independently from the train.

3. The Independent Application and Release Pipe makes the same connections as the Actuating Pipe and is used in controlling the independent application and release of the locomotive brakes.

4. The Controlled Emergency Pipe is trainlined to all units, connecting the Rotair valves and S-40 brake valves to the D-24 control valves. Connections through this pipe cut the controlled emergency application passages in or out.

5. The Throttle Pipe connects the controllers in the units for multiple operation from a single "A" unit.

6. The Brake Pipe runs the length of the train with connections to the brake valves, D-24 control valves, and B-3-A conductor's valves on each locomotive unit. It supplies air to the control valve reservoirs and is used in controlling automatic brake applications.

7. The Signal Pipe runs the length of the train and provides a means for signalling the engineer by the signal car discharge valves on the units and the cars.

For further information on air brake operation, consult Westinghouse Air Brake Company publications.

PNEUMATIC THROTTLE SYSTEM

Throttle control is accomplished by two actuators for each Diesel engine; one actuator changes the engine governor setting and the other the Carbonstat setting in accordance with the throttle lever position. Air from the main reservoir system is reduced to 70 psi and piped to the controller. The controller regulates the air pressure in the lines to the actuators. Magnet valves in the actuator lines reduce the actuator pressure during wheel slippage. The magnet valves are operated electrically from the wheel slip protection system.

HORN, BELL, WINDOW WIPER, AND SANDING SYSTEMS

These systems are connected directly to the main reservoir system. The horn, bell, and window wiper lines each are equipped with control valves. The flow of air through the sand nozzles is controlled by the sander magnet valve which is connected electrically to the K-3 sander switch. The sander switch is air operated either from the hand sander valve on the brake pedestal or automatically during an emergency brake application. When locomotives are operated in multiple, the sander magnet valves of all units are energized through the K-3 sander switch in the controlling "A" unit. The connections between the sander switch and the sander valve are so interlocked with the reversers that sand is applied only to the sides of the wheels in the direction of locomotive travel.

RADIATOR SHUTTER OPERATING AND CONTROL SYSTEMS

The radiator shutters are operated by air cylinders which receive air from the main reservoir system through a 70 psi reducing valve. The shutters for each engine are operated separately and an electrically operated shutter valve is installed in each operating cylinder line. These valves are controlled by temperature switches in a separate shutter control system.

The air from the 70 psi supply is also used in the shutter controlling line, and connected through a 17 psi reducing valve to the Grad-U-Stats for each engine. The Grad-U-Stats respond to varying engine cooling water temperature by varying the pressure in the air lines leading to the temperature switches. One of the temperature switches for each engine is connected electrically to its shutter valve and causes the shutters to open or close in response to Grad-U-Stat pressure variations. The other temperature switch in each control line is used for automatic regulation of the radiator fans.

POWER SWITCH AND REVERSER SYSTEM

The power switches, which close the circuit from the generators to the traction motors, and the reversers in the traction motor field circuits are air operated. Small electro-pneumatic switches control the air pressure which operates the high voltage contactors of switches and reversers. This equipment is connected to the main reservoir system through a 70 psi reducing valve.

AIR COMPRESSOR UNLOADING SYSTEM

The air compressors are loaded and unloaded by means of air cylinders in the compressor cylinder heads. The air pressure to these cylinders is controlled by an FA-2 magnet valve which either allows full reservoir pressure to be exerted against the unloader cylinders or exhausts the air from the cylinders. The action of the magnet valves is controlled by the S-16 compressor governor which is also in the main reservoir line and is connected electrically in series with the magnet valve. When the main reservoir pressure drops to 125 psi the reduced pressure causes the S-16 compressor governor switch to close, energizing the FA-2 magnet valve. This opens the unloading cylinders to the atmosphere through the magnet valve and the compressor operates loaded, pumping air into the main reservoirs. When the main reservoir pressure reaches 140 psi the governor switch opens, de-energizing the magnet valve. This admits main reservoir pressure to the unloader cylinders, causing the compressors to stop pumping air. When two or more locomotive units are operated in multiple, each S-16 compressor governor is connected electrically through the train line receptacle to the FA-2 magnet valves on all units. This

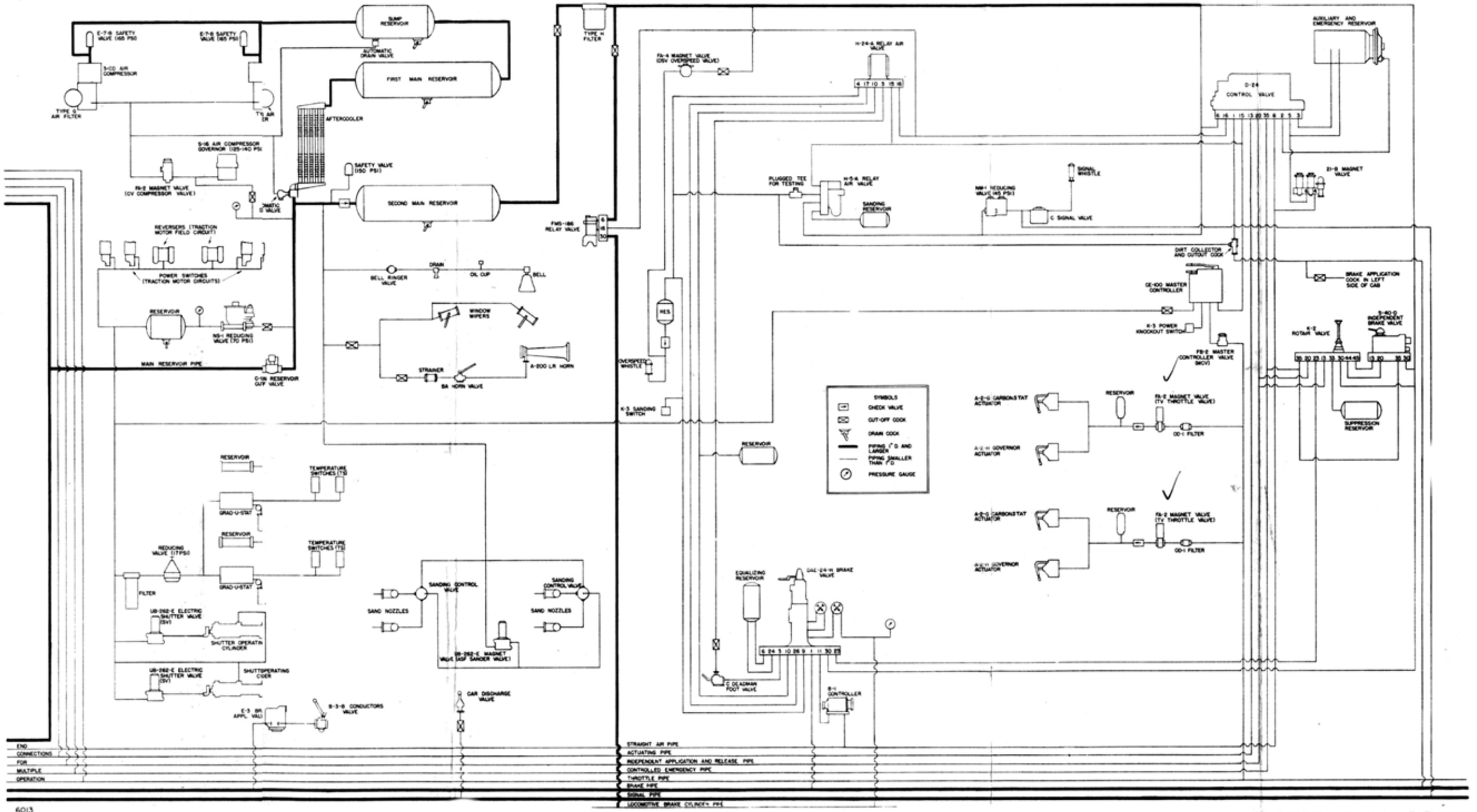
synchronizes all air compressors in the combination, all compressors loading or unloading at the same time in response to the compressor governor in any unit.

ELECTRO-PNEUMATIC EQUIPMENT

The following electro-pneumatic equipment is shown on the schematic piping diagrams and is also discussed in Section 4 of this manual. The following table is included for cross-reference purposes.

Electrical Symbol	Item	Function
ASV	Sander Valve ("A" Unit) UB-262-E Magnet Valve	Controls air to sand nozzles.
FSV	Sander Valve ("B" Unit) UB-262-E Magnet Valve	Controls air to forward sand nozzles.
RSV	Sander Valve ("B" Unit) UB-262-E Magnet Valve	Controls air to reverse sand nozzles.
--	K-3 Sander Switch	Actuates Sander Valves.
OSV	Overspeed Valve, FA-4 Magnet Valve	Controls overspeed brake application.
MCV	Master Control Valve, FB-2 Magnet Valve	Prevents accidental use of throttle valves in non-controlled units.
TV	Throttle Valves, FA-2 Magnet Valve	Reduce throttle line pressure during wheel slippage.
--	S-16 Compressor Switch	Actuates compressor load control.
CV	Compressor Valve, FA-2 Magnet Valve	Controls air flow to compressor load control.
--	K-3 Power Knockout Switch	Idles engine during emergency brake application.

Electrical Symbol	Item	Function
P	Power Switches	Connect traction motors to main generator.
--	Reverser	Reverses traction motor field circuits.
TS	Temperature Switch	Actuates shutter valves and radiator fan controls.
SV	Shutter Control Valve, UB-262-E Magnet Valve	Controls air to shutter operating cylinders.
--	B-1 Controller	Relays self-lapping brake action.
--	21-B Magnet Valve	Controls straight air pipe pressure.



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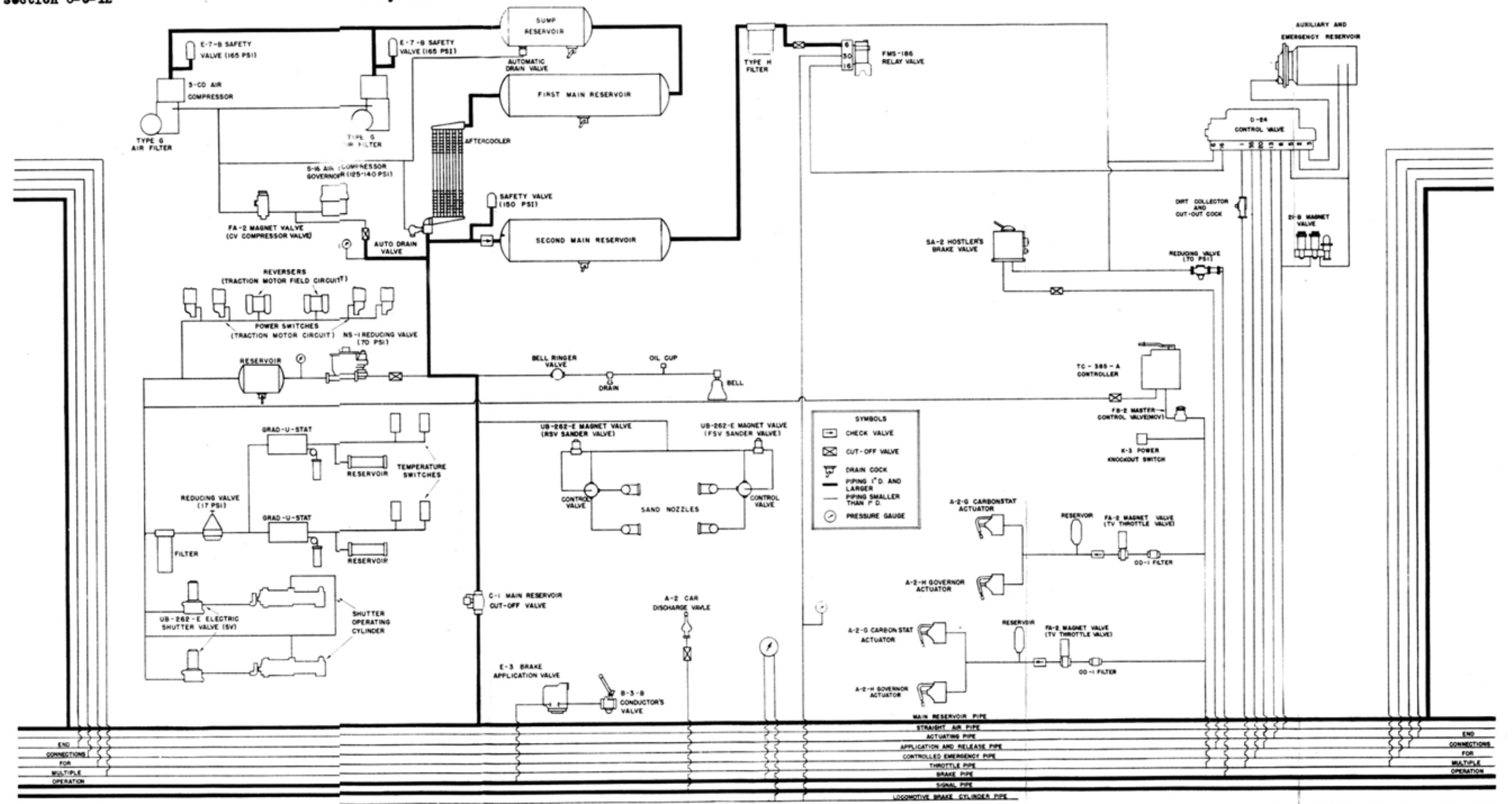
AIR PIPING DIAGRAM - "A" UNIT
Figure 1



AIR PIPING DIAGRAM - "B" UNIT
Figure 2

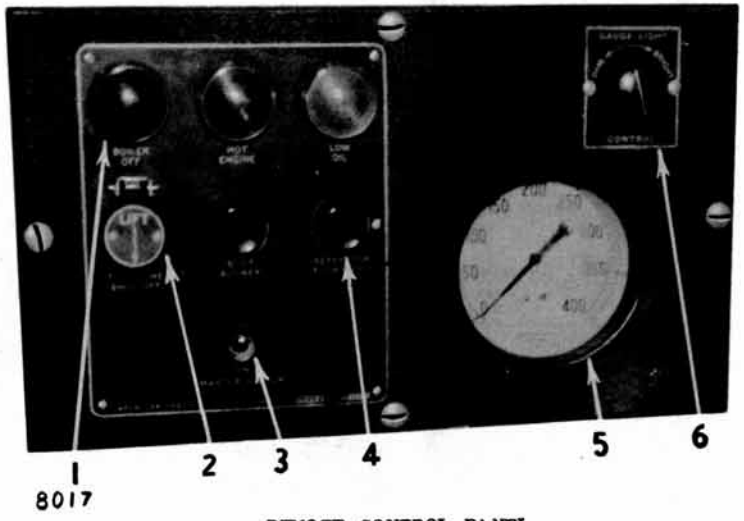
STEAM HEATING BOILERS

CONTENTS

STEAM HEATING BOILERS

The boilers are rated at 3000 pounds per hour of water evaporation and are set to maintain a boiler steam pressure of from 225 to 275 psi. The train line steam pressure may be varied from 50 to 240 psi. The boilers are of the continuous water tube type with forced circulation. The steam passes through steam separators where water is separated from the steam for return to the water supply tank. Any solid particles collect in a sump for periodic blowing out.

The burner operates on Diesel fuel oil with electric ignition. The fuel is supplied to the burner wit a fuel pump, and air is delivered to the combustion chamber by a blower. Water from the boiler supply tan is forced into the coils by a feed pump.



REMOTE CONTROL PANEL
Figure 1

CONTROLS AND INSTRUMENTS

The following instruments and controls are located on the instrument panel at the fireman's position in "A" unit cabs. These controls are adequate for normal operation of the boiler after it is started. See Figure 1.

1. Boiler-Off Warning Light.

2. Train Line Shut-Off Switch. This switch is for use in shutting off the steam supply to the train steam line. It is fitted with a protective cover to prevent accidental actuation of the switch.

3. Master switch. This is the control switch for the boiler controls at the fireman's position. In the "ON" position it connects the other switches for operation and turns on the gauge light.

4. Separator Blowdown Switch. Actuation of this switch opens the steam separator blowdown valve.

5. Train Line Steam Pressure Gauge.

6. Gauge Light Control.

OPERATION

I. PRELIMINARY

A. Check that the following valves are open.

1. Water suction stop valve.
2. Coil shut-off valve.
3. Water inlet valve to by-pass regulator (9, Figure 2).
4. Boiler stop valve.
5. Return water outlet valve at steam separator (6, Figure 4).
6. Water return valve to tank.
7. Atomizing air admission valve.

B. Check that the following valves are closed.

1. Washout solution admission valve.
2. Washout solution return valve.
3. Manual water by-pass valve (8, Figure 2).
4. Coil blowdown valve (9, Figure 3).
5. Water Pump test valve (10, Figure 3).
6. All drain valves in the line between the water tank and the water pumps.

C. Place the following switches in the positions indicated.

1. Place the motor re-set button on the control panel "in" (1, Figure 2).
2. Place the stack switch re-set button "in" (3 Figure 3).
3. Place the high temperature re-set button "in".
4. Set the steam pressure switch at the desired maximum steam pressure, preferably not less than 160 psi.

II. TO START THE BOILER

A. Open the separator blowdown valve (8, Fig. 4). This valve is foot-operated. Keep it open for about one minute to drain steam separator, then close the valve.

B. Open fill-test valve (7, Fig. 4).

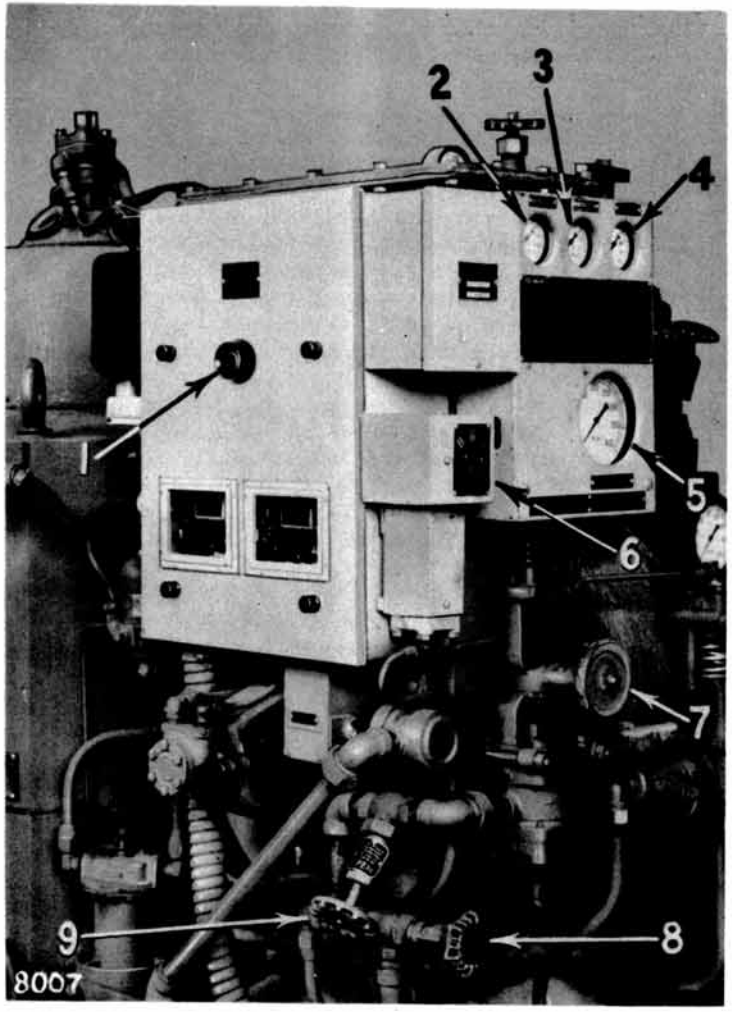
C. Close the main switch. The main switch is mounted on the rear wall of the "A" unit engine room.

D. Turn the control switch (6, Fig. 2) to the "FILL" position.

E. As soon as water flows evenly from the fill-test valve, close the valve. Then open the separator blow-down valve and turn the control switch to the "RUN" position. The fire at the burner should start immediately.

If the fire fails to start within 10 seconds, look through the peep sight glass at the top of the boiler and note whether sparking is occuring at the spark plug electrodes. If there is no sparking, turn the control switch to the "OFF" position immediately and inspect the ignition cable for breaks or loose connections. If sparking is normal and the fire will not start, check the water pressure and fuel pressure.

F. When the generator pressure builds up to 130 psi close the separator blowdown valve.



BOILER OPERATING CONTROLS
Figure 2

1. Main Re-set Button
2. Air Pressure Gauge
3. Fuel Manifold Pressure Gauge
4. Fuel-to-Nozzle Pressure Gauge
5. Train Line Pressure Gauge
6. Control Switch
7. Water By-Pass Regulator
8. Manual Water By-Pass Valve (Closed)
9. Inlet Valve to Water By-Pass Regulator (Open)

G. Depress the latching lever on the train line shut-off valve. This will admit steam to the train line.

H. Set the water by-pass regulator (7, Fig. 2) to the required steam line pressure.

J. Before leaving the terminal, after starting the steam generator, inspect the following pipe openings for leaks: separator blowdown (8, Fig. 4), coil blowdown (9, Fig. 3), and water treater drain. If leaking, check that the valves are closed tightly.

K. Caution:

1. Do not start the boiler until the coils are filled with water. The water level indicator in the steam separator gauge glass does not indicate that the coils are filled.

III. SAFETY DEVICES

The boiler is equipped with the following automatic safety devices which stop the burner or the motor under unsafe operating conditions.

A. Outfire Control: A steam pressure actuated latch which trips the control switch to "OFF" position and stops the motor when the pressure drops below 160 psi.

B. Servo-Fuel Control: Meters fuel to the burner in the correct proportion to the rate of water entry to the coils; adjusts the air damper for proper combustion; stops the fire if insufficient water is entering the coils.

C. Stack Switch: Opens and stops the motor when the stack temperature exceeds 900° F.

D. Fuses: Two fuses are in the control circuit and two in the ignition circuit.

E. Other safety devices are the fuel pressure regulator, steam temperature limit control, steam pressure safety valves and so forth.

IV. OPERATING THE BOILER

A. Turn the master switch on the remote control panel to the "ON" position.

B. Regulate the train steam line pressure as desired by adjusting the hand-wheel on the water by-pass regulator.

C. Approximately every hour, press the steam separator blowdown pushbutton and hold "in" for 10 seconds.

D. The train line steam shut-off valve can be closed by lifting the protecting cover over the pushbutton and depressing the button. This will be necessary only when a car is to be cut out of the train.

E. After the train line steam shut-off valve has been closed, steam is admitted back into the train line by opening the shut-off pilot valve at the boiler by depressing the latching lever.

F. Approximately every hour, turn the handle on the fuel oil filter one full turn (6, Fig. 3).

G. Periodically, feel the feed water check valve, which should be warm. Overheating is due to insufficient fuel. A dirty fuel filter may be the cause. If the filter is in a satisfactory condition, increase the fuel pressure slightly with the fuel key metering valve. If the check valve is too cold, decrease the fuel pressure with the fuel key metering valve.

H. Periodically, check the water pressure gauge (2, Fig. 4). It should not read over 450 psi. The gauge should be steady with no jumping action. Jumping action indicates vapor-bound suction valves. Opening the air bleeder valves on the water pump suction valve caps should correct the trouble.

I. Empty the drip pan under the water pump packing

as required. Slight leakage is normal. The boiler may stop periodically, lighting the "boiler off" warning light on the remote control panel. If the alarm bell is not ringing, this is caused by the pressure reaching the pressure switch setting. The boiler will start automatically when the pressure has dropped sufficiently.

K. If the boiler stops and the alarm bell rings, one of the protective devices is operating. Turn the operating switch off. Check all re-set buttons. If all the re-set buttons are "in", check the fuses. If a re-set button is "out", refill the boiler coils as outlined under Paragraph II-A, D above, then press the re-set button "in" and re-start the boiler as outlined above. It may require 4 minutes time before the thermal elements in the protective devices cool to the point where the re-set buttons will stay "in".

V. TO STOP THE BOILER

A. Close the train line shut-off valve.

B. Close the stop valve.

C. Set the steam pressure switch up to 200 psi.

D. At 200 psi steam pressure, turn the operating switch to the "OFF" position.

E. Open the coil blowdown valve (9, Fig. 3). The knob on the valve must be pulled outward to release the handle for opening the valve.

F. Return the steam pressure switch to the normal operating setting.

G. Close the atomizing air admission valve.

H. Turn the control switch to "OFF".

I. When the steam pressure drops to 50 psi, close the coil blowdown valve.

J. Open the separator blowdown valve (8, Fig. 4) and blow down the steam separator with the re-

maining pressure.

K. Close the separator blowdown valve when all the steam pressure is gone.

L. Open the main switch.

VI. TO DRAIN THE BOILER

If it becomes necessary to drain the boiler to prevent freezing, or for other reasons, proceed as follows:

A. Complete steps A to J in the preceding paragraph, leaving the separator blowdown valve open until the pressure is completely gone.

B. Remove the water strainer tank cover. Lift out the strainer and empty the water from the tank.

C. Open the water pump test valve, turn the control switch to "FILL", and pump air through the valves and pipes for a few minutes.

D. Disconnect the water pump discharge line at the entrance to the water by-pass control. Connect an air hose to this line and blow out any water remaining in the system.

E. Open all valves.

FOR FURTHER INFORMATION

This section includes only general instructions for the operation of the boiler. For more detailed instructions and for maintenance information, see the BLW Maintenance Bulletin Book and Vapor Car Heating Company publications.

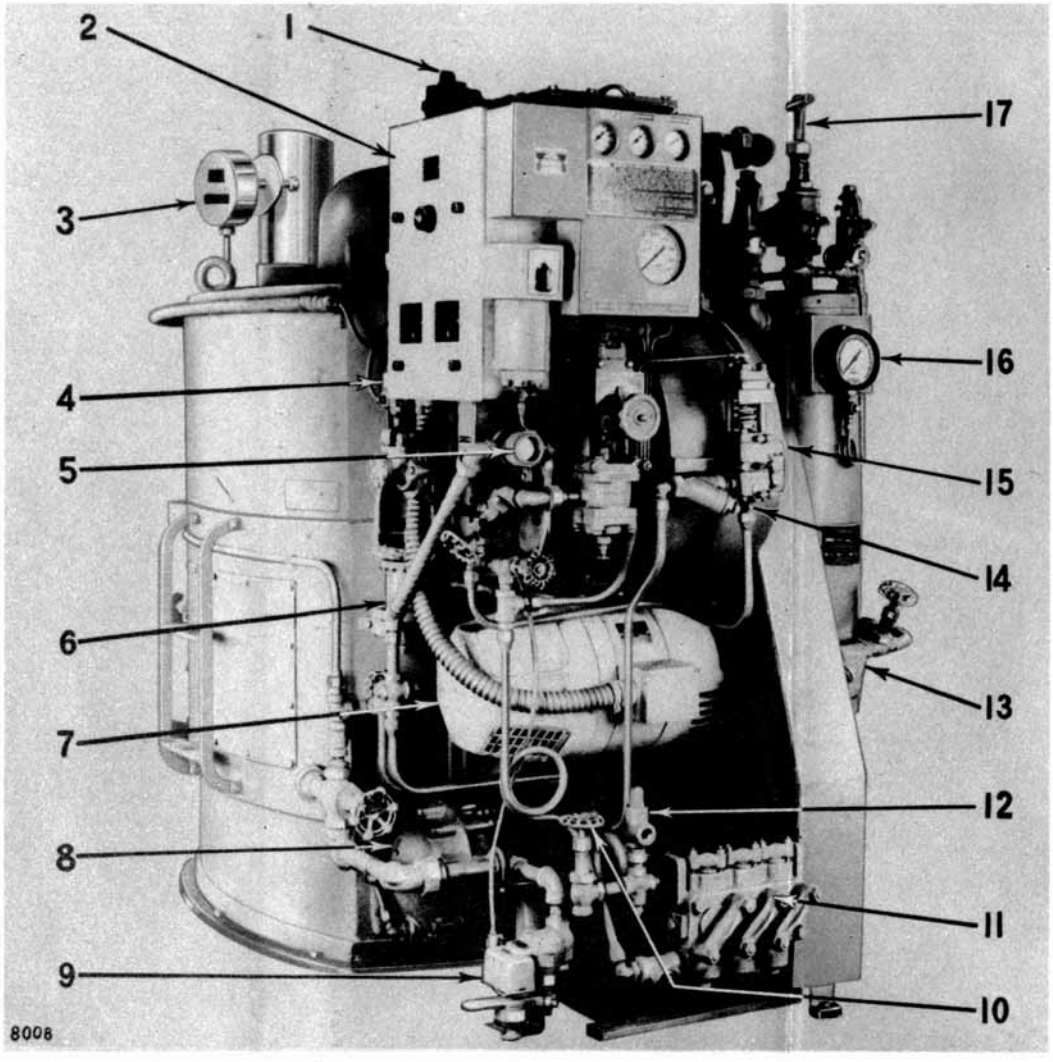


Figure 3

1. Fuel Spray Head
2. Control Panel
3. Stack Switch Re-set Button
4. Air Solenoid Valve
5. Return Water Flow Indicator
6. Fuel Filter
7. Motor Convertor
8. Heat Exchanger
9. Coil Blowdown Valve
10. Water Pump Test Valve (Closed)
11. Water Pump
12. Water Relief Valve
13. Return Water Strainer
14. Water Strainer
15. Water By-Pass Control
16. Generator Pressure Gauge
17. Separator Stop Valve (Open)

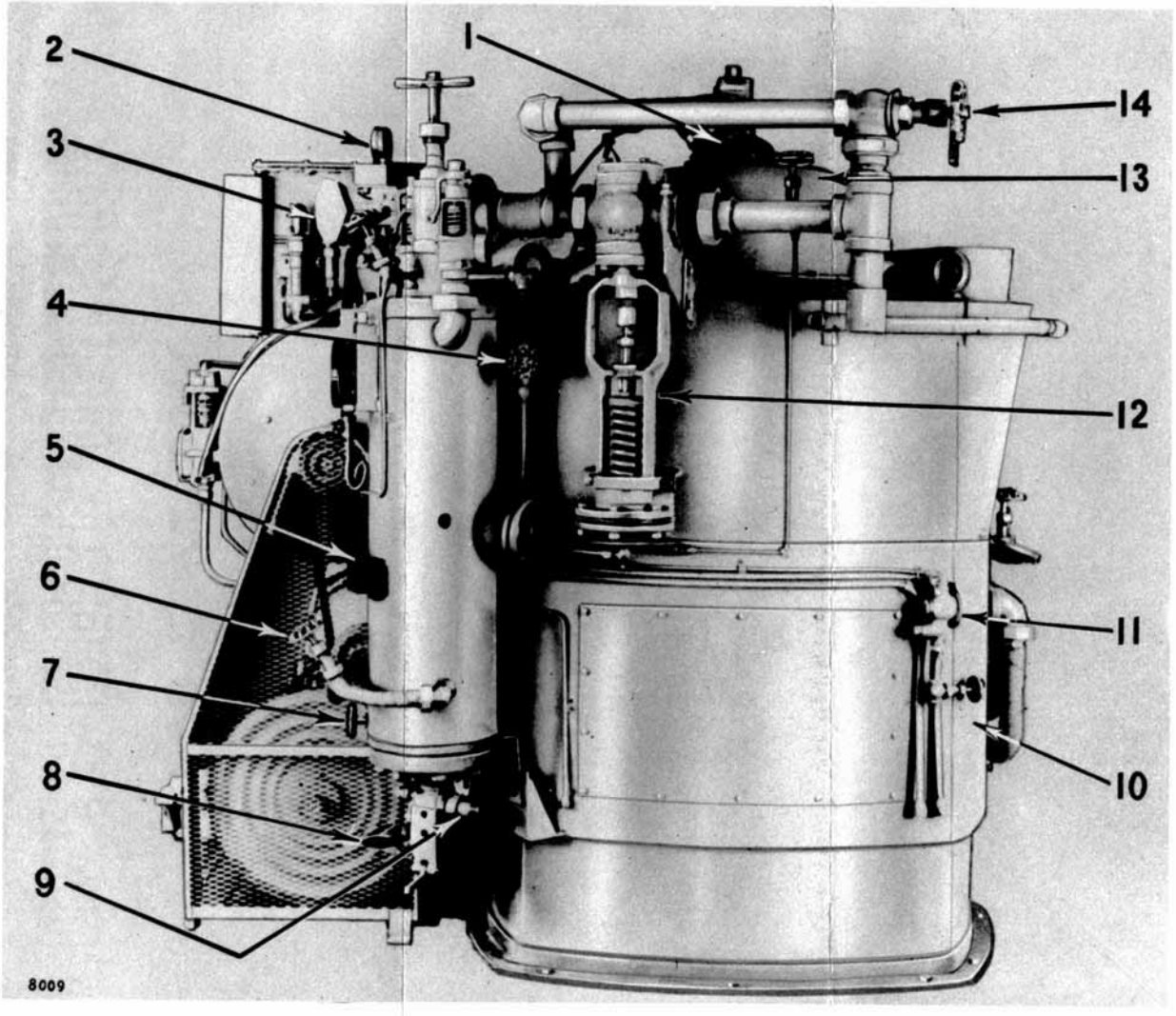


Figure 4

1. Peep Hole
2. Water Pressure Gauge
3. Servo Control
4. Back Pressure Regulator Diaphragm Shut-off Valve (Open)
5. Steam Temperature Limit Control
6. Return Water Outlet Valve (Open)
7. Fill Test Valve (Closed)
8. Separator Blowdown Valve
9. Steam Trap
10. Atomizing Air Shutoff Valve
11. Air Pressure Reducing Valve
12. Back Pressure Regulator
13. Water By-Pass Regulator Steam Valve (Open)
14. Emergency By-Pass Valve

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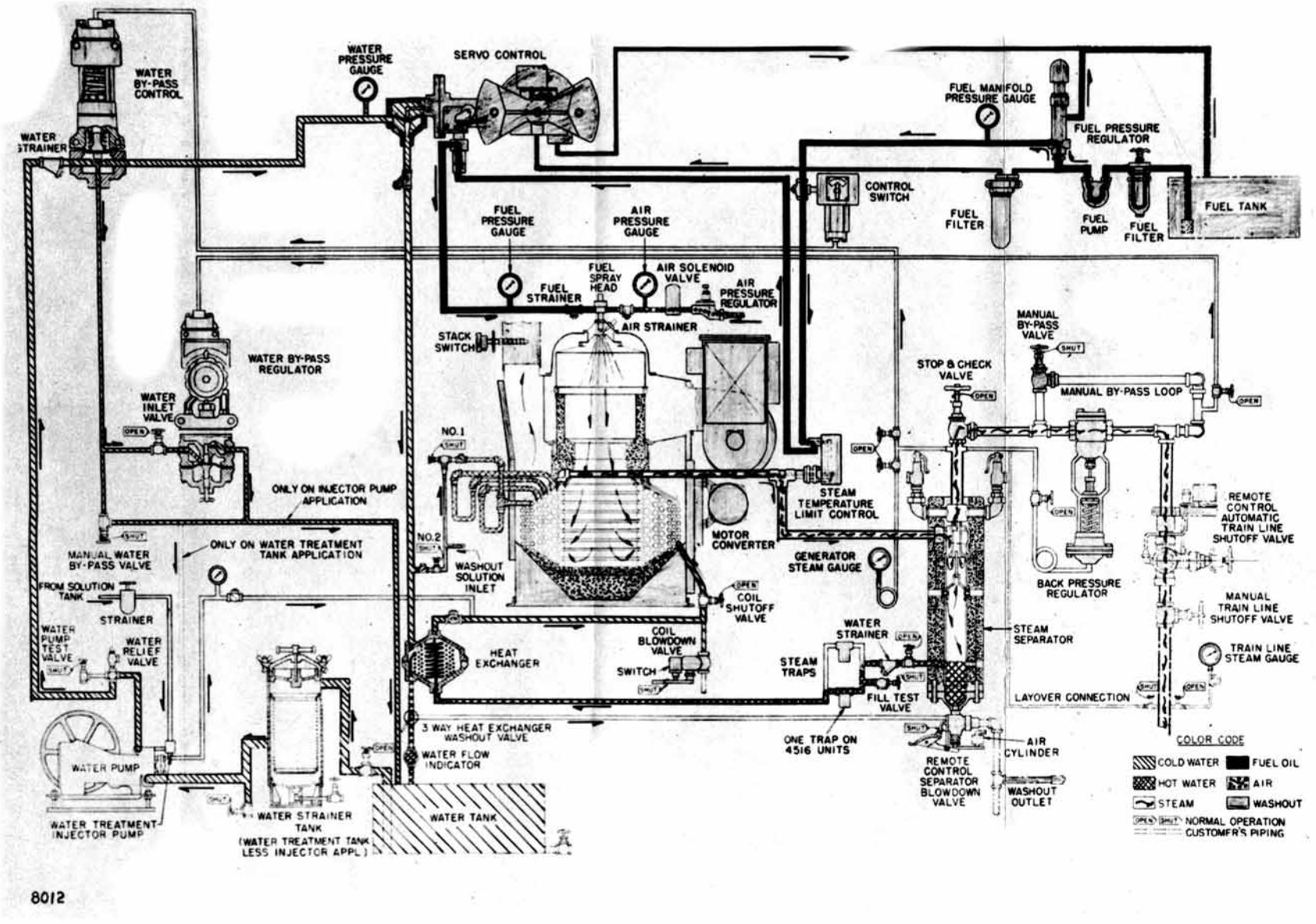
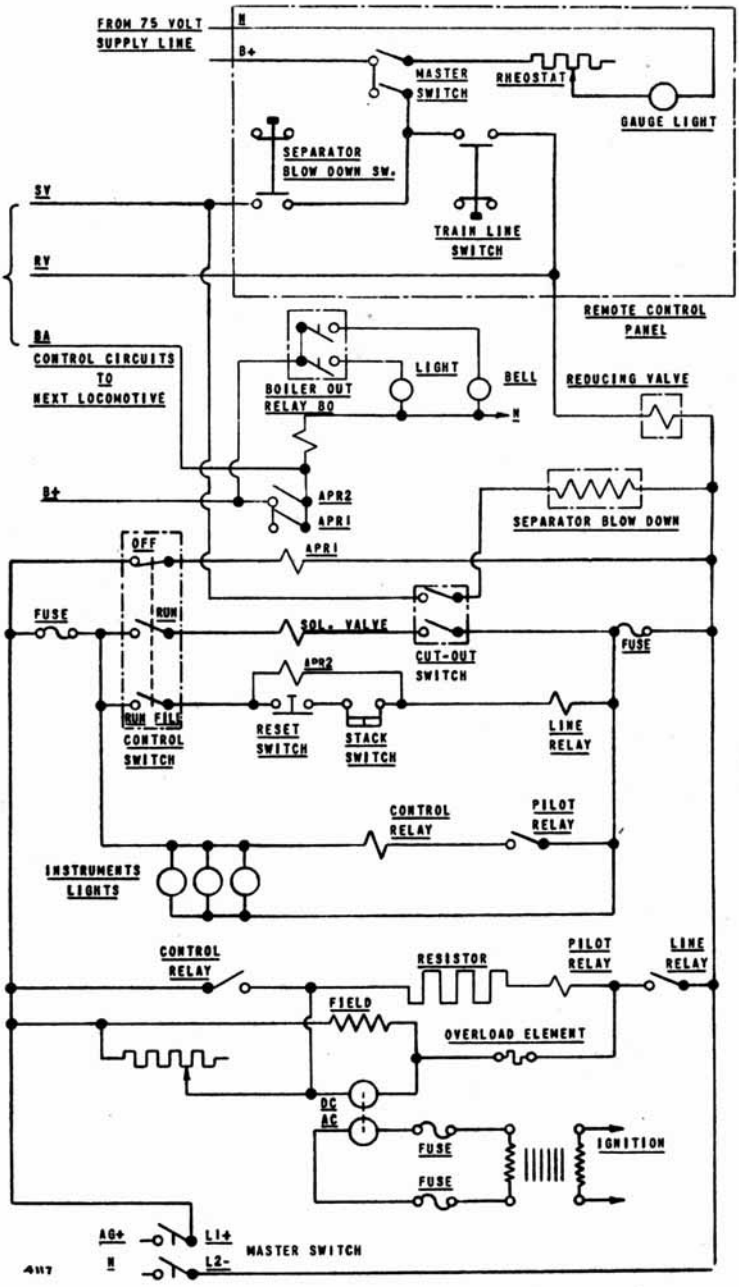


SCHEMATIC DIAGRAM OF BOILER
Figure 4



STEAM BOILER ELECTRICAL CIRCUITS
Figure 6

TRAIN COMMUNICATION

The locomotive is equipped with an inductive train communication system. This system permits conversation with other points on the same train, between trains, and between the train and a block station. A control stand with a handset talking instrument and a loudspeaker are located in each operating cab.

OPERATION

The train communication system has two talking channels, "High" and "Low", indicated with large letters, "H" and "L", respectively, located on the opposite lower corners of the control station panel. The "H" channel shall be used for talking between trains and from end to end of the same train. The "L" channel shall be used for talking between the train and the block station. In an emergency, either channel may be used for calling and talking to any other trainpoint unit.

Train communication equipment must be used only in connection with company business, train movements, etc. Use for casual conversation and similar purposes is prohibited.

To turn the train communication equipment on and off, operate the toggle switch on the control station panel. Should the pilot light fail to light when in the "ON" position, a talking test should be made with another trainphone unit to determine whether or not the system is in serviceable condition. The light may be burned out and therefore fail to indicate properly.

Selector lever "S" is the channel selector and is moved left to "H" or right to "L" to select the channel desired for transmission or reception on the handset. The handset must be removed from the hook and the "S" lever moved fully to the right or left position to select the desired channel. This lever is automatio ally locked in position for the channel selected for conversation on the handset and it returns to its normal neutral position when the handset is replaced on the hook. When the selector is locked in either channel position, do not try to transfer it to the other channel unless the handset switch is depressed to release the magnetic latch holding the lever in position.

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CONTROL STATION
INDUCTIVE TRAIN COMMUNICATION
Figure 1

Calling lever "C" is to be used only in case of an emergency. To send the emergency code call, retain the selector lever "S" in its normal vertical position and move calling lever "C" from "L" to "H" two times which will send the calling code over both channels.

TO TALK:

Remove the handset from its hook and hold it to the side of the head in the same manner as a regular telephone. Move the selector lever "S" to "L" or "H" to connect the handset in the proper channel for talking. When talking, it is necessary to hold down the "Press-to-Talk" button. After talking, this button should be released immediately to set up the equipment for reception. After the channel selection is made, the loud speaker is automatically connected to the opposite channel from the one to which the selector lever is moved. This provides for emergency call reception through the loud speaker.

TO CALL:

(Example) Say "Engine (or cabin car) 6689 east (or west) calling Lewis on Low". Repeat at intervals of not less than five seconds until an answer is received. In all cases, a call from a train or from a block station must indicate what train or station is calling and what train or station is being called.

TO ANSWER:

(Example) Say "Lewis answering engine (or cabin car) 6689 east (or west)". In all cases, the answer from the train or the block station must indicate what train or station is answering and what train or station is being answered.

EMERGENCY CALLS:

First send "Emergency Code Call" and then say "emergency" and make call in usual manner.

EMERGENCY BROADCAST:

First send "Emergency Code Call" and then broadcast the emergency message over each channel separately, as often as may be required.

ANSWER TO EMERGENCY CALLS:

When the "Emergency Code Call" is heard, all persons using the trainphone within the range of the emergency call will discontinue conversation immediately and stand by to answer the emergency call. The party called shall answer at once.

ADJUSTMENTS:

Adjustments on the Control Panel include two "volume controls", one for the handset, the other for the loud speaker. Turning in a clockwise direction will increase the volume of sound from the handset receiver and/or the loud speaker. There are also two noise suppressor controls, one for each "L" and "H" channel.

VOLUME CONTROLS:

The handset and loud speaker volume controls should be adjusted to a point where the volume is sufficient for good reception but not too loud to cause distortion or annoyance. Crews, particularly on the engines, should endeavor to talk in a normal manner and under no circumstances attempt to raise the voice above the engine noises. Extremely loud talk is of no benefit in transmission; in fact, it serves only to distort the conversation.

NOISE SUPPRESSORS:

Noise suppressor controls on the "H" and "L" channels are for the purpose of adjusting the train communication receivers to their best operating condition. When it is necessary to adjust the noise suppressor, start from #1 position on the dial and turn the control knob clockwise until the noise in the handset receiver disappears. Do not turn beyond the point so determined. Before attempting to adjust the noise suppressor controls, it is necessary to move the selector lever "S" to the proper channel. The normal setting for the noise suppressor is about #2 on the dial. It will rarely be necessary to operate at dial positions in the neighborhood of #10.

DEPARTURE TEST:

Engine crews shall make a departure test between the locomotive and the test set located at the terminal. After a freight locomotive is attached to a train with train communication-equipped cabin cars, an end-to-end test shall be made before leaving the yard.

REPORTING DEFECTS:

All failures of train communication units in locomotives and cabin cars and instances of inability to communicate with other trainphone units occuring on each trip shall be reported at the end of the trip by the engineman and by the conductor.