GEJ-3815

# EDUCATIONAL MANUAL

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# GENERAL ELECTRIC MODEL U25B DIESEL-ELECTRIC LOCOMOTIVE

GENERAL ELECTRIC

H. LIBAN

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# EDUCATIONAL MANUAL

# GENERAL ELECTRIC
# MODEL U25B
# DIESEL-ELECTRIC
# LOCOMOTIVE

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

GENERAL ELECTRIC

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5. Upward movement of the power piston to the tripped position also rotates the terminal lever, raising the end of the floating lever at the speed droop bracket pin. This reduces the pressure of the speeder spring and allows flyweights to move out quickly. Rotation of the terminal lever also pushes the overspeed lockout rod back until the lockout latch engages and raises the reset button.

## TRIP INDICATOR AND RESET

Visual indication that the unit is in tripped position is provided by a red band below the reset button, visible when the button is up. To reset the governor following an overspeed trip, push down on the reset button.

## ADJUSTMENTS

The governor has 2 points for adjustment:

1. The speed droop bracket - located inside the governor on the terminal lever - must be set at mid-position.

2. The trip-speed setting screw in the governor cover must be adjusted to provide trip action at the specified overspeed for the engine.



# OPERATING INFORMATION

## INTRODUCTION

All of the operating devices, manual and visual, normally used by the engineman during locomotive operation are located near the operator's position. Most of these devices are located either on the master controller, on the air brake stand, or on the engine control panel.

NOTE: Customer equipment requirements often differ from one railroad to another. Therefore, physical locations and appearance of some devices illustrated in this manual may not agree entirely with the equipment furnished to any particular railroad.

## MASTER CONTROLLER
FIG. 9-1 and 9-2

The master controller is a set-up switch used by the operator to control the locomotive. It has a throttle handle, a selector handle, and a reverse handle. These handles control motoring and dynamic braking (if used). Various control switches, circuit breakers, and indicating lights are mounted on the housing of the controller.

Mechanical interlocking between the handles prevents improper operation of any handle. See INTERLOCKING BETWEEN HANDLES.

### THROTTLE HANDLE

The throttle handle has an IDLE and 8 major and 8 intermediate positions or notches. Major notches are registered by a number. Intermediate notches are registered by a dot or "1/2" mark. This handle controls tractive effort when motoring and braking effort when dynamic braking is being used.

### REVERSE HANDLE

The reverse handle has positions FORWARD, OFF, and REVERSE. It is used to control the direction of locomotive movement.

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# LOCOMOTIVE DATA

## MAJOR EQUIPMENT

| | |
|---|---|
| Diesel Engine | 7FDL16 |
| Main Generator | GT-598 |
| Traction Motors | GE-752 |
| Auxiliary Generator | GY-27 |
| Exciter | GY-50 |
| Air Compressor (Gardner-Denver) | WBO |
| (WABCO) | 3CWDL |
| Fan & Blower Unit | GDY-40 |
| Air Brake System | 26L |
| Wheel Diameter (New) | 40 inch |
| Permissible Variations in Size (40 Inch Diameter Wheel) | |
| Wheels on Same Axle | None |
| Wheels on a Locomotive Unit | 25 Tapes |

## SYSTEM CAPACITIES

| | |
|---|---|
| Fuel Oil - Large Tank | 2900 gal. |
| Small Tank (Optional) | 1700 gal. |
| Water Tank (Optional) | 1200 gal. |
| Lubricating Oil | 330 gal. |
| Cooling Water | 220 gal. |
| Engine Governor | 2 quarts |
| Fan & Blower Unit | 10 1/2 gal. |
| Compressor - Small Crankcase | 10 quarts |
| Sand | 32 cu. ft. |

## BRAKE SYSTEM ADJUSTMENTS

| | |
|---|---|
| Brake Cylinder Piston Travel - Min. | 2 1/2 in. |
| - Max. | 6 in. |
| Compressor Governor Switch - Cut In | 130 psi |
| - Cut Out | 140 psi |
| Compressor Intercooler Safety Valve | 65 psi |
| Main Reservoir Safety Valve | 150 psi |
| Regulating Valve | Variable |
| Independent Brake Valve, Full Service | 45 psi |
| Control Air Reducing Valve | 70 psi |
| Power Cutout Switch (PCS) - Open | 30 ± 1 psi |
| - Close | 42 ± 1 psi |

# LOCOMOTIVE DATA

## OPERATING SETTINGS

| | |
|---|---|
| Diesel Engine, Idle | 400 ± 15 RPM |
| Diesel Engine, Full Speed | 1000 ± 4 RPM |
| Overspeed Shutdown Trips | 1100 ± 10 RPM |
| Diesel Engine Operating Temperature | 160-180 F |
| Hot Engine Alarm (ETS) - Close | 200 ± 2 F |
| - Open | 193 ± 2 F |
| Engine Lubricating Oil Header Pressure - Idle | Approx. 15 psi |
| - Full Throttle | Approx. 45 psi |
| Oil Pressure Shutdown (OPS) - Engine at Idle (40 Second delay) | 10-14 psi |
| - Engine above 1st Notch (No delay) | 25-30 psi |

## ENGINE SYSTEMS PRESSURE VALVES

| | |
|---|---|
| Fuel Oil Pump Pressure, Relief Valve | 75 psi |
| Fuel Header Pressure Regulating Valve | 35 psi |
| Lubricating Oil Pump Pressure Relief Valve (Begins to Open) | 90 psi |
| Lubricating Oil Pressure Regulating Valve | 50 psi |
| Lubricating Oil Filter By Pass Valve | 20 psi |

## WEIGHTS (Approximate Weights for Lifting Purposes Only)

| | |
|---|---|
| Complete Locomotive (Fully Serviced) | 250,000 lbs. |
| One Truck (Complete) | 43,000 lbs. |
| One Truck Frame | 6,050 lbs. |
| One Swing Bolster | 1,475 lbs. |
| One Spring Plank | 390 lbs. |
| One Motor, Wheel and Axle Assembly | 11,600 lbs. |
| Traction Motor (Less Gear Case) | 7,000 lbs. |
| Air Compressor (Dry) | 1,370 lbs. |
| One Battery Tray | 300 lbs. |
| Engine Hood Assembly (Not Including Radiator Hood) | 4,000 lbs. |
| Fan & Blower Unit (Complete with Fans) | 4,500 lbs. |
| Each Radiator Fan | 370 lbs. |



LOCOMOTIVE DATA

| | |
|---|---|
| Fan & Blower Unit Drive Shaft and Couplings | 200 lbs. |
| Radiator and Frame Assembly | 1,750 lbs. |
| Each Radiator Section | 280 lbs. |
| Equipment Blower Rotor | 200 lbs. |
| Engine and Generator (Complete) | 57,000 lbs. |
| Main Generator with Auxiliaries | 17,500 lbs. |
| Auxiliary Generator | 690 lbs. |
| Exciter | 625 lbs. |
| Engine (Less Generator) | 37,500 lbs. |
| Engine Component Parts | |
| Main Frame (Bare) | 10,670 lbs. |
| Crankshaft | 3,955 lbs. |
| Turbocharger | 1,330 lbs. |
| Intercooler (Dry) | 480 lbs. |
| Cylinder Complete | 540 lbs. |
| Piston and Master Rod Assembly | 207 lbs. |
| Piston and Articulating Rod Assembly | 94 lbs. |
| Oil Pump | 250 lbs. |
| Water Pump | 248 lbs. |
| Control Governor | 112 lbs. |
| Governor Drive Assembly | 159 lbs. |
| Oil Pan | 995 lbs. |
| Free-End Cover | 1,330 lbs. |
| End Cover (Generator End) | 89 lbs. |
| Lube Oil Cooler (Dry) | 570 lbs. |
| Lube Oil Filter Tank (Dry-including 8 elements) | 600 lbs. |

# LOCOMOTIVE DESCRIPTION

## GENERAL

The General Electric Model U25B diesel-electric locomotive is especially designed and built to meet the requirements of modern high-speed freight traffic. The design provides for high horsepower per axle with a minimum of equipment and weight. With available modifications, the locomotive can be used in passenger service.

## POWER PLANT

### DIESEL ENGINE

The locomotive is powered by a 16-cylinder four stroke cycle, turbocharged diesel engine with 9 inch by 10 1/2 inch cylinders in a 45 degree Vee arrangement. The engine has an integral head and cylinder arrangement which can be removed in a minimum of time. It is equipped with cast-iron pistons, valve seat inserts and the Bendix fuel system. The cylinder liner is chrome plated and 3/16 inches thick.

### GOVERNOR

The engine governor is of the self-contained, electro-hydraulic type. It automatically regulates the horsepower output at each throttle setting.

### OVERSPEED PROTECTION

The engine is automatically shut down if the speed exceeds maximum rated r.p.m. by 10 per cent.

### COOLING SYSTEM

Water is circulated through the engine, turbosupercharger, radiator, and lubricating-oil cooler by a gear-driven centrifugal pump integral with the diesel engine. An expansion tank is provided with a sight gage to indicate water level; fill pipes are located on each side and at the roof of the locomotive.

### ENGINE TEMPERATURE CONTROL

A flow control valve, thermostatically operated, automatically maintains temperature by regulating the flow of cooling water through the radiator sections.

# LOCOMOTIVE DESCRIPTION

## FUEL SYSTEM

A motor-driven pump transfers fuel from the tank through filters to the injection pumps.

Each cylinder is equipped with high pressure fuel injection pump and injector.

## LUBRICATING SYSTEM

A full-pressure system is supplied by a gear-type pump integral with the diesel engine.

A lubricating-oil reservoir is located in the engine sub-base. Lubricating oil filters, strainer, and water cooled oil cooler are provided. Abnormally low lubricating oil pressure automatically shuts down the engine.

## ENGINE STARTING

The diesel engine is cranked by the traction generator from storage battery power.

## ELECTRIC TRANSMISSION

## TRACTION GENERATOR

One General Electric, GT-598 traction generator is mounted directly on the engine. It is a direct -current, single anti-friction bearing, separately-excited machine and is equipped with windings to permit starting the engine by storage battery power.

## TRACTION MOTORS

Four, General Electric GE-752 traction motors are furnished. The traction motor is direct current, series wound, separately ventilated by the cleaned-air system. The armature is mounted in anti-friction bearings.

Motors drive through single-reduction spur gearing. They are supported by the axles to which they are geared and by resilient nose suspensions on truck transoms.



LOCOMOTIVE DESCRIPTION

## CONTROL

The locomotive is equipped with General Electric railway-type single end-single unit control and basic equipment. Control devices are grouped in a pressurized steel compartment, fitted with access doors. The reverser and line contactors are electro-pneumatically operated. Other contactors are magnetically operated. Circuit breaker type switches are used in control circuits where overcurrent protection is required.

Transition is automatic.

## EXCITER

One General Electric, Type GY-50 is provided. It is gear-driven from the traction generator and provides controlled excitation of the traction generator field.

## BATTERY-CHARGING GENERATOR

One General Electric, Type GY-27 battery-charging generator is provided.

It is gear-driven from the traction generator and furnishes power at regulated potential for battery charging, lighting and control.

## STORAGE BATTERY

A 32-cell lead acid type storage battery is furnished for starting the engine and to furnish power for lights and other auxiliaries when the engine is shut down.

## WHEEL SLIP CORRECTION

Wheel slip is automatically detected by comparison of output signals from an alternator mounted on each axle. Slip is corrected by an automatic light application of locomotive brake.

## GROUND RELAY PROTECTION

If a ground occurs, engine speed returns to idle, power is removed and visual indication is given to the operator.

# LOCOMOTIVE DESCRIPTION

## OPERATING CONTROLS

Controls and instruments for operating the locomotive are grouped at the operator's station and at auxiliary panels in the operator's cab.

Operating Controls:

Controller with throttle reverser, and selector levers.
Engine start push buttons. Engine stop push button. Brake valves.
Sander valve. Bell ringer valve. Air horn valve.
Window wiper.
Circuit breakers and switches.
Emergency engine stop button.
Emergency fuel shutoff.

Instruments:

Brake gages. Load meter.

Warning Indicators:

Low engine lubricating oil pressure -- alarm bell and warning light.
High engine water temperature -- alarm bell and warning light.
Wheel slip -- buzzer and warning light
Ground relay -- red indicator
Engine shutdown -- alarm bell
No battery charge -- alarm bell and warning light

A number of accessories and modifications are available to suit customer needs.

## LOCOMOTIVE BRAKES

### AIR BRAKES

Schedule 26L with D control valve combined independent and automatic is furnished as basic equipment.

Locomotive brakes may be operated either independently or with train brakes. Connections for furnishing compressed air to the train brakes are provided at each end of the locomotive.



LOCOMOTIVE DESCRIPTION

### COMPRESSOR

One, 3 cylinder, 2 stage, water-cooled engine-driven air compressor furnishes air for the locomotive and train braking systems.

### RESERVOIRS

Two reservoirs are furnished for storing and cooling air for the brake system.

### BRAKE EQUIPMENT

Brake cylinders are mounted on the truck frames and operate fully equalized brake rigging, which applies brake shoes to each wheel.

Brake rigging is furnished with hardened steel bushings, and adjustment is provided to compensate for wheel and shoe wear. Two brake shoes are provided per wheel.

### HAND BRAKE

A hand brake located in the front compartment is provided for holding the locomotive at standstill.

## RUNNING GEAR

The running gear of the locomotive consists of two four-wheel, two-axle, side-equalized, swing motion swivel trucks.

The truck frame, bolster, and spring plank are of cast steel. The frame is supported by two equalizers on each side with coil springs between the equalizer and the frame. Elliptic springs are applied between the bolster and spring plank. The spring plank is supported by forged steel swing links pinned to the truck frame.

# LOCOMOTIVE DESCRIPTION

## WHEELS

Solid multiple wear, rim-treated rolled steel of 40 inch diameter. The wheels have standard AAR tread and flange contour.

## AXLES

Axles are of forged open hearth steel, conforming to AAR material specifications.

## JOURNAL BOX

Journal boxes are equipped with roller bearings, grease-lubricated.
Journal box guides, housings, pedestal openings and equalizer seats are lined with renewable steel wear-resistant plates.

## CENTER BEARINGS

Center bearings are equipped with hardened steel liners, arranged for lubrication and protected by dust guards.

## SIDE BEARINGS

Side bearings with renewable wear-resistant steel plates are provided.

## SAFETY HOOKS

Body and truck safety hooks are provided to prevent slewing and to permit the trucks to be lifted with superstructure.

## SUPERSTRUCTURE

The superstructure, of welded steel construction, consists of a front hood, an operator's cab, an engine hood and a radiator compartment. The hoods are bolted to the underframe and are removable on some models. On others only the engine hood is removable.

## FRONT HOOD

The front (short) hood contains sandboxes and a dry type sanitary fixture. Doors and a roof hatch provide access. Headlights, marker lights and number boxes are arranged for maximum accessibility.



LOCOMOTIVE DESCRIPTION

## OPERATING CAB

The sides and roof of the operating cab are insulated and steel lined. The floor, raised above the platform, is insulated and covered with heavy duty vinyl tile.

The cab has safety glass windows in the front, rear and each side, providing visibility in all directions. Two-pane center windows on each side of the cab have sliding sash equipped with latches. All other windows are fixed and mounted in rubber self-sealing sash.

One door on each side of the operating cab provides access to walkways along the hoods. The doors have windows, weather stripping and provision for locking.

## WALKWAYS

Platform walkways with handrails and non-skid treads are provided at each end of the locomotive and along the hoods.

## ENGINE HOOD

The engine hood encloses the diesel engine, the traction generator and the air compressor.

Full height side access doors extend the length of the engine and generator on both sides of the hood. Doors in the roof provide access to engine cylinders. Detachable roof sections permit removal of equipment.

## RADIATOR COMPARTMENT

The radiators are roof-mounted. A reinforced screen over the air outlet opening is removable to allow access to the radiators, fans and gearbox, and the equipment air cleaner. Dynamic braking grids, when provided, are mounted along each side of the radiator compartment.

An end section holds two sandboxes, serviced from the outside walkway, rear headlights, marker lights and number boxes.

## LOCOMOTIVE DESCRIPTION

EQUIPMENT COMPARTMENTS

Main propulsion control equipment is located on the left side of the locomotive beneath the operating cab. This compartment, maintained under positive air pressure to keep out dirt and water, contains contactors, reverser, braking switch, resistors and auxiliary electrical devices.

All air brake devices and air operated equipment, battery trays, and air filter assemblies for the engine are located in easily accessible compartments along the sides of the locomotive.

VENTILATION

Mechanically filtered air is provided through a large self-cleaning air cleaner in the bottom of the radiator compartment and is delivered under pressure for the engine, for equipment cooling, and cab ventilation. Engine air is additionally cleaned by oil bath filters.

### UNDERFRAME

The underframe is fabricated by welding, using low alloy steel sections and plate, with cast steel centerplate bolster, bolster side members and draft gear housing.

Hoods, cab, equipment and tanks are supported by the main frame members. Space between these members is enclosed with plate, top and bottom, to form an air duct.

WEARPLATES

Renewable, wear-resistant hardened steel plates are applied to the center bearing side bearing pads and draft gear housing.

COUPLERS

AAR Type E top-operated couplers with rubber-cushioned draft gear are provided at each end of the locomotive.

PILOTS AND SIDE STEPS

A pilot is provided at each end. Side steps providing access to the platform are integral in each side of each pilot.



## LOCOMOTIVE DESCRIPTION

LIFTING AND JACKING

Four jacking pads in combination with lugs for cable slings are integrally cast in the side bolsters.

FUEL TANK

A heavy gage welded steel fuel tank is bolted to the underframe between the trucks. Filler connections and fuel level gages are furnished on each side of the locomotive. An emergency fuel trip valve, baffle plates, clean-out plugs and water drains are provided.

# DIESEL ENGINE
# DESCRIPTION & SPECIFICATIONS

## COMPONENT LOCATION TERMS

The following terms will be used throughout this book in locating various components on the engine. (See FIG. 3-1.) Their designation or explanation is as follows:

FREE END - The end of the engine where the turbocharger and intercoolers are mounted.

GENERATOR END - The end of the engine where the generator is mounted.

RIGHT AND LEFT SIDE - The right or left side of the engine is determined by viewing the engine while facing the generator end.

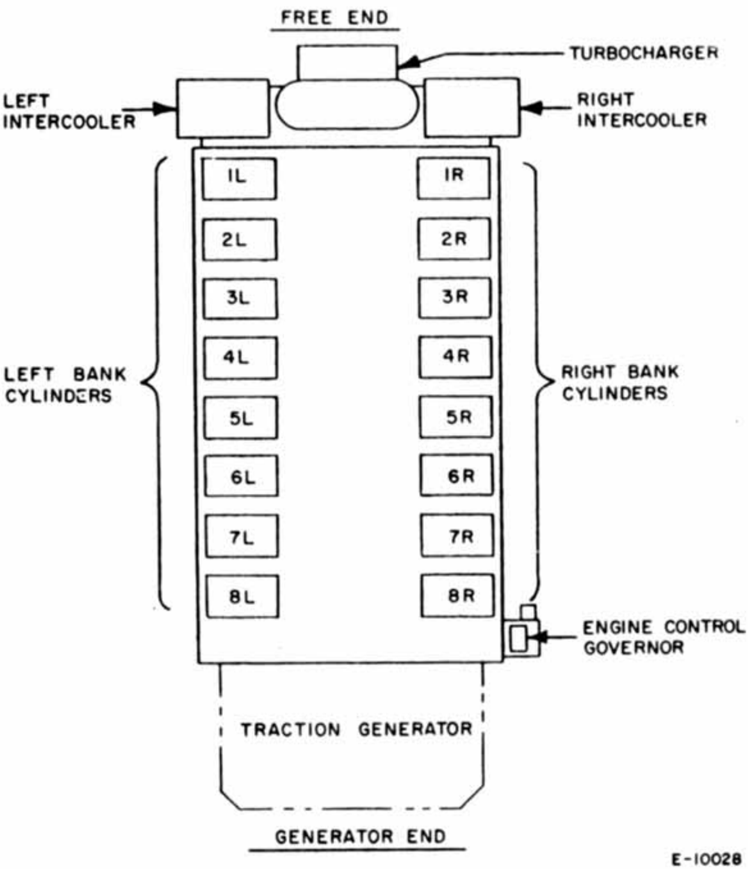
CYLINDER LOCATION - The cylinders are numbered from the FREE END to the GENERATOR END. (Number 1 Right and 1 Left cylinders are nearest the turbocharger. Number 8 Right and 8 Left cylinders are nearest the generator.)

CRANKSHAFT ROTATION - During engine operation the crankshaft rotates clockwise when viewed from the FREE END or counterclockwise when viewed from the GENERATOR END.

## ENGINE SPECIFICATIONS

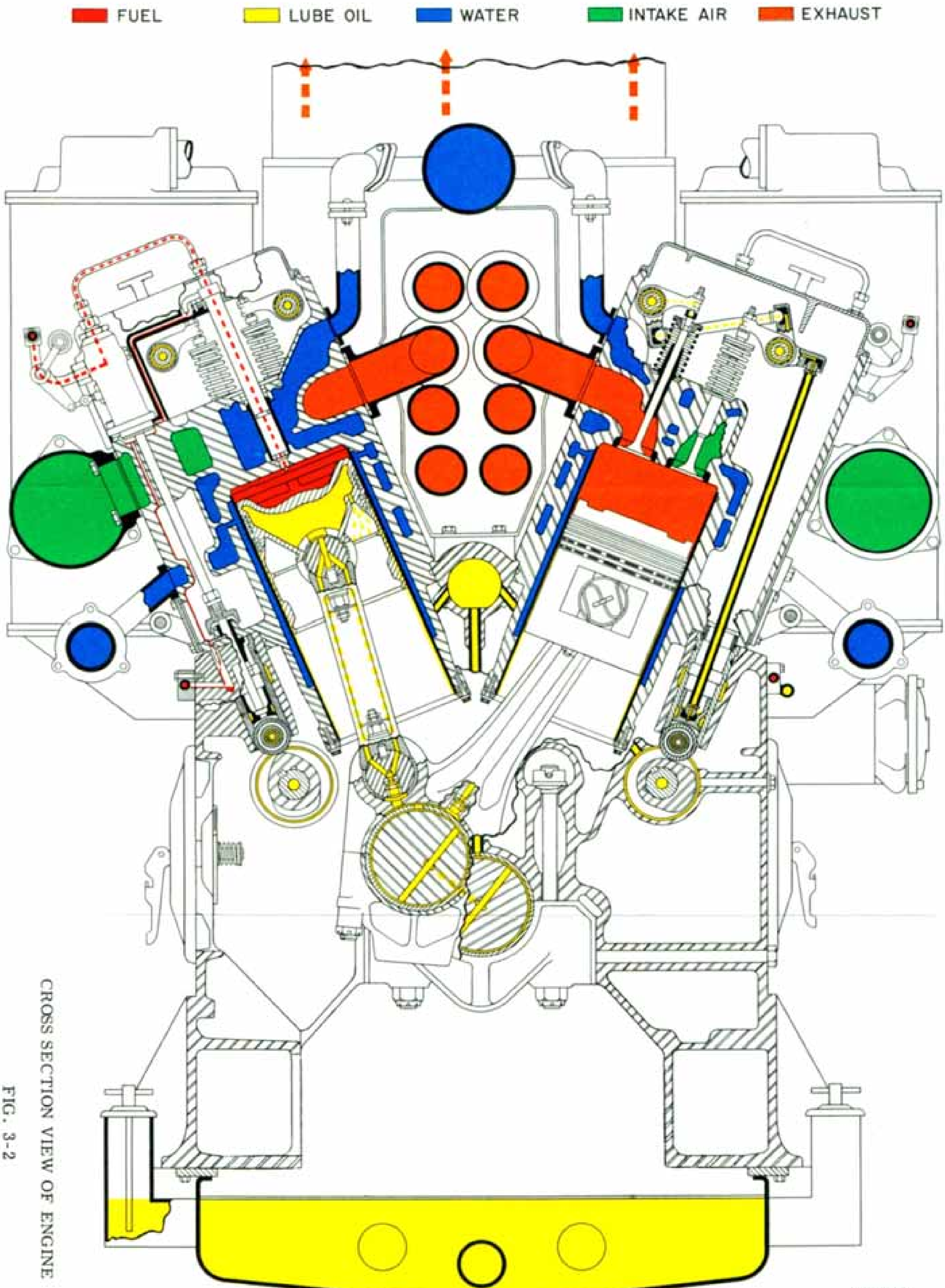
| | |
|---|---|
| Model | 7FDL16 |
| Gross Horsepower | 2750 |
| Number of Cylinders | 16 |
| Stroke Cycle | 4 |
| Cylinder Arrangement | $45^{o}$V |
| Bore | 9-In. |
| Stroke | 10 1/2-In. |
| Compression Ratio | 12.7-1 |
| Idle Speed | 400 RPM |
| Maximum Governed Speed | 1000 RPM |
| Firing Order | 1R - 1L - 5R - 5L - 2R - 2L - 6R - 6L<br>8R - 8L - 4R - 4L - 7R - 7L - 3R - 3L |
| Turbocharger | Single |
| Engine Dimensions | |
| Height (Overall Including Stack) | 8 Ft. 10 3/4 In. |
| Length (Overall Including Generator) | 21 Ft. 8 7/16 In. |
| Width (Overall) | 5 Ft. 8 1/4 In. |
| Weight (Including Generator) | 57,000 Lbs. |

# DIESEL ENGINE DESCRIPTION & SPECIFICATIONS




SCHEMATIC OVERHEAD VIEW OF ENGINE

FIG. 3-1




CROSS SECTION VIEW OF ENGINE

FIG. 3-2

# LUBRICATING OIL SYSTEM

## DESCRIPTION

The engine lubricating oil system provides pressure lubrication to bearings within the engine and carries away heat produced by friction and combustion.

The lubricating oil system consists of the following components in their order of oil flow. See FIG. 4-7.

1. Engine crankcase
2. Pump
3. Relief valve
4. Filter
5. By-pass valve
6. Cooler
7. Regulating valve
8. Strainer
9. Engine supply system

An oil pan is bolted to the main frame to enclose the bottom of the crankcase and hold the oil supply. Two oil fill openings, one on each side of the crankcase, are sealed by removable-type plugs to which dip-sticks are attached.

Oil from the crankcase is drawn over an inverted trap and into the suction side of the gear-type lube oil pump.

### OIL FLOW OUTSIDE THE ENGINE

Oil discharged from the pump is piped to the lube oil filter. A relief valve protects the system against excessive pressure.

Oil is forced through the oil filter which contains eight identical, clamped-in elements. A by-pass valve is externally connected between the filter inlet and discharge pipe. This valve insures continuing engine lubrication if filters become clogged.

Oil discharged from the filter is conducted to the lower end of the oil cooler. Water flowing through tubes inside the cooler removes heat from the oil.

Oil discharged from the cooler is piped to the engine free-end cover and through the strainer mounted in the cover.

# LUBRICATING OIL SYSTEM

An oil pressure regulating valve, also mounted in the cover at the strainer inlet, controls engine oil header pressure and discharges excess oil to the crankcase.

## OIL FLOW INSIDE THE ENGINE

The main engine supply header and branch passages within the main frame conduct oil to all main bearings and the two free-end camshaft bearings. Oil enters the crankshaft from the main bearings and flows through angularly-drilled passages in the shaft to the connecting rod bearings.

Oil passes upward from the connecting rod bearings through drilled passages in the shaft to the connecting rod bearings.

Oil passes upward from the connecting rod bearings through drilled passages in the rods to lubricate the articulated rod bearings and piston pins and to cool the pistons. It then flows through openings inside the pistons to return to the crankcase.

Oil entering the two free-end camshaft bearings is conducted lengthwise through the drilled camshafts. Holes drilled radially into the shafts supply oil to each of the other shaft bearings.

The camshaft bearings contain annular grooves connecting to drilled passages in the engine main frame. Oil flows through these passages to the valve and fuel push rod cross-heads.

Oil also flows upward through the valve push rods to supply lubrication to the working valve parts at the top of the cylinder. Oil return is through the valve push rod cavities to lubricate the cams and cam rollers, then to the crankcase.

The free-end cover bearing and the idler gear bushings are lubricated through a passage from the oil header to an annular groove around the cover bearing. Another drilled passage connects the annular bearing groove to a drilled passage in the idler gear shaft. Oil from these bearings returns by gravity to the crankcase.

The turbocharger bearings receive lubrication through an external line flange-connected to the oil header at the



LUBRICATING OIL SYSTEM

free-end cover. From the turbocharger oil is returned to the crankcase through a pipe, also flange-connected to the cover.

Lubricating oil is piped to the governor drive assembly and to the low oil pressure shut-down device, located on the engine control governor. This pipe is flange-connected to the engine oil header at the generator end. Oil from the governor drive gear case returns to the crankcase internally

Oil supply for the overspeed governor is maintained in a small reservoir built into the governor drive gear case. The reservoir is kept filled by an oil passage in the drive gear bearings.

The camshaft gears are splash-lubricated through an orifice and pipe from the engine oil header.

The auxiliary drive gear, located on the crankshaft, is lubricated internally by oil flowing through a passage within the shaft and through the gear hub.

Bearings and drive gears of the oil and water pumps are lubricated by running partially submerged in lube oil contained within the free-end cover reservoir.

## LUBRICATING OIL

Heavy duty lubricating oil must be used. It is a neutral mineral oil compounded with suitable additives to provide a stable lubricant that is resistant to oxidation, is not corrosive, is resistant to the formation of acid and sludge, and upon removal will leave an engine that requires no further cleaning. The additives will also control foaming, pour-point, and viscosity index.

## LUBRICATING OIL PRESSURE

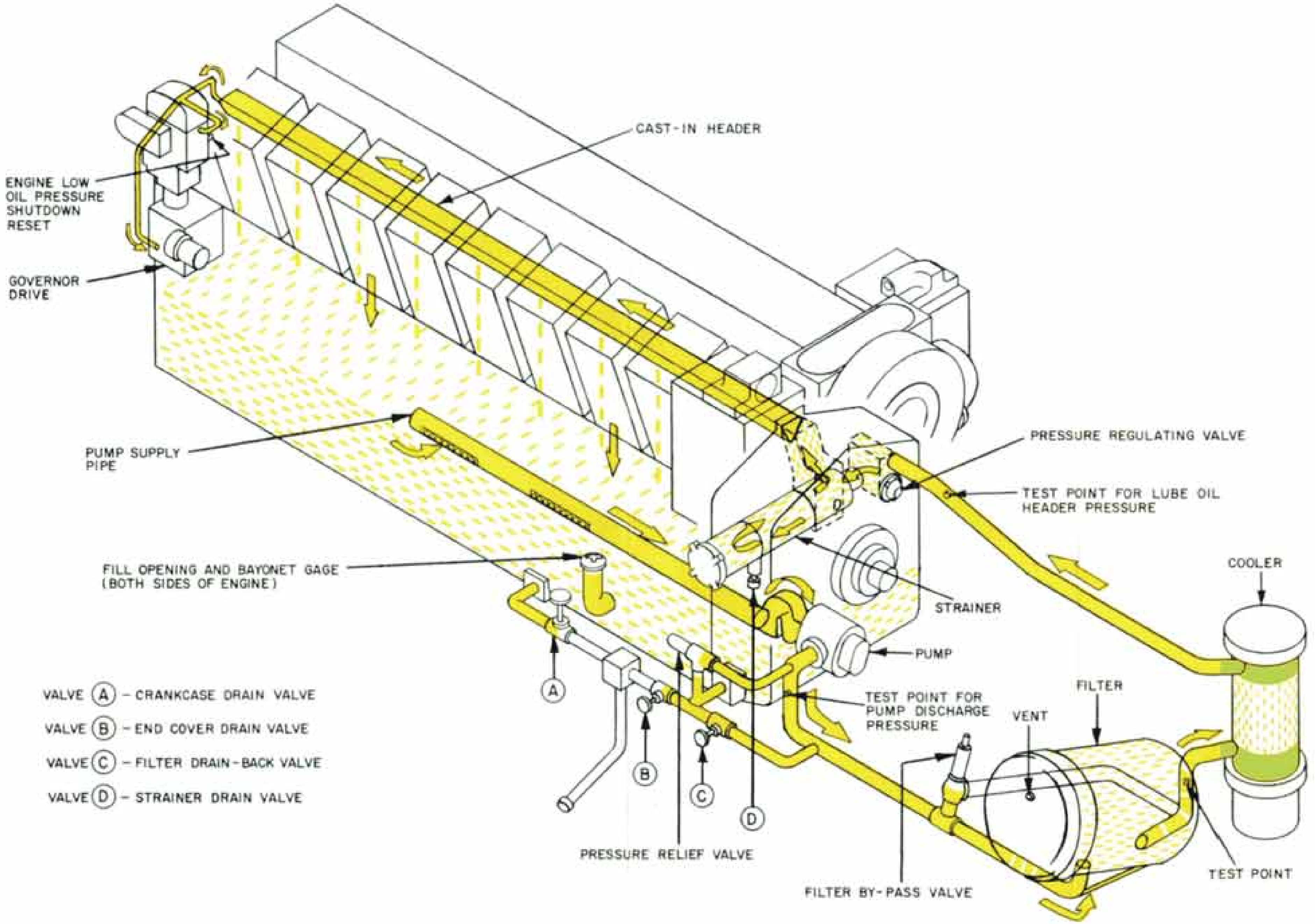
Oil pressure must be maintained at all times during engine operation. Insufficient or no oil pressure will cause extensive damage to bearings, pistons, cylinders and other moving parts within the engine.

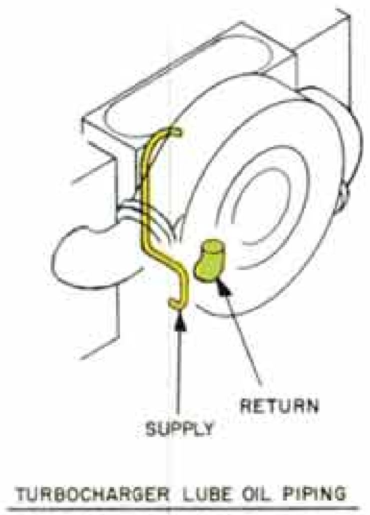
The low lube oil pressure device will stop the engine and turn on a yellow indicating light in the operator's cab if a condition of insufficient oil pressure exists.

# LUBRICATING OIL SYSTEM

When the engine is operating within its normal temperature range, the oil header pressure will be approximately as noted on the DATA sheet.

During engine starting, a time delay built into the low oil pressure shut-down device allows time for engine oil pressure to build up. If pressure fails to build up within the time allowed, the low oil pressure device will trip and prevent the engine from starting.

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LUBRICATING OIL SYSTEM

FIG. 4-7

# FUEL OIL SYSTEM

## DESCRIPTION

The engine fuel supply is contained in two fuel tanks located below the locomotive platform. Fuel is drawn from the forward tank by the electric-driven fuel-booster pump and circulated through the system. See FIG. 5-8.

The fuel system consists of the following components, listed according to fuel flow from the fuel tank and through the system:

1. Fuel Tank(s)
2. Emergency fuel cut-off valve
3. Primary filter
4. Fuel booster pump
5. Relief valve
6. Secondary filter
7. Engine fuel header
8. Injection equipment
9. Regulating valve

The suction side of the system is between the tank and the booster pump. Fuel is drawn through the emergency fuel cut-off valve and a two-element primary fuel filter before reaching the pump.

The pressure side of the system is between the booster pump and the pressure regulating valve which discharges excess fuel back to the tank. Fuel discharged by the booster pump flows to a three-element secondary fuel filter. A relief valve is connected to the pump discharge and protects the booster pump from overloads caused by flow restrictions in the pressure side of the system.

The three-element secondary fuel filter serves to more completely filter foreign particles from the fuel. Fuel is conducted from the secondary fuel filter through a pipe to the engine fuel header.

# FUEL OIL SYSTEM

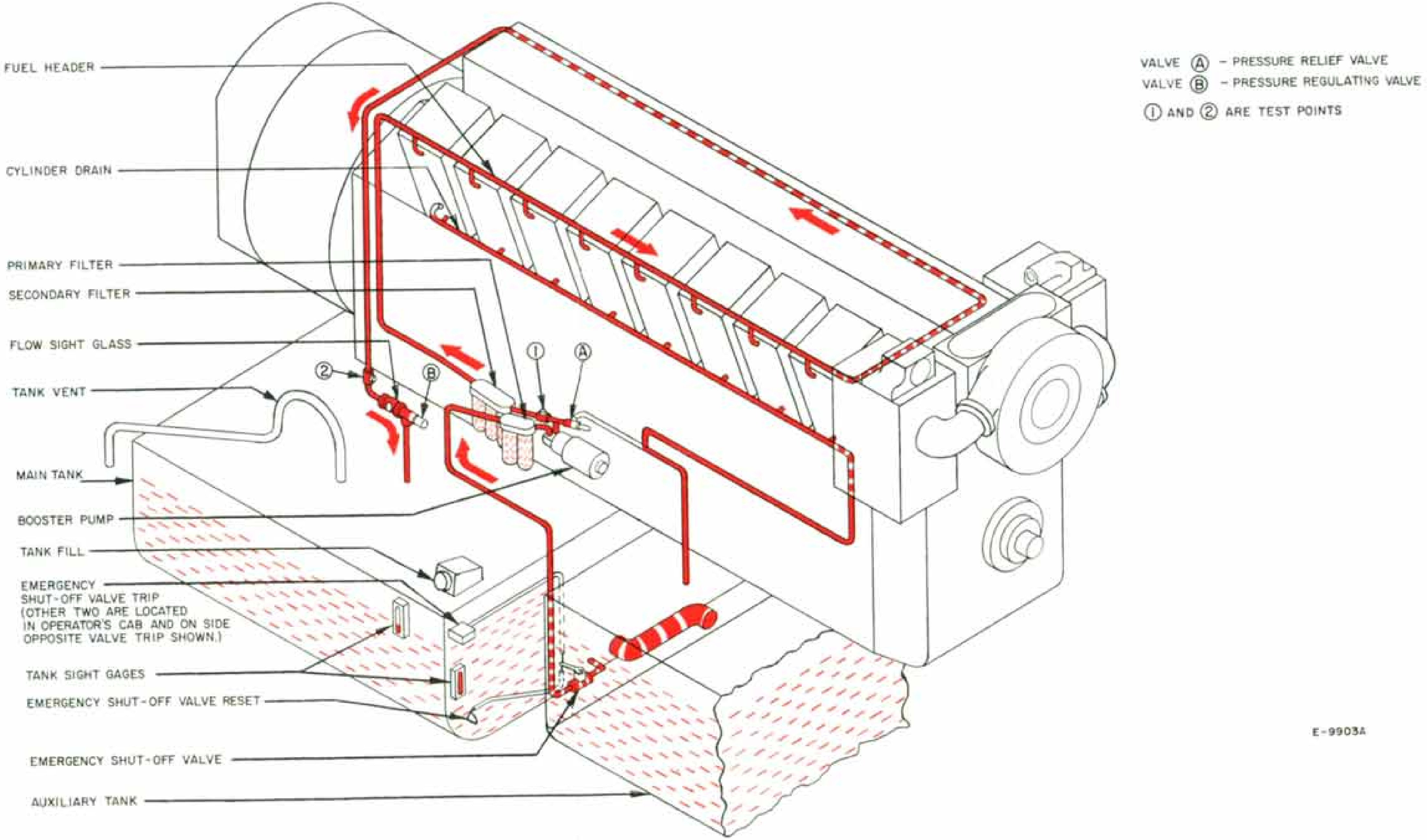
Individual flexible hoses connected between the injection pump inlet fittings make up the engine fuel header. The fuel header first supplies fuel to the injection pumps on the right bank, then crosses over near the turbocharger and supplies the injection pumps on the left bank.

Excess fuel returns to the tank through a regulating valve. The regulating valve is adjusted to maintain pressure in the engine fuel header.

## FUEL SUPPLY TANKS

A locomotive may be equipped with either of two arrangements of fuel supply tanks. One arrangement consists of one large capacity tank fitted between the trucks. The other consists of two tanks (main and auxiliary), the combined capacity of which, approximates the one large tank.

Filler connections, vents, and fuel level gages are furnished on each side of the locomotive. An emergency fuel trip valve, baffle plates, clean-out openings and water drains are also provided.




ENGINE FUEL OIL SYSTEM

FIG. 5-9

# COOLING WATER SYSTEM

## DESCRIPTION

### COMPONENTS

The cooling system consists of the following principal components:

1. Water Storage Tank
2. Water Pump
3. Water Inlet Headers
4. Water Discharge Header
5. Flow Control Valve
6. Radiator Panels
7. Cab Heaters

### SYSTEM OPERATION

The water storage tank is in an elevated location on the engine side of the bulkhead between the engine compartment and the radiator compartment. A water level sight glass is mounted on the side of the tank. Water and water treatment may be added through the fill pipe on top. On each side an additional pipe extends from beneath the underframe to the inside of the tank near its top. These pipes are for pressure filling, vent and overflow purposes. See FIG. 6-5.

The lubricating oil cooler is bolted to the bottom of the water storage tank. Water flows down through vertical tubes inside the cooler to cool lubricating oil circulating around the tubes. From the lube oil cooler water enters the gear-driven centrifugal water pump.

Water discharged from the pump enters a lateral passage in the free end cover of the engine which distributes it to the inlet water header pipes, the turbocharger and the intercoolers.

Each of the two inlet water headers is made up of eight individually removable sections, with each section including a flanged jumper pipe bolted to the cylinder. The sections are connected by Dresser couplings. The assembly is supported by the connections to the cylinders.

# COOLING WATER SYSTEM

The cylinder contains a wet-type liner surrounded by vertical fluted passages. The incoming water enters half of these passages and flows downward to the bottom of the liner where it crosses over to the alternate passages and flows upward into passages in the cylinder head to cool the upper head area. It then flows to the outlet header.

A portion of the system water flows through two intercoolers which cool the engine air supply. They are fabricated steel cases containing tube and fin-type radiator cores. Water enters the intercooler bases from a passage in the free-end cover of the engine. From the intercooler bases, water flows to the inlet water headers and also upward through the intercooler tubes. The two top covers conduct water to the discharge water header.

The turbocharger, located at the free end of the engine, is water cooled. Water enters the turbocharger casing through a jumper pipe flange connected to the free end cover water passage. Water is discharged through three openings located on the exhaust inlet side near the top of the turbocharger casing and connected to the left intercooler discharge pipe.

Water is supplied to the cab heater and air compressor from the engine inlet water header and is returned to the engine outlet water header.

The outlet water header is a single pipe centrally located lengthwise over the engine. Welded-in branch pipes are connected to individual cylinders by Dresser fittings. The water discharge header pipe is connected to a junction box mounted on top of the right intercooler. Water discharged from the turbocharger and intercoolers combines with cylinder discharge water and flows through a single pipe from the top of the right intercooler to the flow control valve.

The flow control valve regulates water temperature by routing the water as follows:

1. Directly to the water storage tank - when minimum engine cooling is required.
2. To the forward two radiator sections - when partial engine cooling is required.



# COOLING WATER SYSTEM

3. To all radiator sections - when full engine cooling is required.

Water is cooled in the radiators and returned to the storage tank. When only minimum cooling is required, or when the engine is stopped, the flow of water to the radiators is cut off and they drain by gravity into the storage tank. Thus, there is no possibility that they will freeze in cold weather.

## COOLING WATER TREATMENT

The water used in the engine cooling system should not contain an excessive amount of minerals which can cause scale formation when the water becomes heated. Such scale, if permitted to form on the inner surfaces of the cylinder-jackets, radiator-cores and other areas, will reduce heat transfer and cause restriction of water flow. Only clean, treated water should be used in the cooling system. Untreated distilled water is not recommended for use in the system because of its high content of free oxygen which will cause corrosion and rusting.

Water is said to be either acid or alkaline, depending on its chemical makeup. Proper alkaline condition of water is important in order to prevent corrosion of internal system parts.

The water should be tested for alkalinity once a month, or more often if necessary. This test must indicate that the cooling water has a ph value of 8.5 or greater. If the ph is less than 8.5, further treatment is necessary to protect against corrosion.

A number of suitable commercial chemical water softeners are available. One widely used in locomotive cooling systems is sodium chromate. To maintain a ph value of 8.5 minimum and a chromate concentration of 2000 parts per million minimum, chromate compound should be used in the proportion of 1/2 ounce by weight per gallon of cooling water.

Treatment chemicals should not be added to the system in a dry form. They should first be dissolved in a small quantity of water, then added to the system. If applied dry, directly to the system, the compound may not dissolve completely. Undissolved compound may cause restrictions within the system passages.

# COOLING WATER SYSTEM

If it is desirable to use a type of water treatment other than that mentioned, the manufacturer's recommendations must be closely followed.

## FILLING

The locomotive cooling water system can be pressure-filled through either fill pipe. To avoid damage do not apply over 25 psi water pressure to the system when filling. Filling may also be accomplished through the pipe on top of the water storage tank.

The pressure fill pipes are so arranged in the water storage tank that system venting and filling to proper level is automatic. When filling from one pipe the other functions as a vent and overflow. If excessive overflow is permitted when adding water to the system, a weakening of the water treatment will occur.

When filling the system from a completely drained condition, adjust the water to proper level after starting the engine. Correct system water level is indicated by marks on the side of the storage tank.

Large fluctuations in sight gage water level will occur during engine operation. When cooling is required, a portion of the water leaves the tank and is diverted to the radiators. This will lower the water level in the sight gage and is a normal condition which does not indicate that water should be added.

Normal operating temperature of the engine discharge water is thermostatically-controlled to maintain a temperature between 170 F and 175 F. This temperature can be measured at the flow control valve test opening. No manual adjustments are provided.

The high temperature alarm switch is adjusted to close its electrical contacts when the engine discharge water temperature is excessively hot. Closing and opening temperatures are listed on the DATA sheet at the end of this section.



# COOLING WATER SYSTEM

## DRAINING

Three manually-operated shut-off valves are used in the cooling system. See FIG. 6-5.

1. MAIN SYSTEM DRAIN VALVE (A). This valve, located near the base of the lubricating oil cooler, drains water from the engine, storage tank, and lubricating oil cooler.

2. SECONDARY DRAIN VALVE (B). This valve, located near the compressor, drains water from the air compressor, cab heater, and associated piping. Valve (C) must be open when draining through valve (B).

3. SHUT-OFF VALVE (C). This valve is located in the operator's cab at the cab heater inlet pipe. It regulates or stops water flow to the cab heater.

The system may be completely drained by opening valves (A), (B), and (C). In freezing weather, also remove the 1/4 inch drain plug located in the bottom of the water-pump impeller casing.

## FLOW CONTROL VALVE

Cooling water temperature is regulated by the flow control valve, an assembly made up of the six thermostats, two piston-type valves and a filter screen, all housed in a fabricated steel case.

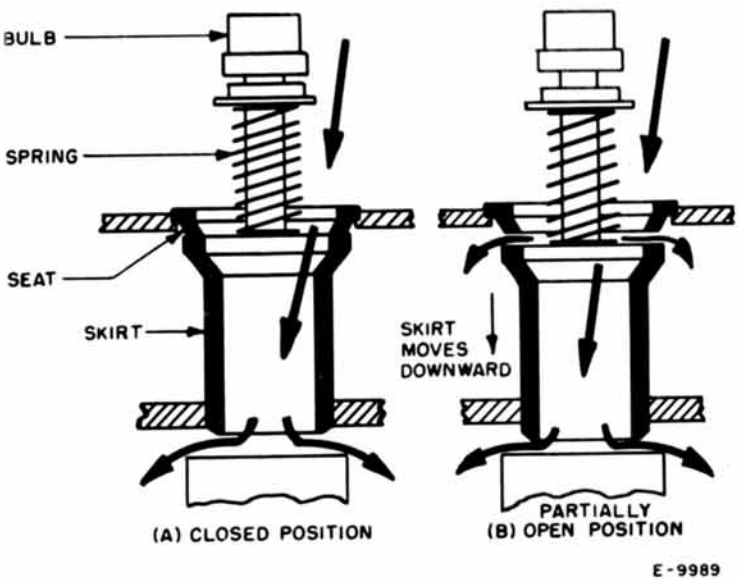
Located on top of the water tank, the flow control valve case has a removable top cover to permit access to the internal parts. A temperature or pressure gage can be installed in the pipe boss on the side of the case for test.

### VALVES WITHIN THE CASE

The thermostats function as two-way valves. When water temperature is below their operating point, as in FIG. 6-1 (A), they pass the water directly through their cylindrical bodies to the water tank below.

When the water temperature increases, the temperature-sensitive compound in the bulb (located on top) expands, overcoming spring pressure and forcing the skirt

## COOLING WATER SYSTEM




OPERATION OF THERMOSTATS

FIG. 6-1

downward. (See FIG. 6-1 (B).) As this skirt moves, the opening at the bottom becomes more and more restricted, while the previously closed opening at the top of the skirt - increasing in size - permits water pressure to start building up in the adjacent chamber.

The thermostats are identical and are individually renewable. The cooling system will operate satisfactorily with as few as four of the six thermostats functioning, except during extreme conditions of ambient temperature.

Successful operation of the system during freezing weather depends upon water flow through the radiator sections being either at a high rate or completely off. If trickles of water were permitted to pass through the radiators, ice would form in the tubes.

These conditions of flow are controlled by the two "snap action" piston-type valves, V1 and V2. (See FIG. 6-2.) Vertically-mounted within the case, they each consist of an



## COOLING WATER SYSTEM

upper and a lower piston connected by a stem. These valves are identical and interchangeable. The center portion is hollow to permit water which leaks past the upper pistons to return through the valves to the storage tank. Thus leakage has no effect on operation. To assure accurate operation, the weight of each valve is held within close limits during manufacture.

### COMBINED OPERATION

The flow control valve regulates the temperature of the cooling system by directing water flow in the following manner:

1. When minimum engine cooling is required (FIG. 6-2):

   Water discharged from the engine enters Chamber A to flow downward through the filter screen and thermostats. Since the thermostats are below operating temperature, water passes through their lower openings to the tank.

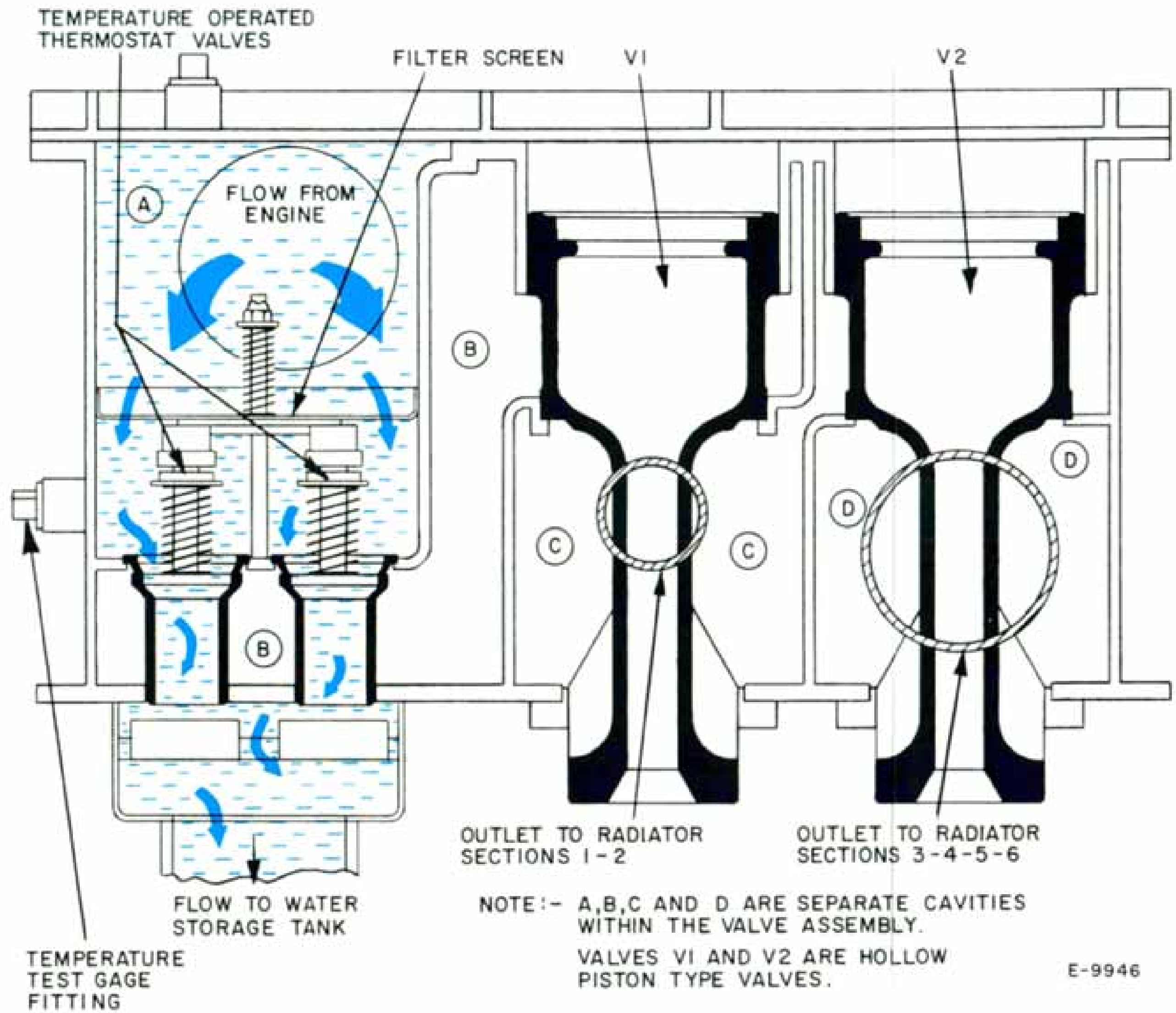
2. When partial engine cooling is required (FIG. 6-3):

   As the engine discharge water temperature rises, the thermostats begin to operate. Downward movement of the skirts partially restricts water flow to the tank. At the same time, openings at the top of the lower skirts allow water to enter Chamber B.

   Pressure now begins to develop in Chamber B. When the thermostats have moved their skirts enough to cause this pressure to reach approximately 4 psi, valve V1 "snaps" upward to the limit of its travel.

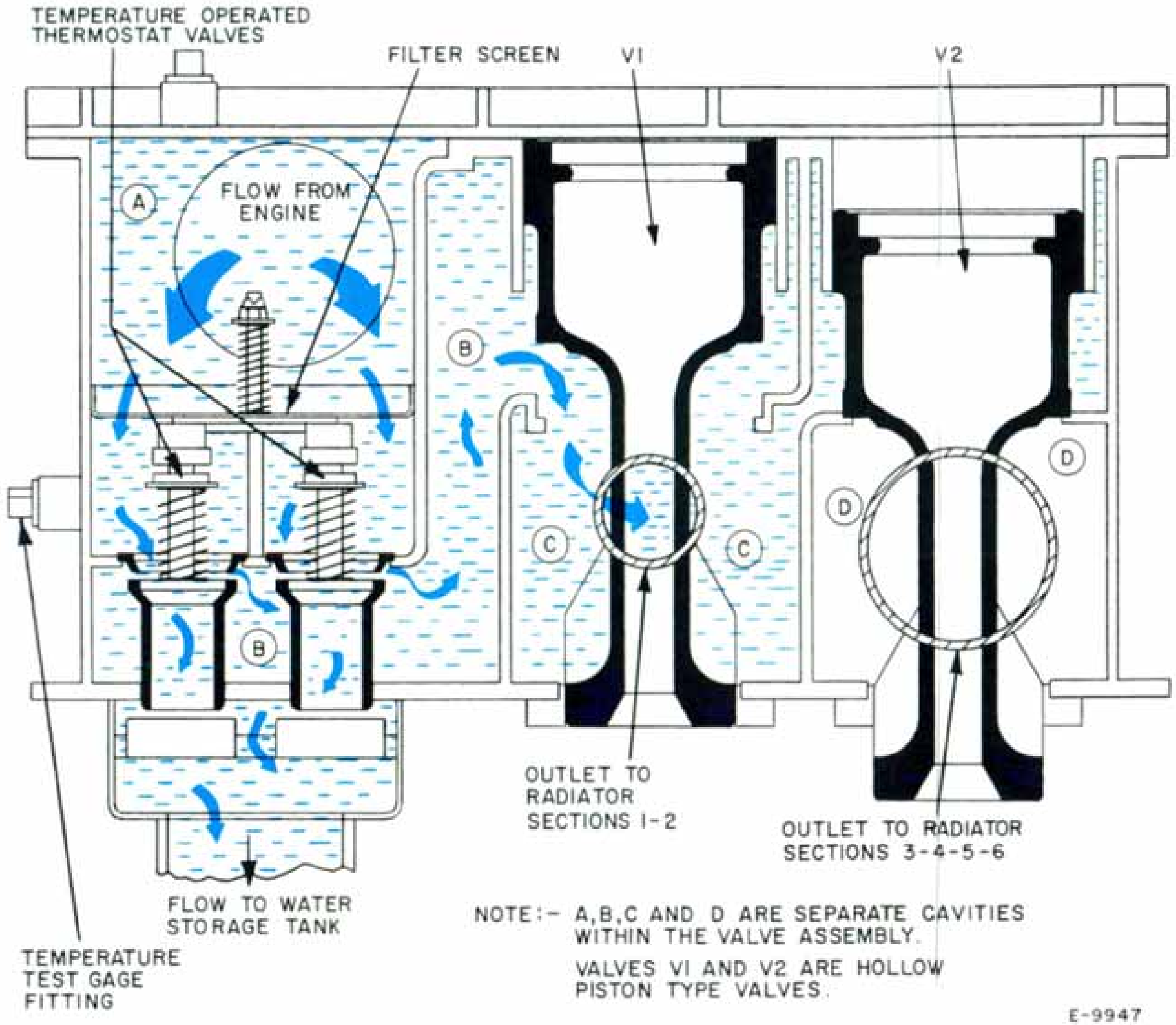
   Chamber B is now open to Chamber C, and Chamber C is closed to the storage tank by the lower piston of valve V1. Water flows from Chamber C through the pipe connection to radiator sections 1 and 2.

   At the moment valve V1 opens, water pressure in Chambers B and C falls somewhat below 4 psi, thus valve V2 does not open. Valve V1 remains up, however, because the area of the bottom of its upper piston that is exposed to pressure is still large enough to hold V1 up, even with reduced pressure.



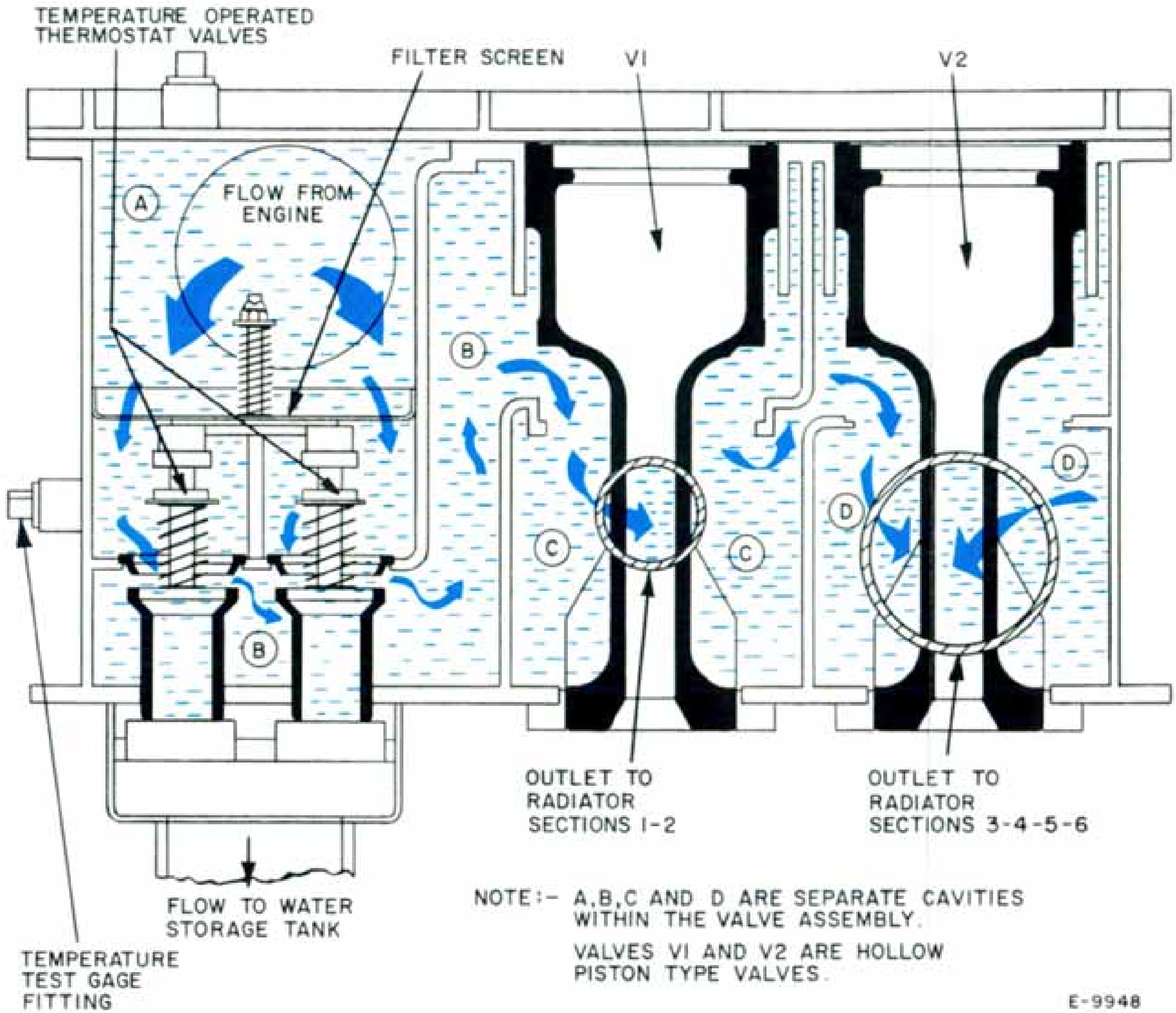

FLOW CONTROL VALVE OPERATION
CONDITION: MINIMUM ENGINE COOLING REQUIRED

FIG. 6-2




FLOW CONTROL VALVE OPERATION
CONDITION: PARTIAL ENGINE
COOLING REQUIRED

FIG. 6-3




FLOW CONTROL VALVE OPERATION
CONDITION: FULL ENGINE
COOLING REQUIRED

FIG. 6-4

# COOLING WATER SYSTEM

water flow to Chambers B, C and D. When the pressure in these chambers falls off to the point that it can no longer hold valves V1 and V2 open, gravity will pull both valves to their lower position, completely stopping flow to all radiator sections. All water will drain out of the sections back to the tank, due to air from the tank venting the radiators through Chambers C and D.

As determined by load and ambient conditions, the flow control valve will now repeat its cycle of operation, starting in Step 1.

## INSPECTION AND REPAIRS

It is not necessary to drain the water system to inspect or replace parts in the flow control valve. Proceed as follows:

1. Remove the top cover.

2. Check the piston type valves for free vertical movement by lifting and releasing.

3. Remove the filter screen and clean.

4. Remove the six thermostats and test in agitated hot water for proper operation. See DATA for temperature values. Replace defective units.

5. Reassemble parts and replace the top cover. Renew the cover gasket, if damaged.

## ENGINE HIGH TEMPERATURE SWITCH

The engine high temperature switch, mounted on the flow control valve case, should be tested in agitated hot water for correct pick-up and drop-out temperatures. See DATA for the proper values.

## RADIATORS

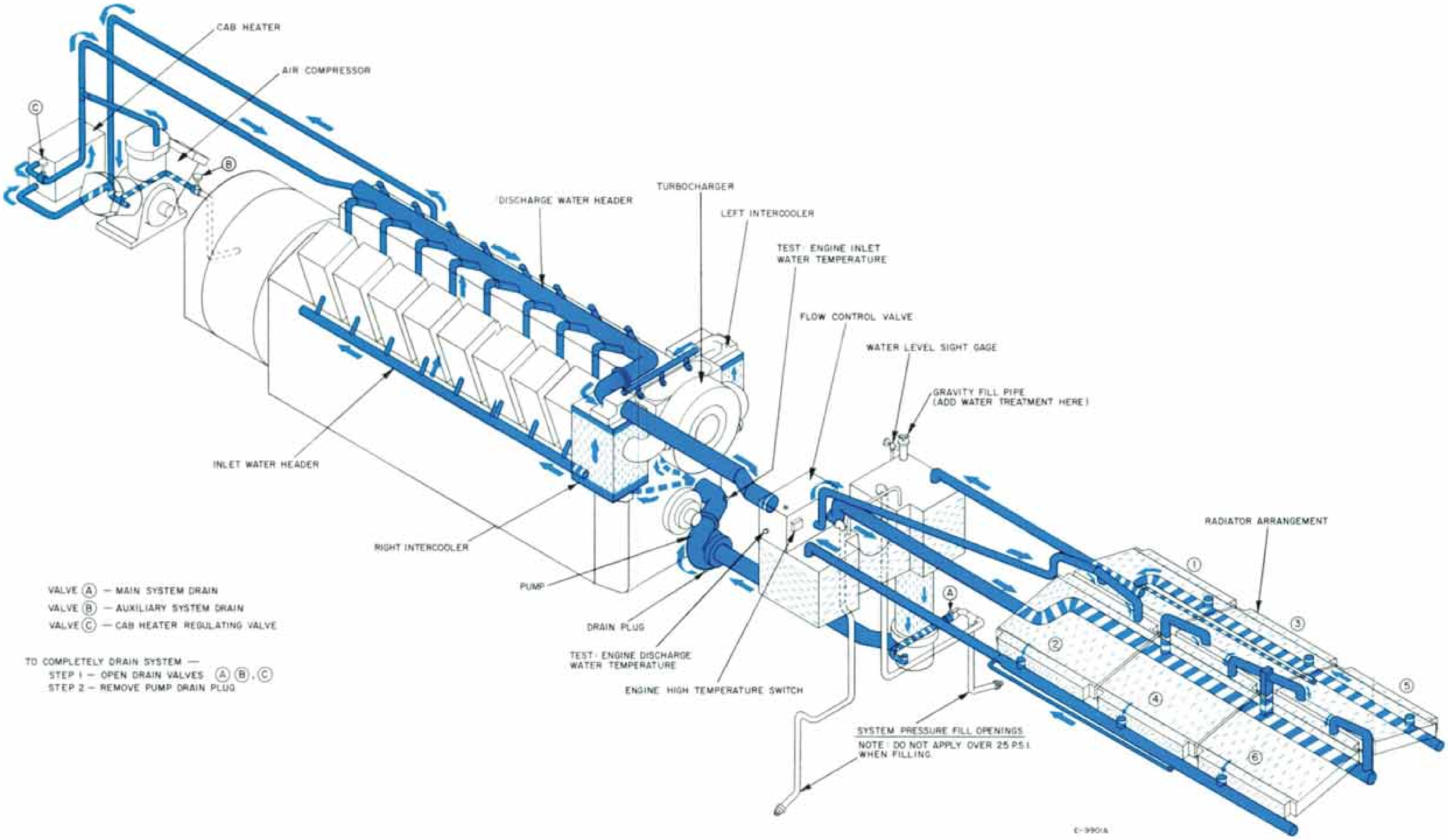
The radiator is made up of six individual sections, three on each side of the locomotive, mounted so as to slope downward from the locomotive center line to the outer sides. Wire screening is mounted over the upper side of the radiators to protect them from damage.

# COOLING WATER SYSTEM

Radiator sections are alternately numbered, odd numbers on the right, even numbers on the left starting from the water storage tank.

A pipe connects Chamber C of the flow control valve to the inlets of sections 1 and 2 of the radiator. Pipes connect Chamber D of the flow control valve to the inlets of radiator sections 3, 4, 5 and 6. Radiator pipe connections are made by various forms of Dresser fittings to permit easy removal.

Cooled water flows from the radiator panels through their respective drain header pipes to the water storage tank. A small pipe, connected parallel to the large drain header pipe, assures complete draining even if the locomotive is on track that is not level.




LOCOMOTIVE COOLING WATER SYSTEM

FIG. 6-5

# AIR SYSTEMS

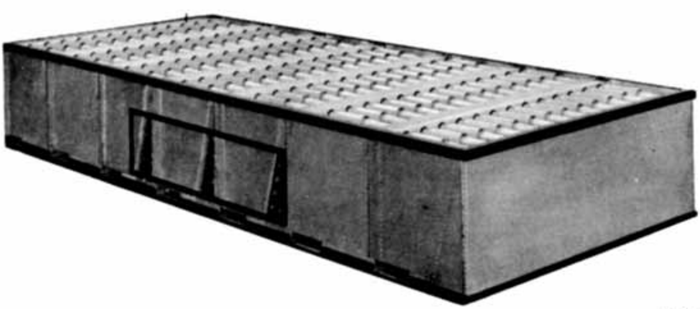
## DESCRIPTION

### LOCOMOTIVE AIR SYSTEM

All air used by the locomotive enters horizontally through both sides of the radiator compartment at the opposite end from the operator's cab. The incoming air passes first through the dynamic braking grids, if the locomotive is so equipped, and then divides its flow, with part of it being driven upward, through the radiators by the two radiator fans, and the remainder being driven downward by the equipment blower into the primary air cleaner. See FIG. 7-12. This is the air supplied to the engine, used for equipment cooling, and for ventilating the operator's cab.

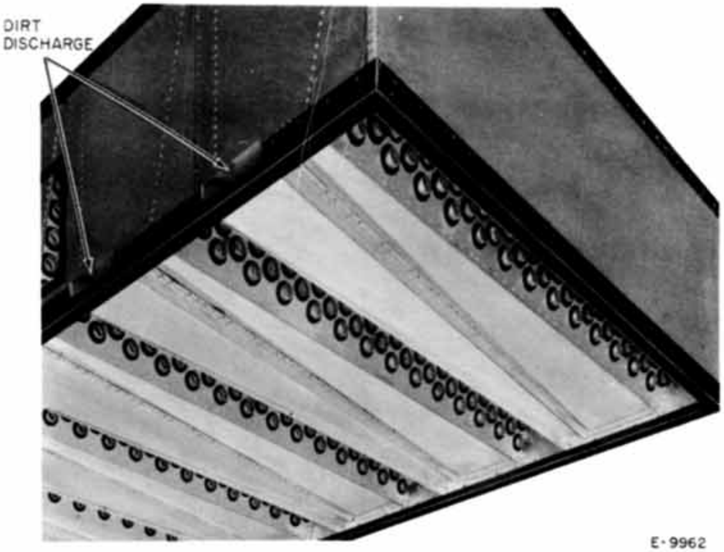
As shown in FIG. 7-1 and 7-2, the primary cleaner is made up of 1470 individual cleaning tubes, arranged in seven banks of 210 tubes each, with suitable ducts to direct the air flow.

Each tube acts as a miniature cyclonic dirt separator. Referring to FIG. 7-3, incoming air enters the outer tube around the periphery of the inner tube. Turning vanes cause the air to swirl. Dirt particles, being heavier, go to the outside, and eventually leave the far end of the outer tube. The clean air swirling in the central portion makes a 180 degree turn, coming out of the inner tube in the opposite direction to which it entered the outer tube.




PRIMARY AIR CLEANER - TOP VIEW

FIG. 7-1




PRIMARY AIR CLEANER - BOTTOM VIEW

FIG. 7-2

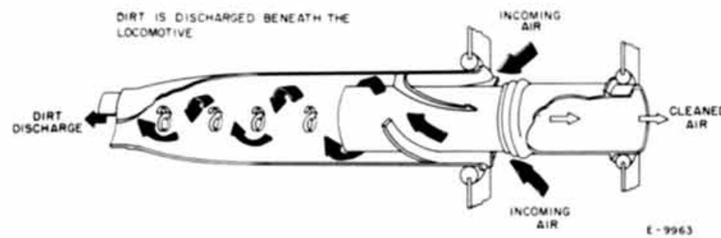
As shown in FIG. 7-2, a small opening at the bottom of each bank of tubes permits the separated dirt to escape. It is discharged from the locomotive continuously, through an outlet beneath the underframe. Approximately 5 per cent of the total air entering the cleaner is discharged with the dirt.

Test results show that all dirt particles 8 microns or larger are removed by this cleaner. Although some of the incoming dirt particles smaller than this will pass through with the cleaned air, the over-all efficiency of the cleaner is better than 95 per cent.

The greater portion of the cleaned air passes from the open bottom of the cleaner into the main air duct of the locomotive, which has been formed by enclosing the space between the center sills, top and bottom, with metal plates welded air tight.

The main duct supplies air to each traction motor directly, through a bellows-type connection. Other outlets supply air to the main generator, exciter, auxiliary genera-






PRIMARY AIR CLEANER TUBE

FIG. 7-3

tor and control compartment. Air is also circulated through the cab heater core section to supply the operator's cab and defrosters. Cab temperature may be controlled by adjusting shutters and a damper, and by adjusting a valve in the hot water line supplying the heater.

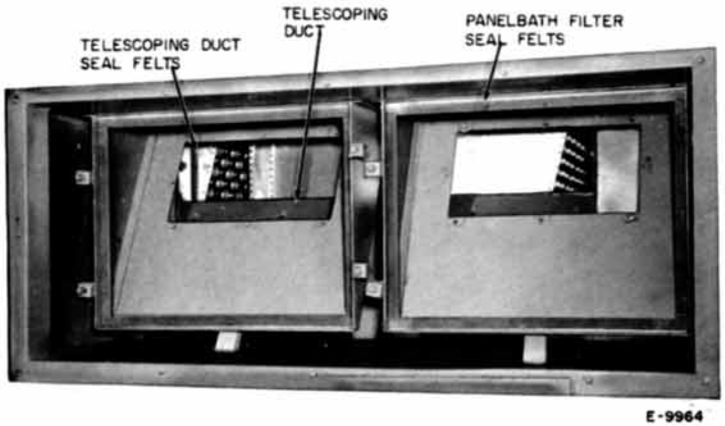
The portion of the cleaned air used for engine combustion is discharged from the triangular openings on each side of the primary cleaner through telescoping ducts slanting downward and outward into the Panelbath filter chambers. As shown in FIG. 7-4, the air flows around the bottom and sides of the Panelbath filters, enters the filters - where it is cleaned further - then flows into the top portion of these compartments and through ducting into the turbocharger.

ENGINE AIR SYSTEM

The turbocharger, driven by engine exhaust, compresses the air for delivery through intercoolers -- where part of the heat of compression is removed -- to the sectional air intake manifolds on each side of the engine.

The overspeed shutdown butterfly valves and their actuators are located between the outlets of the intercoolers and the first sections of the intake manifolds. In normal engine operation, the engine overspeed governor takes engine lube oil, increases its pressure, and delivers this oil to the butterfly valve actuators. Each actuator is con-

## AIR SYSTEMS




FILTER COMPARTMENT WITH PANELBATH FILTERS AND ACCESS COVERS REMOVED

FIG. 7-4

structed very much like an air brake cylinder. Pressure on the head causes the piston to advance, opening the butterfly valve.

When engine overspeed is detected by the overspeed governor it cuts off oil pressure supply to the butterfly valve actuators. Both actuator springs then return the pistons, closing the butterfly valves and cutting off air supply to both sides of the engine.

To prevent overheating of the oil being pumped to the butterfly valve actuators by the overspeed governor, as would result if no flow were permitted, the actuators are built so that a small amount of oil circulates through them to the crankcase. At the same time, this feature also hastens "dumping" the oil which is in the actuators and closing the butterfly valves when an overspeed is detected.

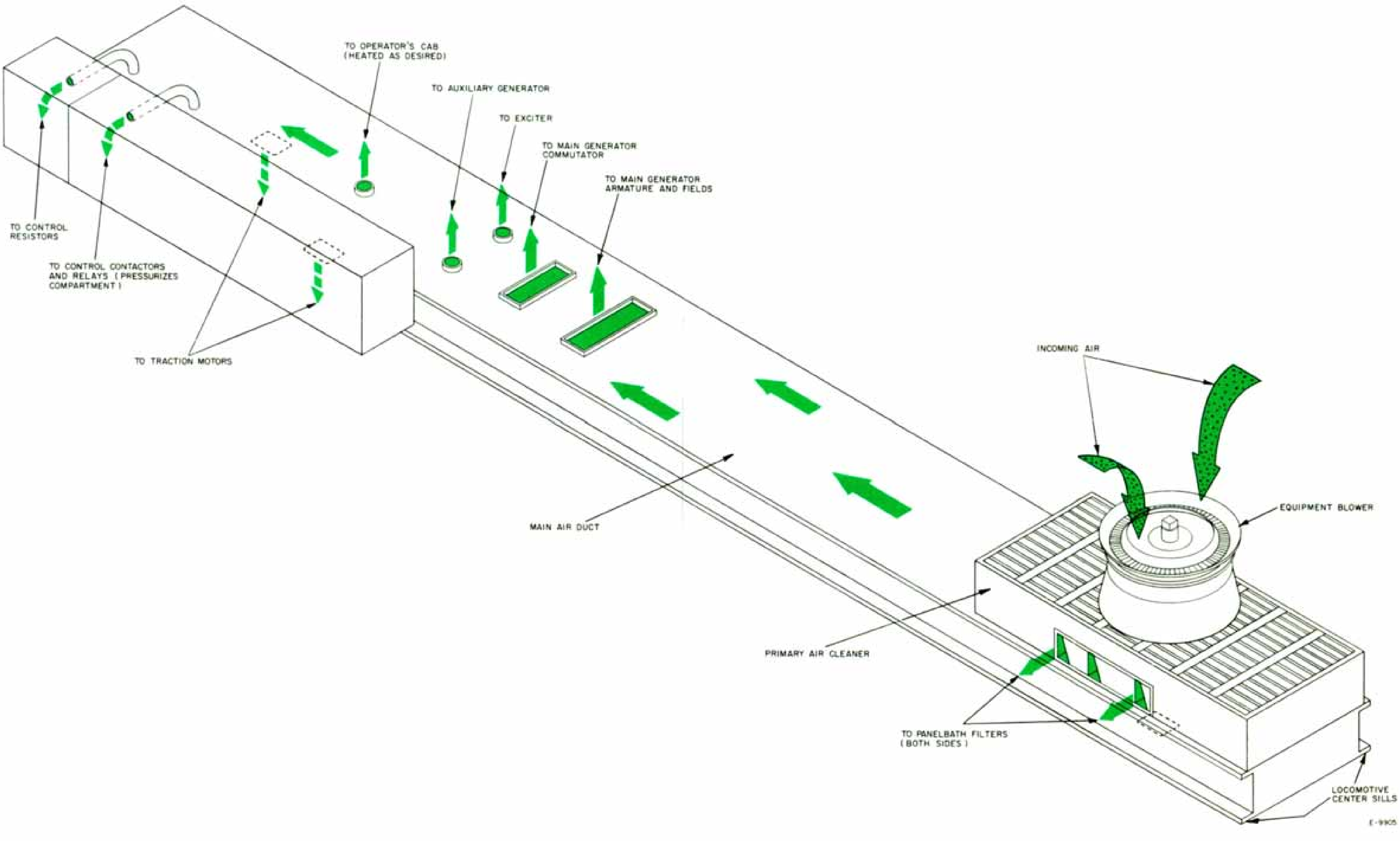
The sectional intake air manifold is made up of lightweight castings bolted to each cylinder with connecting sheet metal tubes sealed by "O" rings under clamping flanges. This allows easy application to the cylinder and eliminates the need for precise line-up of cylinder assemblies, intercoolers and manifolds.



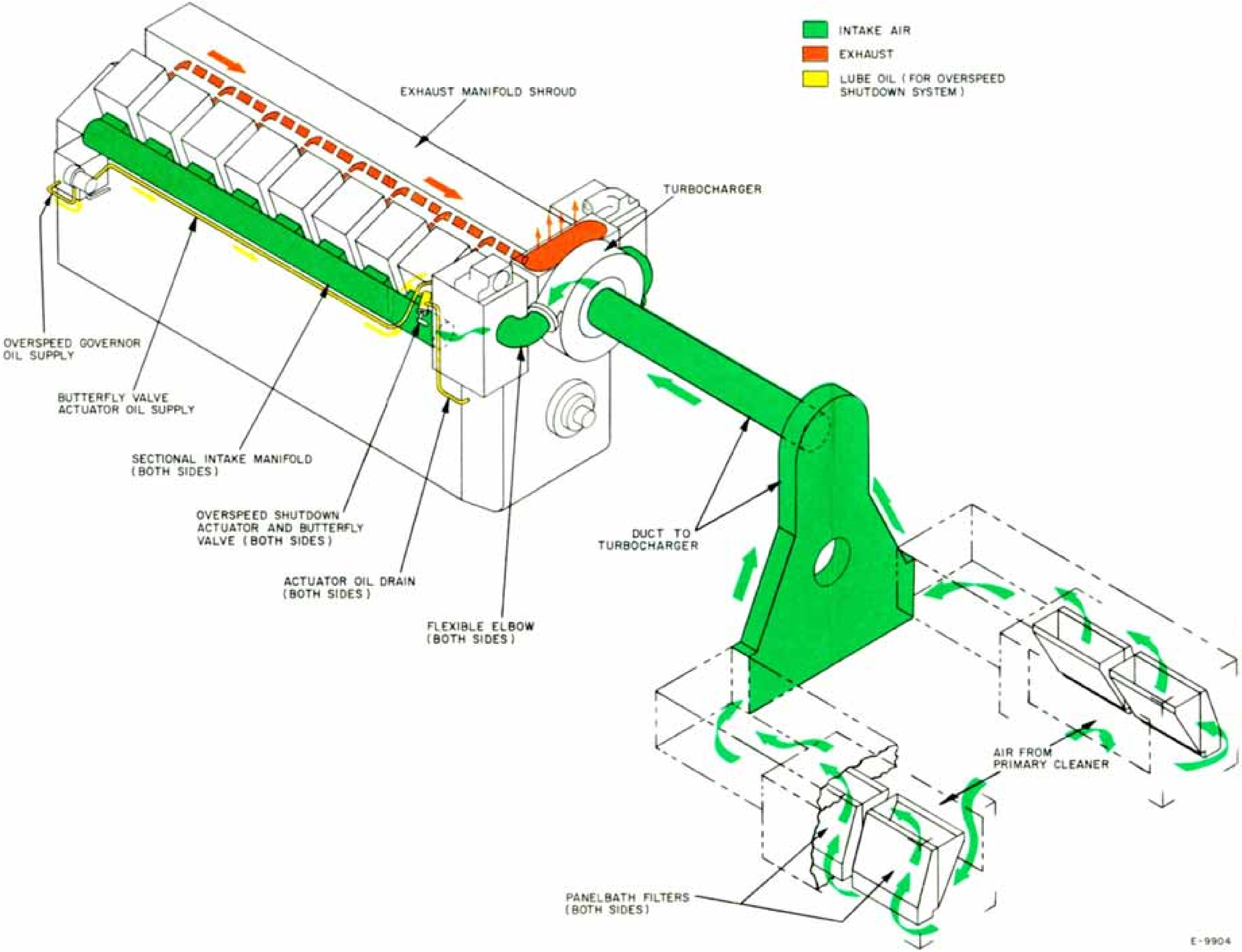
## AIR SYSTEMS

The diesel engine exhaust system consists of eight stainless steel exhaust pipes - surrounded by a metal shroud - which conduct the hot exhaust gases to the turbocharger inlet. Each individual exhaust pipe serves two cylinders. Each pipe for the first four cylinders on both banks is made in one section, with bellows providing flexibility and permitting thermal expansion. Each pipe serving the four rear cylinders in both banks is made in two sections. These sections are joined together by a bolted flange with gasket. The exhaust manifold is shown in FIG. 7-5 with the top portion of the shroud removed.

Each exhaust pipe is flange connected, with a gasket, to the turbocharger inlet.



TO OPERATOR'S CAB
(HEATED AS DESIRED)
TO AUXILIARY GENERATOR
TO EXCITER
TO MAIN GENERATOR
COMMUTATOR
TO MAIN GENERATOR
ARMATURE AND FIELDS
TO CONTROL
RESISTORS
TO CONTROL CONTACTORS
AND RELAYS (PRESSURIZES
COMPARTMENT)
TO TRACTION MOTORS
INCOMING AIR
EQUIPMENT BLOWER
MAIN AIR DUCT
PRIMARY AIR CLEANER
TO PANELBATH FILTERS
(BOTH SIDES)
LOCOMOTIVE
CENTER SILLS
E-9905




ENGINE AIR SYSTEM

FIG. 7-13

# OVERSPEED SYSTEM

## DESCRIPTION AND OPERATION

The function of the overspeed system is to protect the locomotive power plant by preventing excessive rotational speed.

The overspeed system consists of the following principal components:

1. Overspeed governor.

2. Two overspeed shutdown butterfly valves, each with a hydraulic actuator connected by mechanical linkage.

3. Associated interconnecting lines.

The overspeed governor is located on the right side of the engine below the speed control governor. Like the speed control governor, it is driven from the right bank camshaft gear through the governor drive gearing. See FIG. 8-1.

During normal engine operation, the overspeed governor delivers engine lubricating oil at regulated pressure of 200 psi to the actuators of the two overspeed shutdown butterfly valves.

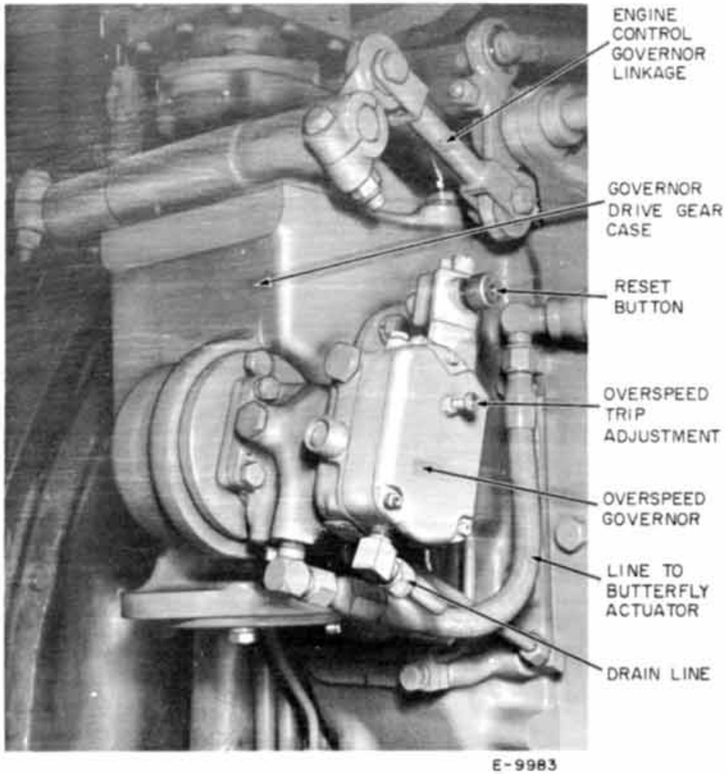
These valves are mounted, one on each side of the engine, between the air outlets of the intercoolers and the first sections of the intake manifolds. See FIG. 8-2.

The overspeed shutdown butterfly valves are shown in cross-section in FIG. 8-3. When open, they permit air to flow from the intercoolers into the intake manifolds. When closed, air supply to the engine is cut off.

The actuators of the butterfly valves are constructed very much like an air brake cylinder. Oil under pressure from the overspeed governor causes the actuator pistons to advance, opening the butterfly valves.

When engine overspeed is detected by the overspeed governor, it cuts off oil pressure to the butterfly valve actuators and permits the lines to drain. The actuator springs then return the pistons, closing the butterfly valves and cutting off air supply to both cylinder banks.

## OVERSPEED SYSTEM




OVERSPEED GOVERNOR ARRANGEMENT

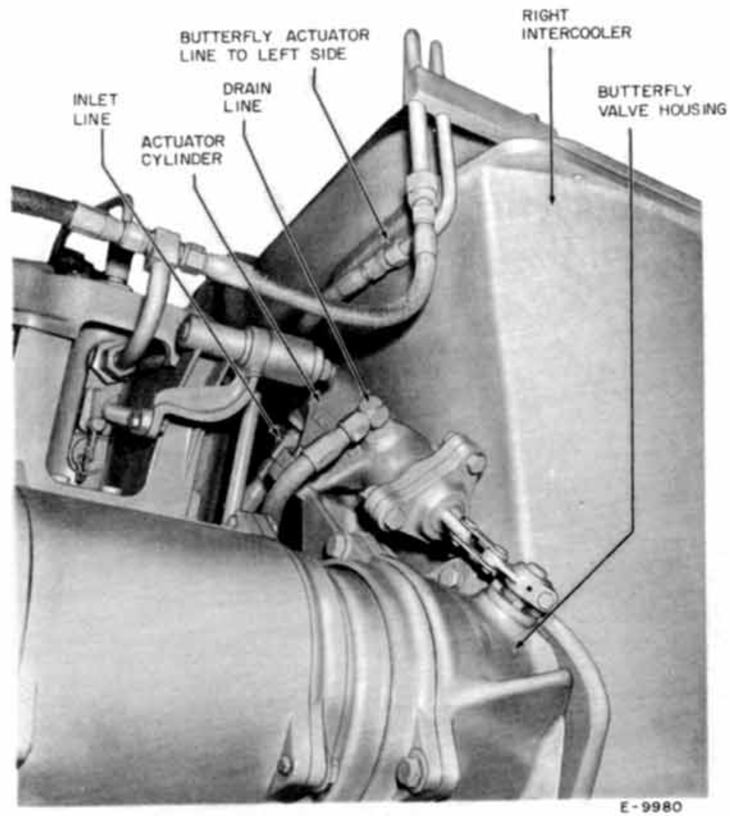
FIG. 8-1

The overspeed governor draws the lubricating oil, which it delivers to the actuators, from a small reservoir inside the governor drive gear housing. While the engine is running, oil in this reservoir is constantly replenished from the main lube oil header. The reservoir holds enough oil when the engine is shut down to permit the overspeed governor initially to open the butterfly valves when the engine is started.

To prevent overheating of the oil being pumped to the butterfly actuators by the overspeed governor, and to cool components of the overspeed system, the actuators are



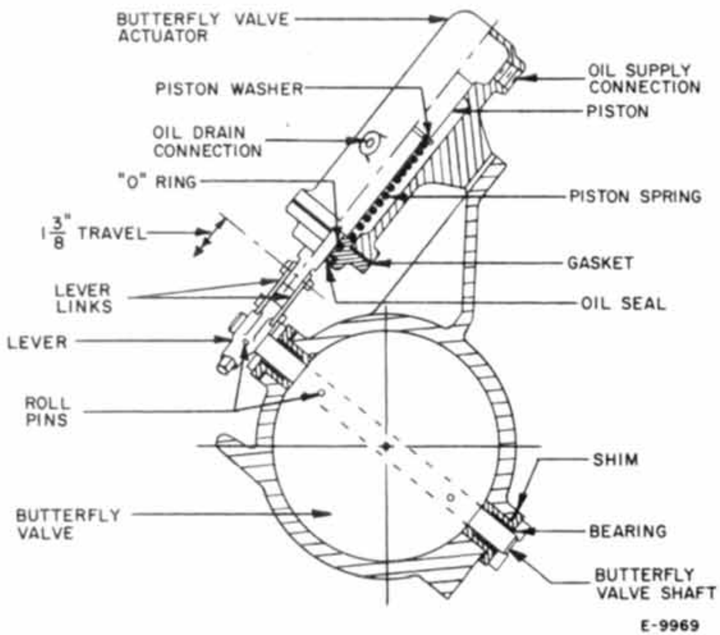
## OVERSPEED SYSTEM




BUTTERFLY VALVE ARRANGEMENT - RIGHT SIDE

FIG. 8-2

# OVERSPEED SYSTEM




OVERSPEED SHUTDOWN BUTTERFLY VALVE AND ACTUATOR (SHOWN IN CLOSED POSITION)

FIG. 8-3

built intentionally "leaky" so that a small amount of oil circulates through them to the crankcase. At the same time, this feature also hastens "dumping" of oil which is in the actuators and closing of the butterfly valves when overspeed is detected.



OVERSPEED SYSTEM

The overspeed system is "fail safe" in operation. A broken oil line, loss of engine oil or governor failure will stop the diesel engine.

NOTE: If an engine shutdown occurs due to overspeed investigate the cause and make necessary repairs. Reset the overspeed governor by depressing the reset button before cranking the diesel engine.

## OVERSPEED GOVERNOR

### DESCRIPTION

The governor main body contains the following components:

1. A pilot valve plunger with speeder spring and linkage.
2. A pair of flyweights mounted on the end of the drive shaft.
3. A power piston at the end of which is mounted the terminal lever.
4. An oil pressure relief valve mounted in the side of the governor case.

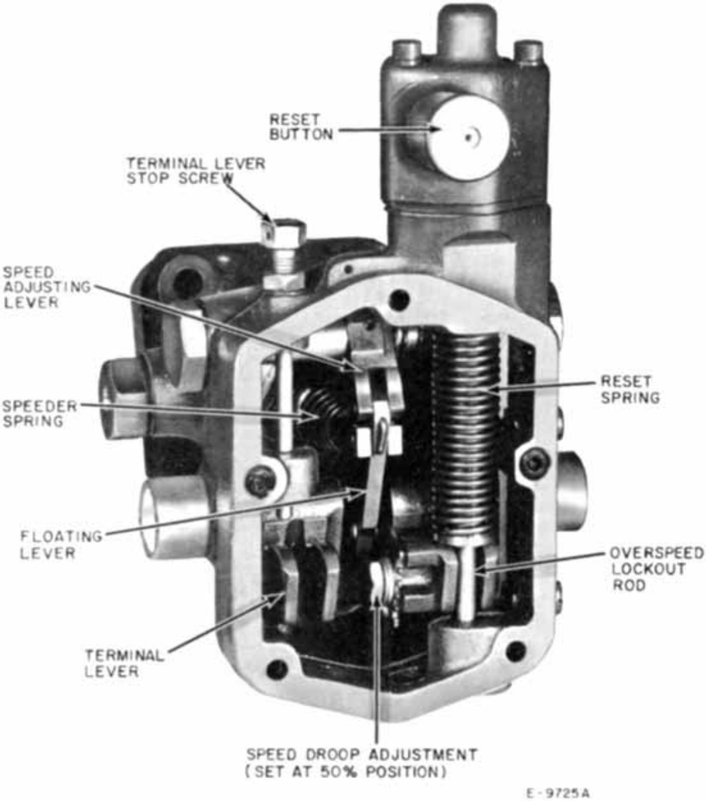
The base portion contains a positive displacement gear pump. The outer case portion contains the lock-out and latching mechanism. See FIG. 8-4.

### OPERATION

Engine Running (Normal Speed Range) - See FIG. 8-5.

NOTE: On the engine the overspeed governor is mounted with its drive shaft horizontal. In FIG. 8-5 and FIG. 8-6 the governor is shown with the drive shaft vertical. The following text refers to the governor as it is shown in the FIGURES, NOT as it is mounted on the engine.

# OVERSPEED SYSTEM

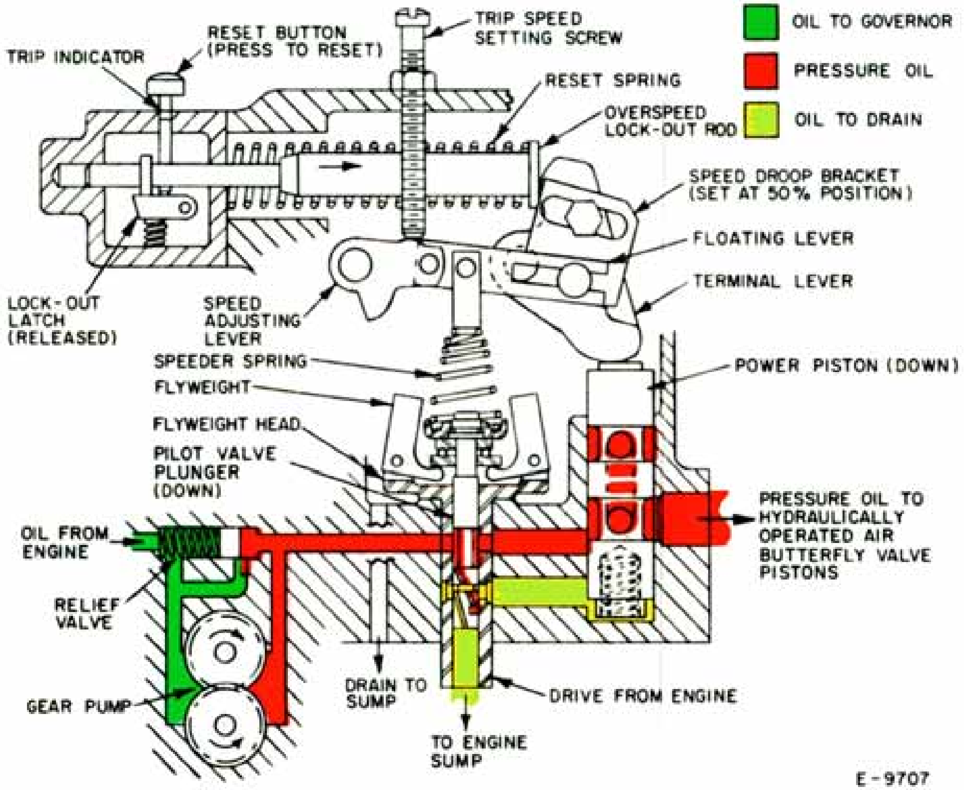



OVERSPEED GOVERNOR WITH COVER REMOVED

FIG. 8-4

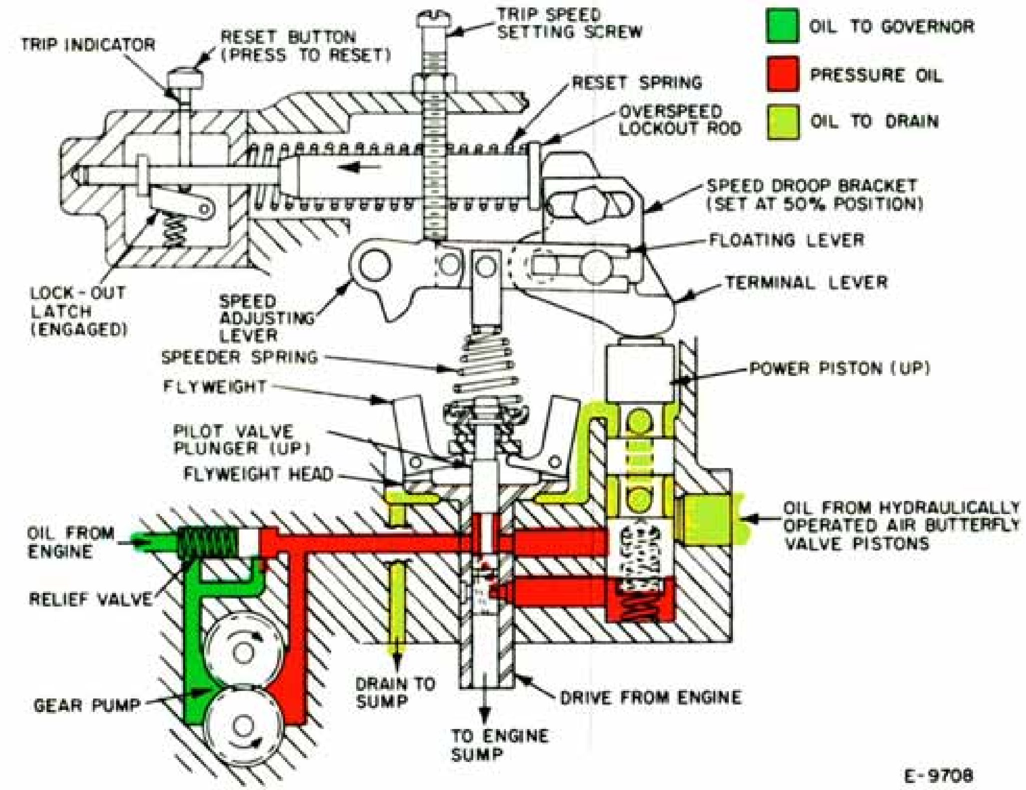
1. The reset spring and overspeed lockout rod will position the terminal lever to hold the power piston down in its bore (lockout latch released).

2. Downward pressure of the speeder spring - as set by adjustment of the trip-speed setting screw - will hold the flyweights in and the pilot plunger down.




OPERATING CONDITION
ENGINE RUNNING AT
NORMAL SPEEDS

FIG. 8-5




TRIPPED CONDITION
AS A RESULT OF
ENGINE OVERSPEED

FIG. 8-6

# OVERSPEED SYSTEM

3. In these positions the bottom of the power piston is connected to drain to the engine sump through ports in the pilot valve bushing to a groove in the pilot valve plunger, and through a slanting hole drilled from the groove to the lower end of the pilot valve plunger.

4. Oil under pressure (200 psi) from the pump is delivered through porting in the pilot valve bushing, around the pilot valve plunger and out to the power piston. With the piston down, the oil can flow around the lower groove and out of the governor case through connecting lines to the butterfly valve actuators.

   Note that the upper groove in the power piston will also contain oil under pressure by means of drilled holes connecting to the lower groove. Also, a slot in the pilot valve plunger - below the port connecting to the power piston - is connected to the pressurized oil in the pilot valve bushing through a second diagonally drilled hole.

<u>Engine Overspeeding (Tripping Action)</u> - See FIG. 8-6.

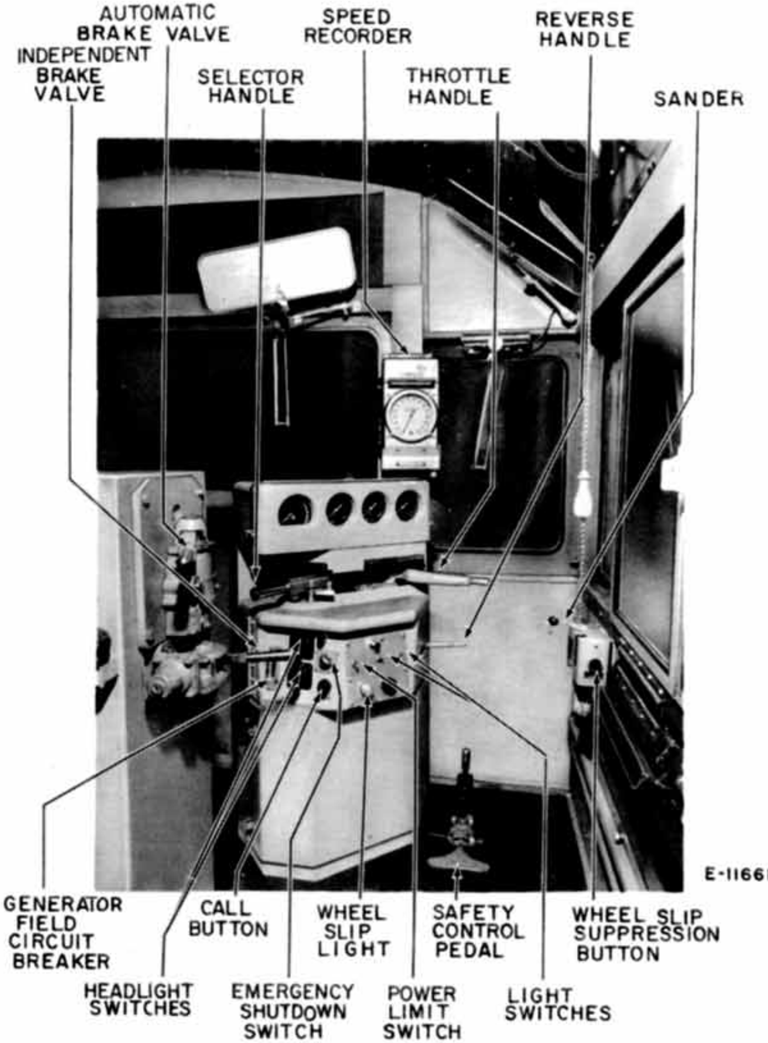
1. As engine speed increases to the overspeed setting, the flyweights will move outward and raise the pilot valve plunger, bringing the pressurized oil slot in line with the port connected to the power piston.

2. Pressurized oil flowing under the power piston will force the piston up to close off the supply of pressurized oil to the butterfly valve actuators, and will position the upper groove in the piston above the top of the power piston bore.

3. This allows oil from the butterfly valve actuators to flow back through the holes connecting the two grooves in the power piston, over into the flyweight head cavity in the governor case, and down through a drain hole to the engine sump.

4. This releases the spring-loaded butterfly valve pistons and the butterfly valves close, shutting off the engine air supply.

# OPERATING INFORMATION

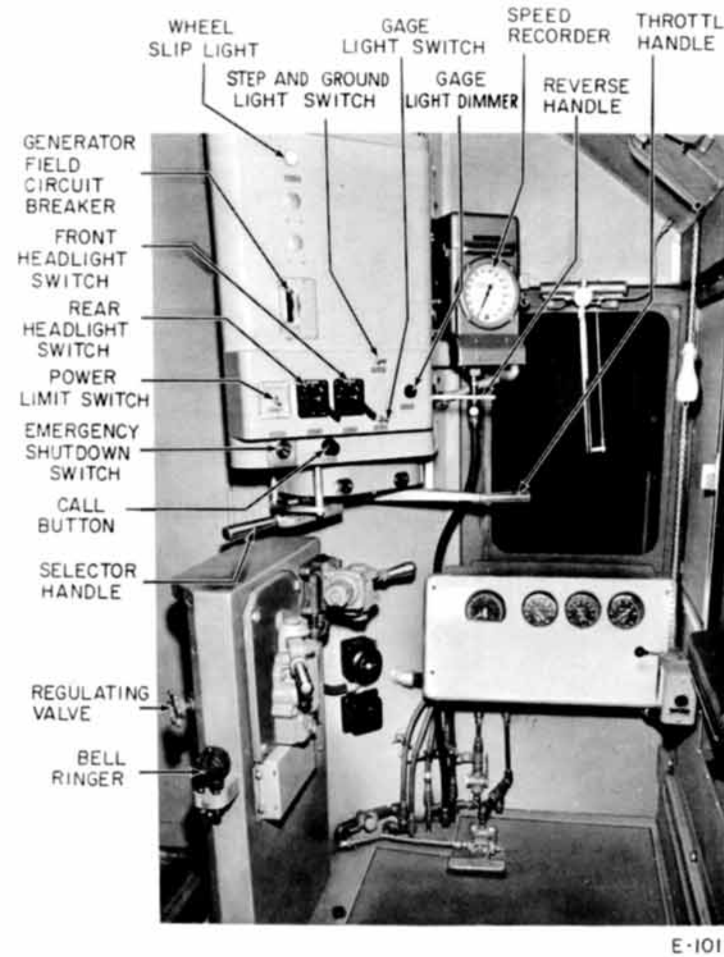



ENGINEMAN'S POSITION
(LOW NOSE LOCOMOTIVE)

FIG. 9-1



# OPERATING INFORMATION




ENGINEMAN'S POSITION
(HIGH NOSE LOCOMOTIVE)

FIG. 9-2

# OPERATING INFORMATION

SELECTOR HANDLE

The selector handle has positions 4, 3, 2, 1, OFF and B. The numbered positions are used when motoring. Position B is used when in dynamic braking.

In ordinary operation, since all U25B locomotives are equipped with automatic transition, the selector handle may be placed in position 1 during motoring and left there.

Positions 2, 3, and 4 are used to provide transition for any locomotive units which are in multiple operation and are not equipped with automatic transition. Handle movement is governed by transition speed of locomotive units in the consist.

INTERLOCKING BETWEEN HANDLES

Interlocking between handles of the master controller is governed in the following manner:

1. The reverse handle can be taken out only when in the OFF position. The selector handle must also be in OFF or 1 and the throttle handle in IDLE position.

2. The reverse handle cannot be moved unless the selector handle is in OFF or 1 and throttle handle is in IDLE.

3. The throttle handle cannot be advanced from IDLE unless the selector handle is in 1, 2, 3, 4, or B.

4. The throttle handle can be moved with the reverse handle in any position.

5. The selector handle cannot be moved into B (braking) unless the throttle handle is in IDLE and the reverse handle is in FORWARD or REVERSE.

DEVICES ON MASTER CONTROLLER HOUSING

The following operating devices are located on the master controller housing:



# OPERATING INFORMATION

1. M.U. EMERGENCY SHUTDOWN SWITCH

   This switch has two positions, STOP and RUN. The normal position is RUN. When this switch is turned to STOP, the diesel engines on all units in multiple unit locomotive consist, will shut down.

   This switch is provided for emergency use only. Normal shut-down should be made by moving the throttle to IDLE, engine control switch (EC) to START, and depressing STOP button on engine control panel.

   After an emergency shut-down, the engine control switch (EC) must be turned to START and engine(s) must be restarted in the normal manner.

2. POWER LIMIT SWITCH

   This switch has two positions, NORMAL and NOTCH 7. When locomotive units of the same horsepower are operated in the locomotive consist, this switch is ordinarily in NORMAL position.

   When the leading unit is slipping excessively, the power limit switch can be moved to notch 7 to reduce power while the trailing units are operating at full power. This will reduce the tractive effort on the leading unit and will usually improve the ability of the locomotive to hold the rail under bad rail conditions.

   When other locomotives of lower horsepower ratings are operated in the consist, under certain conditions, this switch must be moved to the NOTCH 7 position, unless the locomotives are equipped with automatic power matching control.

3. OTHER SWITCHES

   a. Front headlight - OFF-DIM-BRIGHT.

   b. Rear headlight - OFF-DIM-BRIGHT.

   c. Step and walkway lights (when used).

   d. Gage lights and dimmer control.

4. CALL BUTTON

Call button is used to sound alarm bell in all locomotive units.

5. WHEEL SLIP LIGHT

Light indicates when a pair of wheels are slipping.

6. GENERATOR FIELD CIRCUIT BREAKER

The generator field circuit breaker is ON whenever the locomotive is powered. The breaker may also be used to keep the main generator de-energized when it is necessary to run the engine at speeds higher than idle.

ENGINE CONTROL PANEL
FIG. 9-3

The engine control panel is located on the rear wall of the operator's cab. Mounted on this panel are various other switches, circuit breakers and operating devices used during locomotive operation.

ENGINE CONTROL SWITCH

The engine control (EC) switch has two positions, START and RUN. ENGINE STOP buttons are effective only when the EC switch is in the START position.

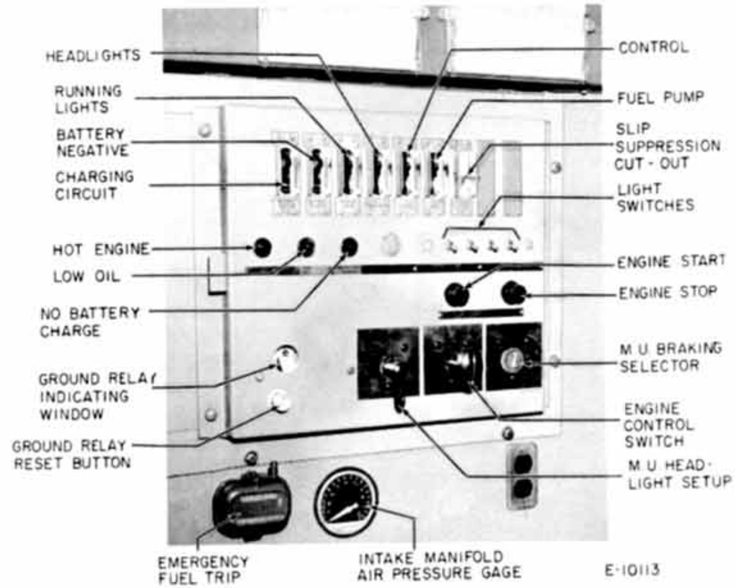
When the engine is running and the EC switch is in START position, engine speed is held at idle and power cannot be applied to the locomotive. The power plant is said to be "off the line".

When the engine is idling and the locomotive is to be operated, the engine control switch (EC) must be moved to RUN position.

ENGINE START AND STOP BUTTONS

To start the diesel engine, depress the ENGINE START button firmly and hold until the engine starts. To stop the engine, depress the STOP button firmly and hold until engine stops.






ENGINE CONTROL PANEL

FIG. 9-3

The ENGINE START and STOP buttons are effective only when the engine control switch (EC) is in the START position.

M.U. HEADLIGHT SET-UP SWITCH

The M.U. HEADLIGHT SET-UP SWITCH has five positions. Positioning of this switch is determined by location of the locomotive unit in the consist and whether the front of the locomotive unit is leading or trailing. Switch positions are as follows:

SINGLE OR MIDDLE UNIT Place switch in this position on any locomotive unit operated singly or on all units except the leading or trailing unit, when the locomotive consist is made up of more than one unit.

## OPERATING INFORMATION

SHORT HOOD LEAD - LEADING UNIT Place switch in this position when leading unit is operated with the short hood forward.

LONG HOOD LEAD - LEADING UNIT Place switch in this position when leading unit is operated with the long hood forward.

SHORT HOOD TRAIL - TRAILING UNIT Place switch in this position when final trailing unit is connected so its short hood trails.

LONG HOOD TRAIL - TRAILING UNIT Place switch in this position when final trailing locomotive is connected so its long hood trails.

M.U. BRAKING SELECTOR SWITCH

The M.U. BRAKING SELECTOR SWITCH has two positions, G.E. BRAKING and LOOP BRAKING. This selector switch is an optional device. It is present only when field loop braking equipment is installed. Operation of the switch is as follows:

G.E. BRAKING The selector switch must be in this position when the locomotive is to be operated as a single unit, or as a leading unit in multiple with General Electric equipped units.

LOOP BRAKING The selector switch must be in this position on the lead unit only when the locomotive unit is to be operated in multiple with one or more units having loop braking control circuits.

The selector switch must be placed in this position before leaving the terminal and must not be changed enroute, even if an engine is taken "off the line".

CIRCUIT BREAKERS ON EC PANEL

The following circuit breakers are located on the engine control panel:

1. Charging Circuit - Isolates battery charging generator from the control system.



## OPERATING INFORMATION

2. Battery Negative
3. Running Lights (all lights except headlights)
4. Headlights
5. Control
6. Fuel pump

SWITCHES ON EC PANEL

The following switches are located on the engine control panel:

1. Hood-Engine-Control Compartment lights
2. Rear classification lights
3. Front classification lights
4. Number lights
5. Slip Suppression Cut Out - Normally this switch is sealed in the "UP" (closed) position. The switch should only be opened as directed by railroad regulations.

GROUND RELAY

The ground relay is furnished to protect the power and control circuits. An indication pointer moves to a red dot when the relay has tripped. The reset button must be pushed to reset the relay.

### MISCELLANEOUS CONTROLS

In addition to the afore described operating devices, the following other controls are used by the engineman during locomotive operation.

1. Bell Valve - Mounted on the engineman's brake stand.
2. Horn Valve - Mounted on the ceiling of the operator's cab. Operated by a pull cord.

# OPERATING INFORMATION

3. Sander Switch - Mounted on the side wall of the operator's cab, near to the engineman's right hand.

4. Windshield Wiper Valves - Located at engineman's and fireman's positions.

5. Hand Brake - Located in nose compartment (high nose locomotive). Located on outside of nose compartment (low nose locomotive).

6. Fireman's Emergency Valve - Knob located on front left bulkhead in operator's cab. Pulling this knob causes a full emergency brake application and dropping of power.

7. Slip Suppression Brake Push Button - Mounted on sidewall of operator's cab at engineman's position.

8. Emergency Fuel Trip Handles - A red box marked OPEN DOOR - PULL HANDLE HARD, is located in the operator's cab. Two others are located on either side of the locomotive beneath the platform level. Pulling any one of the handles trips the emergency fuel shut-off valve to shut off fuel to the engine. Alternately, some locomotives are equipped with an electrical emergency fuel trip system utilizing push buttons instead of handles.

9. Emergency Fuel Shut-Off Valve - The emergency fuel shut-off valve is located near the bottom of the main fuel tank. When tripped, this valve must be manually reset by pulling reset handle on the side of the fuel tank. On locomotives with an electrical trip system, the reset pushbutton is on the EC panel.

10. Cab Heater Control Valve - Located on the left side of the cab heater. The valve may be opened or closed to regulate cab temperature.

***********
CAUTION
***********

TO PREVENT FREEZING IN COLD WEATHER, LEAVE THE VALVE OPEN AT ALL TIMES.



# OPERATING INFORMATION

## OPERATING PROCEDURE

The following information related to locomotive operation consists of condensed details. For more specific procedure refer to the locomotive Operating Manual.

### STARTING ENGINE

Before starting the engine make the necessary inspection and preparations required by railroad regulations. Then proceed as follows:

1. Close the battery switch.
2. Close the following circuit breakers on the engine control panel.
   a. Control Circuit
   b. Charging Circuit
   c. Battery Negative
   d. Fuel Pump
   e. Headlights
   f. Running Lights
3. After fuel pressure builds up, push the engine start button on the engine control panel and hold until the engine starts (approximately 25 seconds).

   NOTE: If proper engine lube oil pressure does not build up within approximately 40 seconds, the governor will shut off and prevent the engine from starting.

***********
CAUTION
***********

DO NOT DISCHARGE BATTERY EXCESSIVELY BY REPEATED ATTEMPTS TO START. IF FIRST TWO OR THREE TRIES ARE UNSUCCESSFUL RECHECK PRELIMINARY PREPARATIONS FOR STARTING.

# OPERATING INFQRMATION

4. Turn the engine control switch to RUN.

5. Before moving the locomotive, allow time for the cooling water system to warm up in accordance with railroad regulations.

## OPERATING AS LEADING UNIT

To operate the locomotive as a lead unit of a consist proceed as follows:

1. Make the necessary preliminary preparations for operation.

2. Test air brake in accordance with railroad regulations.

3. Close the generator field circuit breaker.

4. Move reverse handle to the desired direction.

5. Move the selector handle to position 1.

   If any trailing units require manual transition then the selector handle for the trailing unit must be moved to positions 2, 3 and 4 at locomotive speeds required for transition on these units.

6. When equipped with M.U. Braking Selector Switch (optional equipment), move selector switch to G.E. Braking position when trailing units are U25B locomotives.

   Move selector switch to Loop Braking position when one or more trailing units are equipped for loop braking.

7. Operate locomotive in accordance with operating procedure.

## OPERATING AS TRAILING UNIT

### Air Equipment Set-Up

1. Make a full service application with the automatic brake valve handle.



# OPERATING INFORMATION

2. Move the brake valve cut-out (double heading cock) to the cut-out position.

3. Move the automatic brake valve handle to the HANDLE OFF position and remove the handle.

4. Move the MU-2A valve to suit brake equipment on the leading unit (either TRAIL-24 or TRAIL-26 or 6 positions).

5. Place the independent handle in RELEASE position. The handle cannot be removed.

### Electrical Set-Up

1. Move the reverse handle to OFF and remove the handle.

2. Place the selector handle in OFF position. (Leaving the handle in position 1 on the trailing unit prevents loading when in multiple with some type locomotives.)

3. Open the generator field circuit breaker on the master controller. Leave all breakers in the closed position on the engine control panel (EC) except the control circuit breaker. Running lights circuit breaker may be positioned as desired.

4. Place the M.U. Headlight Set-Up switch in the proper position.

5. Place M.U. Braking Selector switch (if used) in G.E. Braking position.

## CHANGING OPERATING ENDS

To change operating control from the cab of one locomotive unit to the cab of another proceed as follows:

### Vacating Unit - Air Equipment Set-Up

1. Make a full service brake pipe reduction.

2. Depress the handle of the brake valve cut-out cock and move it to the CUT-OUT position.

# OPERATING INFORMATION

3. Place the automatic brake valve handle in the HANDLE-OFF position and remove; place the independent brake valve handle in the RELEASE position.

4. Depress the handle on the MU-2A valve and move it to TRAIL-24 position or TRAIL-6 or 26 position, depending on the type of equipment used on the lead locomotive unit.

Vacating Unit - Electrical Set-Up

1. Move the reverse handle to OFF and remove the handle.

2. Place the selector handle in OFF position.

3. Open the generator field circuit breaker on the master controller.

4. Leave all breakers in the closed position on the engine control panel (EC) except the control circuit breaker. Running lights circuit breaker may be positioned as desired.

5. Move M.U. Headlight Set-Up switch to required position.

Operating Unit - Air Equipment Set-Up

1. Insert the automatic brake valve handle in the HANDLE-OFF position.

2. Move the independent brake valve handle to the full application position.

3. Depress the handle of the MU-2A valve and move it to the LEAD or DEAD position.

4. Depress the handle of the brake valve cut-out cock and move it to the CUT-IN position as required by the service in which the locomotive is to be operated.



OPERATING INFORMATION

Operating Unit - Electrical Set-Up

1. Insert the reverse handle into the reverser of the master controller.

2. Close the generator field circuit breaker on the master controller.

3. Close all circuit breakers on the engine control panel (EC).

4. Move M.U. Headlight Set-Up switch to required position.

## DYNAMIC BRAKING OPERATION

Dynamic braking is applied to the locomotive only. A dynamic brake interlock keeps the air brakes on the locomotive from being applied when automatic air braking and dynamic braking are being used.

### M.U. BRAKING SELECTOR SWITCH (When Equipped)

This switch is mounted on the engine control panel. It has two positions: "G.E. Braking" and "Loop Braking" and should be set to correspond to the type of dynamic braking on each unit in the locomotive consist. If all units in the locomotive consist have G.E. excitation and dynamic brake equipment, the M.U. Braking Selector Switch must be set in "G.E. Braking" position. If a U25B locomotive is leading in a mixed locomotive consist with one, two or three locomotive units having dynamic brake equipment requiring loop braking circuit control, the selector switch must be set in "Loop Braking" position on the lead unit only.

The selector switch should be set before leaving the terminal. Positioning must not be changed even if the engine is isolated enroute. If locomotive units in the consist are changed enroute, then the position of this switch may have to be changed.

### APPLYING DYNAMIC BRAKING

Applying dynamic braking is done in the following manner:

1. Move the throttle handle to IDLE.

2. Move the selector handle from 1 to OFF to B.

3. Advance the throttle handle slowly to bunch train slack. (Braking is now controlled by the throttle handle.)

4. After the slack is bunched, advance the throttle handle until the desired braking effort is obtained. Observe and correct braking effort during initial period of dynamic brake application.

***********
CAUTION
***********

LIMIT BRAKING EFFORT TO 7TH NOTCH ON THROTTLE HANDLE AT LOCOMOTIVE SPEEDS ABOVE 64 MPH TO PREVENT TRACTION MOTOR FLASHOVER.

The amount of braking effort obtainable varies with the position of the throttle for the various speeds. The maximum braking effort is obtained at 20 to 22.5 mph in the 8th notch.

USE OF AIR BRAKES DURING DYNAMIC BRAKING

When necessary, the automatic air brake may be used in conjunction with the dynamic brake. Automatic air brakes will apply on the train but not on the locomotive. If the automatic air brake handle is moved to the emergency position, dynamic brake is removed and brakes on the locomotive as well as those on the train go into emergency application.

The independent air brake must not be used during dynamic braking to avoid flat spots on the locomotive wheels caused by sliding.

RELEASE OF DYNAMIC BRAKING

Release dynamic braking in the following manner:

1. Move the throttle handle to IDLE.

2. Move the selector handle from B to OFF to 1.



OTHER OPERATING DETAILS

WHEEL SLIP

When a slip occurs a light independent air brake application is made automatically. This may be observed by a fast flicker of the needle on the brake cylinder air gage. Most slips will be corrected by this automatic action.

If bad rail conditions cause the slip to exceed 3 seconds then sand is automatically applied to the rail. Wheel slip light will come on at about the same time sanding starts. When wheel slips cannot be controlled by braking and sanding, the excitation is reduced automatically.

If the engineman desires to correct an anticipated wheel slip, a lightly-controlled brake application may be made with the Slip Suppression Brake push button.

If, in the engineman's judgment, the wheel slip is not corrected by the automatic control, it may be necessary to reduce the throttle position or manually apply sand, or both, until the wheel slip is fully controlled.

POWER MATCHING

Some U25B locomotives are equipped with an automatic power matching feature. This feature allows the locomotive to be safely operated under heavy load and steep grade conditions with other units of lower horsepower. The equipment automatically reduces the horsepower of the U25B locomotive to a value that prevents damage to the traction motors as long as the ratings on the lower horsepower unit are not exceeded.

# CIRCUIT OPERATION

## INTRODUCTION

The electrical maintenance man will find that the schematic diagram is one of the most important tools in his possession. When the fundamentals of the schematic diagram are understood, the electrical maintenance man (and others interested in the electrical system) can increase his understanding of the operation of the electrical equipment. Through better understanding, he will better appreciate the application of the equipment which is designed for the optimum in control and locomotive performance.

The schematic diagram shows how the electric devices are electrically connected. In other words, it shows how each device (motor, relay, contactor, light, etc.) is connected to a source of power (battery or generator) through control devices (master controller, switches, circuit breakers, etc.). The circuit (complete current path) for each device is readily located on the schematic diagram after certain fundamental points are clearly understood. Each electric device is supplied for a purpose and in some way contributes to the proper operation of the locomotive.

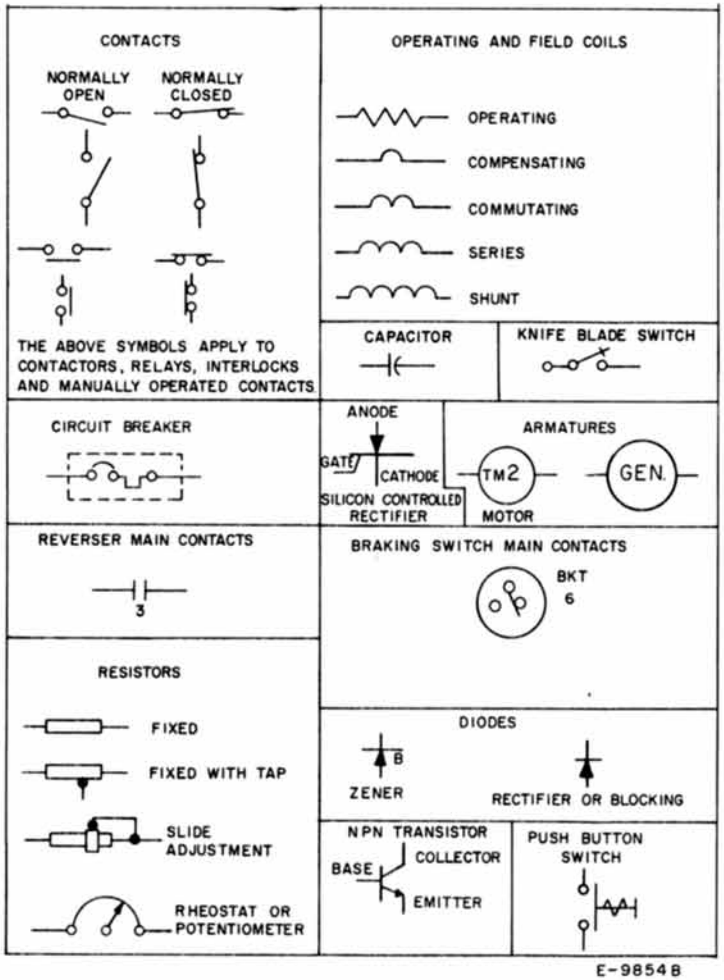
On occasion, the failure of an electric device will interrupt the normal operation of the locomotive. The electrical maintenance man must locate and repair the failed component as quickly as possible. The more efficiently he performs this duty, the quicker the locomotive is returned to service. The understanding and proper use of the schematic diagram are major contributors to short out-of-service time due to electrical failures.

These instructions will explain the fundamentals of the diagram and will describe the circuit operation required to operate the locomotive under normal conditions. The circuit illustrations are simplified for use in this instruction; therefore, the complete schematic diagram should be used with this instruction so that the simplified circuits can be located.

## FUNDAMENTALS OF THE SCHEMATIC DIAGRAM

This instruction does not cover the fundamentals of electricity or the theory of operation of any electrical device. Some circuits and devices may be more thoroughly

## CIRCUIT OPERATION




DEVICE SYMBOLS FOR SCHEMATIC DIAGRAM

FIG. 10-1



## CIRCUIT OPERATION

described than others because of recent initial application. More detailed information may be found in other instructions covering the particular panel, device, or control system.

Each device or part of a device which carries current has a symbol which is representative of that particular type of device. FIG. 10-1 shows the device symbols and what each represents. Since many devices of the same type are used and each has a different function, a letter or number symbol is applied to each device. This helps to identify the device on the schematic diagram. In the instructions that follow, the devices will be referenced by descriptive name and symbol.

All electrically operated devices are shown in a de-energized position, that is, the operating coils are void of current. Manually operated contacts are shown in the position they should be in when the locomotive is completely shut down. Some manually operated contacts are controlled by multi-position handles (i.e., master controller and engine-control switch). Since this instruction is not intended to be used as an operating procedure, the user should consult the operator's manual for the proper use of all switches and the master controller.

The master controller has three operating handles which operate many contacts. The throttle handle (TH), reverse handle (RH), and selector handle (SH) use letters or numbers to indicate the handle position or positions which close a particular contact (i.e., SH 1-4).

The letter and number symbols used to identify a device are the same for each coil and contact of that device. Paneled equipment is outlined with dash lines, but internal devices in the panel are not readily identified. In such cases, the panel schematic diagram should be consulted (for example, wheel slip panel, WSP).

All wires and cables which connect devices are marked with letters for quick identification. The letters shown on the schematic diagram agree with the ones actually used on the locomotive, except that the actual wire marker will have the terminal board number after the symbol. (PC27 is the PC wire going between terminal boards 2 and 7).

## CIRCUIT OPERATION

The reversing switch (REV) and dynamic-braking switch (BKT) have two positions. The reverser is always shown for forward operation and the braking switch is shown for motoring operation. The contacts will take the opposite position if reverser is moved to REVERSE or the dynamic-braking switch is moved to BRAKING position.

A new concept in voltage regulation of control power, wheel slip detection, and automatic transition is used on U25B locomotives. This concept introduces semiconductor components mounted on drawer-type cards. These components in general are blocking diodes, transistors, Zener diodes, and silicon controlled rectifiers. The application of semiconductors eliminates the necessity of many relays and contactors.

A blocking diode allows current to flow in the direction of the arrow stamped on its case and blocks current flow in the opposite direction. Through this principle it can also be used to rectify a-c to d-c current. Schematically, it is represented as shown in FIG. 10-1.

A transistor is used as an automatic switch, to allow current to flow or to block current flow. It has three basic elements; one is called the emitter, one the base, and the other the collector. The characteristic of a transistor allows the use of a very low current signal from base to emitter to turn it on. When it is turned on it allows a large current flow from the collector to the emitter. When the base to emitter signal is removed it turns off the transistor, thus blocking current flow from collector to emitter. Schematically, it is represented as shown in FIG. 10-1.

A Zener diode is really an electrical check valve. It blocks current flow until a precise voltage is reached. When this voltage is reached it conducts (opens) and current can flow in the direction against the arrow. Schematically it is represented as shown in FIG. 10-1.

A silicon controlled rectifier (SCR) is also an automatic switch which acts in much the same manner as a transistor. However, a very small voltage applied to the gate will turn on an SCR and its current carrying capacity is much greater than a transistor. The gate of the SCR is the small lead coming out of the top of the case, the cathode is the lead



CIRCUIT OPERATION

next to the gate lead, and the anode is the stud coming out of the bottom of the case. The anode is also used to mount the SCR. When a small positive voltage is applied to the gate lead, the SCR is turned ON. This completes a junction between the anode and cathode; current will flow from the anode to the cathode in the circuit. Unlike the transistor, when the voltage is removed from the gate the SCR will not turn OFF whereas the transistor will turn OFF when voltage is removed from the base. The SCR will continue to conduct from the anode to the cathode until it is back biased or voltage is removed in the circuit. Back biasing is accomplished by building up a counter voltage to the voltage from the anode to the cathode.

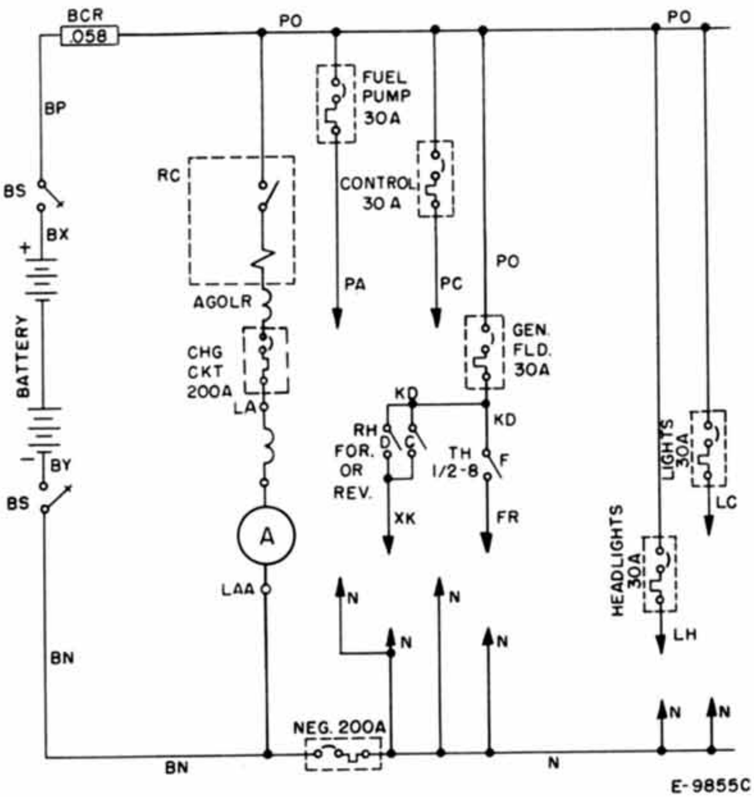
Before attempting to trace individual circuits, the reader should orient himself with the main control wires. The tracing of control circuits will be simplified when the user knows which positive control wires are energized, as well as how they are energized.

FIG. 10-2 shows the main control wires connected to the battery and auxiliary generator (A) which are sources of control voltage. When the engine is running, the auxiliary generator supplies a regulated 74 volts. When the engine is shut down, the battery can supply 64 volts.

The positive side of the battery is connected to the positive side of the auxiliary generator (A) through battery knife switch (BS), BCR resistor, and reverse-current contactor (RC). Both sources are connected to the main positive control wire (PO). The negative side of the battery is connected to the negative side of the auxiliary generator through the battery knife switch (BS) by the BN wire. When the NEG. 200A circuit breaker is closed, the main negative control wire (N) is energized. All low voltage (74 volt) control devices are connected between the positive (PO) wire and the negative (N) wire.

Other circuit breakers set up the remaining control circuits through secondary positive control wires. The CONTROL 30A circuit breaker energizes the positive PC wire. The fuel pump 30A circuit breaker energizes the positive PA wire. The GENERATOR FIELD 30A circuit breaker energizes the positive (KD) wire. When the reverse handle is moved to FORWARD or REVERSE, the XK wire is energized.

# CIRCUIT OPERATION




MAIN CONTROL WIRES

FIG. 10-2

When the throttle is moved to the first notch (1/2), the FR wire is energized. The LIGHTS and HEADLIGHTS 30A circuit breakers energize the positive LC and LH wires.

The description of circuit operation that follows will be broken down into the following basic functions:

1. Engine Cranking
2. Battery Charging and Voltage Control
3. Minimum Power Application - Motoring



# CIRCUIT OPERATION

4. Power Control - Engine Speed
5. Power Control - Excitation
6. Field Shunting and Parallel Operation
7. Automatic Transition Control
8. Dynamic Braking
9. Engine shutdown
10. Alarms and Safeguards

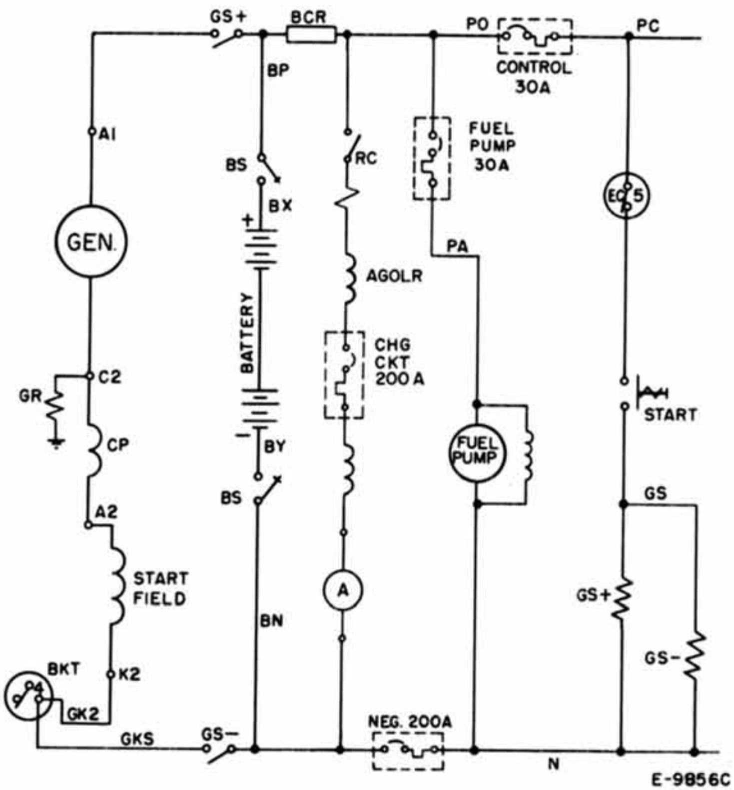
## ENGINE CRANKING

Assume a single-unit locomotive to be completely shut down with all manually operated devices in normal shut-down position. Engine cranking requires the use of the circuits shown in FIG. 10-3. The circuit operation that follows shows how each circuit is set up to operate the various devices which will crank the engine and set engine idle speed.

The only source of power for engine cranking is the battery. The following steps are required:

1. Close battery switch (BS).
2. Close negative circuit breaker (NEG).
3. Close charging circuit breaker (CHG CKT).
4. Close CONTROL circuit breaker.
5. Close FUEL PUMP circuit breaker.
   a. Fuel-pump motor delivers fuel to engine fuel headers.
6. Place EC in START position.
7. Depress engine START button, after fuel pump has had one minute or more operation.
   a. Generator start contactor coils (GS+ and GS-) are energized.

# CIRCUIT OPERATION




ENGINE CRANKING CIRCUITS

FIG. 10-3

b. Generator start contacts (GS+ and GS-) close to connect main-generator armature (GEN) and START FIELD across the battery.

c. Motor action in the main generator cranks the diesel engine.

d. Diesel-engine governor operates fuel control linkage to start fuel injection and, in turn, adjusts the fuel to maintain idle engine speed.



# CIRCUIT OPERATION

8. Release START button when engine exhaust sound indicates that engine is firing regularly.

   a. Generator start contactors are de-energized.

   b. Main generator armature and START FIELD are disconnected from battery.

   c. Engine is idling.

9. Ground relay may trip while cranking if control circuit is grounded.

## BATTERY CHARGING AND VOLTAGE CONTROL

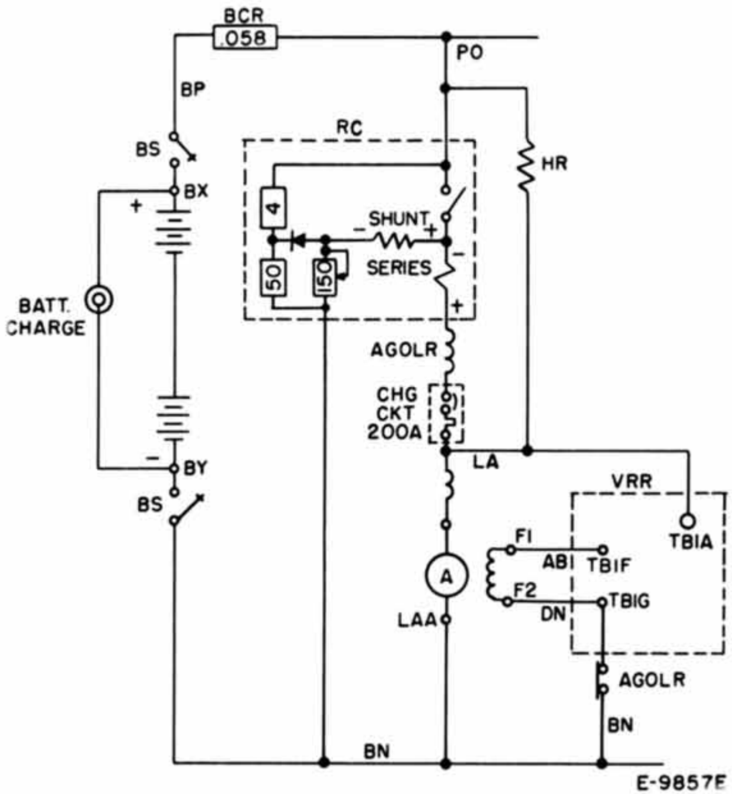
During cranking, the auxiliary generator (A) increases speed. Due to residual magnetism in the fields, auxiliary-generator voltage builds up. When cranking starts, battery voltage is higher than auxiliary-generator voltage, but the latter voltage continues to increase with engine speed. At this time, the auxiliary-generator current is increasing in the series and shunt coil of the reverse-current contactor (RC). See FIG. 10-4.

When auxiliary-generator voltage rises somewhat above battery voltage, the ampere-turns in the reverse-current contactor coils are sufficient to pick up the contactor.

When the reverse-current contactor is picked up, the auxiliary generator supplies battery-charging current as well as the current to operate all low-voltage (74-volt) devices.

The voltage regulator panel (VRR) measures the auxiliary-generator voltage and maintains a constant 74 volts. The voltage regulator panel has a silicon controlled rectifier which allows current to flow through the auxiliary-generator field. If the voltage of the auxiliary generator goes above 74 volts, a voltage reference circuit across the generator will turn on a transistor and shut off the silicon controlled rectifier and decrease the current flow through the auxiliary-generator field.

An overload relay (AGOLR) is connected in seri with the charging circuit breaker to provide additional protection against excessive current.




BATTERY CHARGING AND VOLTAGE CONTROL

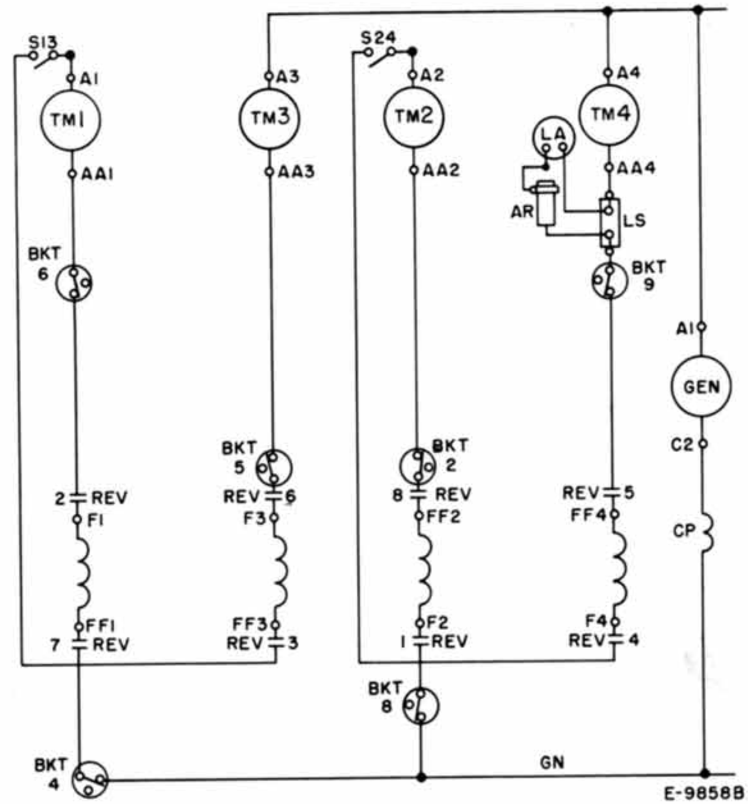
FIG. 10-4

## MINIMUM POWER APPLICATION - MOTORING

Assume that the diesel engine is running at idle speed. When power is to be applied for FORWARD motoring operation, the following steps are taken: See FIGS. 10-5, 10-6 and 10-7.

1. Move engine-control switch (EC) to RUN position.






SERIES-PARALLEL MOTOR CONNECTIONS

FIG. 10-5

2. Move selector handle (SH) to Position 1.

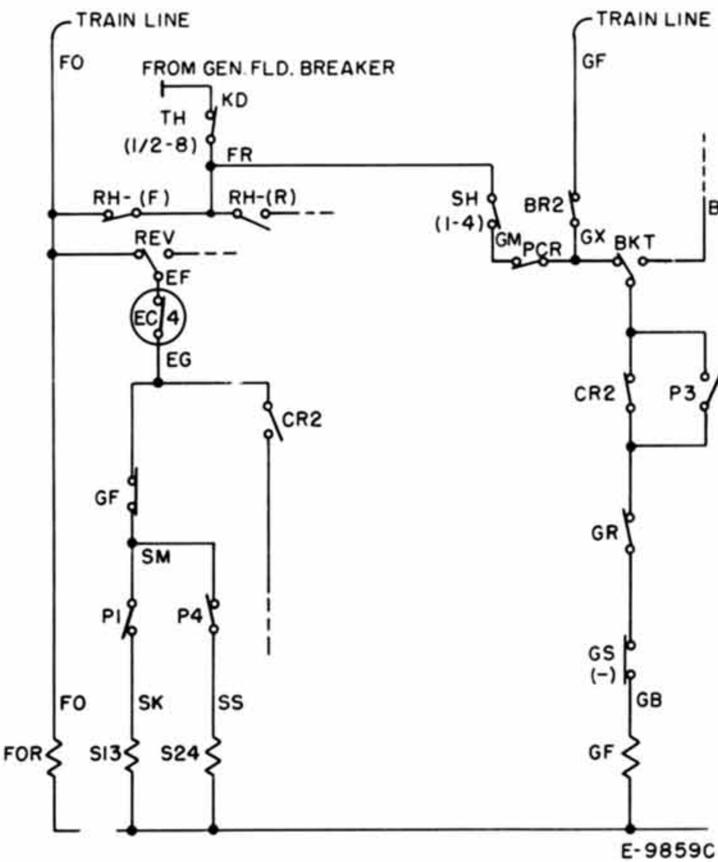
3. Move reverse handle (RH) to FORWARD position.

4. Close GENERATOR FIELD circuit breaker.

5. Move throttle handle to first notch (1/2).

   a. Multiple-unit relay (MR) is energized.

# CIRCUIT OPERATION




MOTOR PROPULSION CONTROL CIRCUITS, SERIES-PARALLEL (E-9859C). (CIRCUIT DRAWN IN ENERGIZED POSITION.)

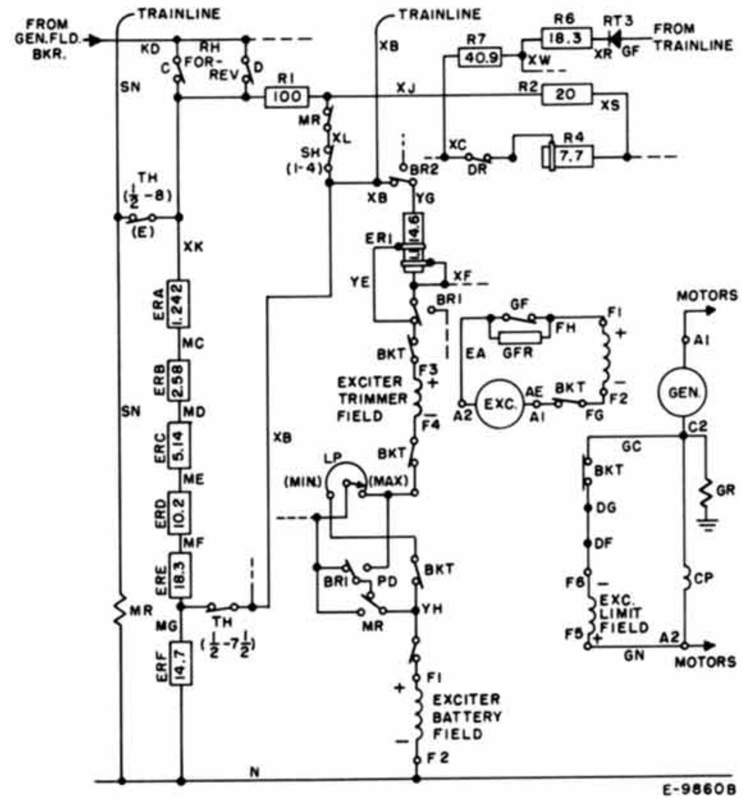
FIG. 10-6

b. EXC. TRIMMER and BATTERY FIELDS are energized.

c. Generator-field contactor (GF) coil is energized. Main-generator shunt field is connected to exciter armature.



# CIRCUIT OPERATION




MINIMUM EXCITATION CIRCUIT
(CIRCUIT DRAWN IN ENERGIZED POSITION)

FIG. 10-7

d. Reverser forward magnet valve (FOR) is energized. Traction motor fields are connected to armatures for forward operation.

e. Power contactor magnet valves (S13 and S24) are energized. Traction motors are connected in series-parallel across main generator, by main contacts of S13 and S24.

f. Minimum power is applied as indicated by load ammeter (LA).

# CIRCUIT OPERATION

FIG. 10-5 shows the power circuits (series-parallel) as used for initial power application. FIG. 10-6 shows the propulsion control circuits used to energize the proper contactor, relays, etc., for initial power application. FIG. 10-7 shows the basic excitation circuit for the initial power application.

Main generator output is controlled by the throttle. When the throttle handle is advanced through the 16 positions (1/2, 1, 1 1/2 through 8) the voltage available to the exciter battery field is increased for each notch as well as each half notch. Engine speed is increased in each full notch, starting with notch 2, to further increase exciter and main generator output. Altogether there are 16 increments of current limit and eight engine speeds, with over-all regulation through the load control of the governor.

## POWER CONTROL - ENGINE SPEED

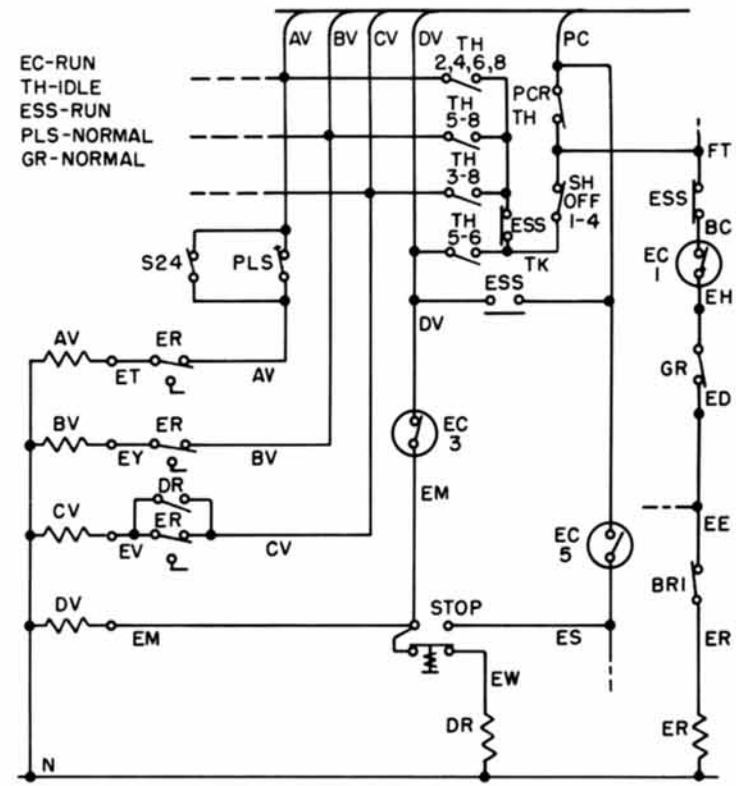
FIG. 10-8 shows the engine-speed control circuits. The governor speed solenoids (AV, BV, CV, DV) are located in the governor and each is controlled by a throttle contact in series with the solenoid. Each of the throttle contacts closes in one or more throttle position to energize a specific governor solenoid. The combination of governor solenoids energized at the same time determines the engine speed.

GOVERNOR SPEED SOLENOID SEQUENCE CHART

| TH POS | AV | BV | CV | DV | Engine Crankshaft RPM's |
|---|---|---|---|---|---|
| IDLE, 1/2, 1, 1 1/2 | | | | | 400 |
| 2, 2 1/2 | X | | | | 486 |
| 3, 3 1/2 | | | X | | 572 |
| 4, 4 1/2 | X | | X | | 658 |
| 5, 5 1/2 | | X | X | X | 744 |
| 6, 6 1/2 | X | X | X | X | 830 |
| 7, 7 1/2 | | X | X | | 916 |
| 8 | X | X | X | | 1000 |



# CIRCUIT OPERATION




ENGINE SPEED CONTROL CIRCUITS
(CIRCUIT DRAWN WITH ER AND PCR ENERGIZED)

FIG. 10-8

The DR relay is picked up whenever the DV solenoid governor valve is energized. It has two functions in locomotive operation. It returns engine speed to idle if the ground relay trips when throttle is in notches 5 through 6 1/2. Its other function is to assist in controlling excitation whenever trailing behind a non-U25B locomotive.

Before the engine speed solenoids can be energized, the power control relay (PCR) must be energized as shown in FIG. 10-23. The PCR relay is energized through the pneumatic control switch (PCS) when the throttle (TH) is in

IDLE and control voltage is on the PC wire. When PCR is energized, it keeps itself energized through a PCR contact in parallel with the TH-IDLE contact. TH-IDLE contact opens when the throttle is advanced to notch 1/2 or higher. A PCR contact sets up the governor solenoid circuits from the PC wire.

The engine relay (ER) is energized from the PC wire through PCR, emergency stop switch (ESS), engine-control switch (EC in RUN position), ground relay (GR), and braking relay (BR1). The ER contacts set up the circuits for the governor speed solenoids.

The power limit switch (PLS) must be in NORMAL position (closed) to allow AV solenoid governor valve to be energized when in series-parallel operation. When PLS is open, the engine is limited to seventh notch speed when motor connections are in series-parallel. In parallel motor connections, the interlock contact S24 will be closed and seventh notch restriction is removed, regardless of PLS position.

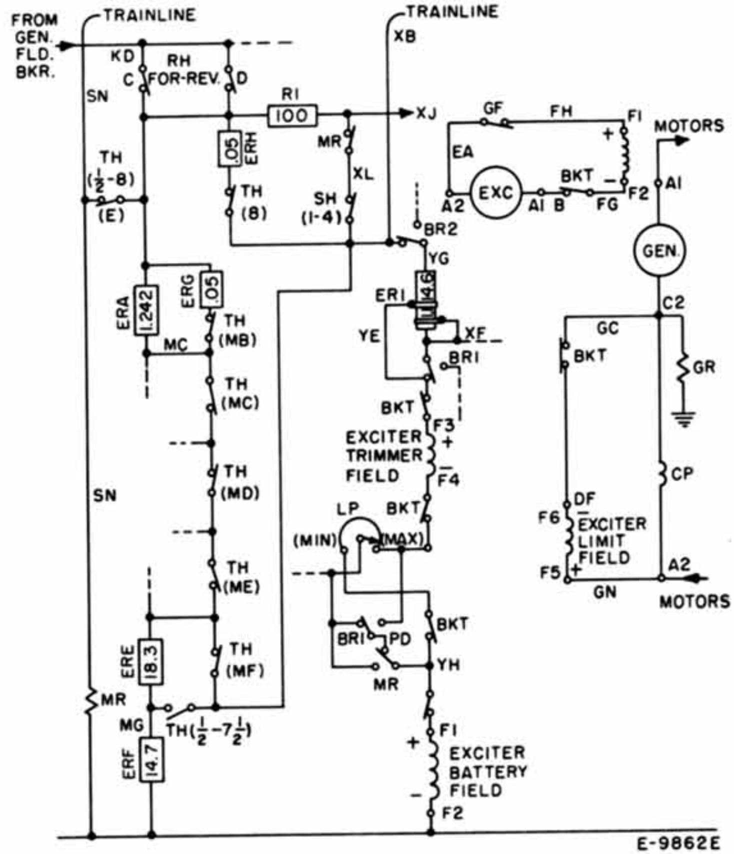
The four throttle contacts can control the AV, BV, CV, and DV solenoids (and DR) with the selector handle (SH) in OFF position or positions 1-4. Each full throttle position energizes a different combination of speed solenoids for eight engine speeds.

## POWER CONTROL - EXCITATION

Voltage available to the battery field of the exciter generator is increased in each half notch, in addition to engine speed in each full notch as explained under POWER CONTROL ENGINE SPEED. When excitation of the exciter generator increases, the exciter voltage rises and increases the excitation and voltage of the main generator. FIG. 10-7 shows the basic excitation control circuits for throttle notch 1/2. Note that the two exciter fields (trimmer and battery) are in series. The resistors connected to XK and XJ wires establish a voltage on the XB wire which, in turn, sets the exciter field current with further control imposed by the governor through the load control rheostat (LP).

FIGS. 10-7 and 10-9 show the complete excitation control circuits for motoring. There are two sets of resistors used to control the voltage on the XB wire and field current.






FULL THROTTLE EXCITATION - MOTORING
(CIRCUIT DRAWN IN ENERGIZED POSITION)

FIG. 10-9

The resistors ERA through ERF are "shorted-out" to increase voltage available to the field as the throttle is advanced. The resistors connected between the engine speed circuits and the XJ wire control voltage to the XB wire and field current as engine speed is changed.

When power is applied to move the locomotive, the traction-motor current can increase to a very high value

# CIRCUIT OPERATION

due to the low resistance of the motor circuits. Since this high current could cause severe damage, it is desirable to limit the current in the following manner:

The exciter limit field is connected across the commutating pole field (CP) of the main generator. Exciter limit field-current is proportional to traction motor load-current and opposes the action of the trimmer and battery fields. This sets a maximum load current for each throttle position and permits 16 increments of current for starting the locomotive and train. As the locomotive speed increases, a countervoltage which reduces load current builds up in the traction motors. This decreases the effect of the differential field and allows excitation and main-generator voltage to increase.

The governor controls the fuel to the engine to maintain the proper engine speed. If the load increases for a particular engine speed, the governor feeds more fuel to the engine. If the generator demands more horsepower than the engine can produce, fuel limit is reached and the governor goes into load control; that is, the load-control potentiometer moves from maximum toward minimun field. Since the load-control potentiometer is in series with the exciter-battery and trimmer field circuit, excitation and generator horsepower demand is reduced to match the engine capabilities and to prevent "bogging" down by overloading.

## FIELD SHUNTING AND PARALLEL OPERATION

When the minimum power application is made, the S13 and S24 power contactors connect the four traction motors in series-parallel. This motor connection will not permit full horsepower utilization over the speed range of the locomotive. Full horsepower utilization is accomplished by changing the motor connections as the locomotive speed increases. Three reconnections take place following the initial series-parallel full-field connection. At predetermined speeds, the following transitions occur automatically.

1. From series-parallel to series-parallel with motor fields shunted (1 to 2).
2. From series-parallel, fields shunted, to parallel full-field (2 to 3).



CIRCUIT OPERATION

3. From parallel full-field to parallel, fields shunted (3 to 4).

The four motor connections are frequently referred to as:

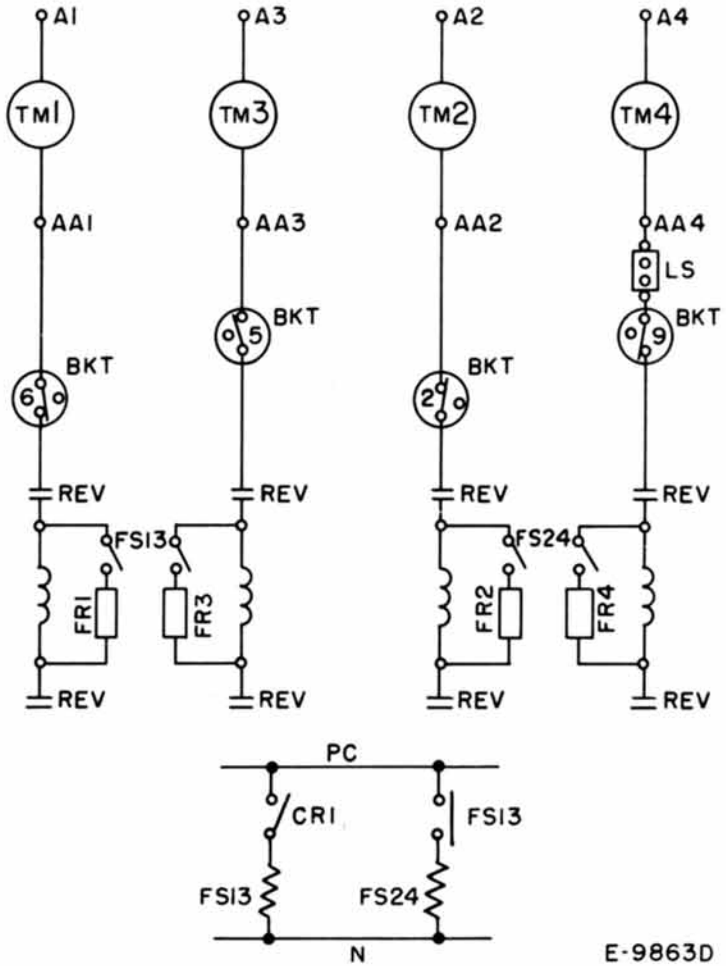
1. SER-PAR, FF or 2S-2P.
2. SER-PAR, FS or 2S-2P, FS.
3. PAR, FF or 4P.
4. PAR, FS or 4P, FS.

The traction-motor circuit transitions are controlled by the transition equipment panel (TEP), which is connected to an axle-driven alternator to operate the transition relays (CR1, CR2) at proper locomotive speed. See AUTOMATIC TRANSITION CONTROL. When proper locomotive speed is reached, the CR1 relay is energized. A contact on relay CR1 energizes the FS13 field-shunt contactor and an interlock on FS13 energizes the FS24 contactor. See FIG. 10-10. There are two main contacts each on FS13 and FS24. When they are closed, the fields of each traction motor are shunted. FIG. 10-10 shows the power and control circuits for field-shunting operation.

If the locomotive continues to accelerate during series-parallel field shunting, the CR2 relay will be energized to change motor connections to parallel full-field. The following sequence occurs to make the transition (See FIGS. 10-6, 10-11 and 10-12):

1. CR2 relay is energized after TTD times out (about 5 seconds).
2. GF contactor is de-energized, ORS is energized.
3. S13 and S24 contactors are de-energized.
4. CR1 relay is de-energized.
5. FS13 and FS24 contactors are de-energized.
6. Parallel contactors (P1, P2, P3, P4) are energized.
7. GF contactor is energized, ORS is de-energized.

## CIRCUIT OPERATION

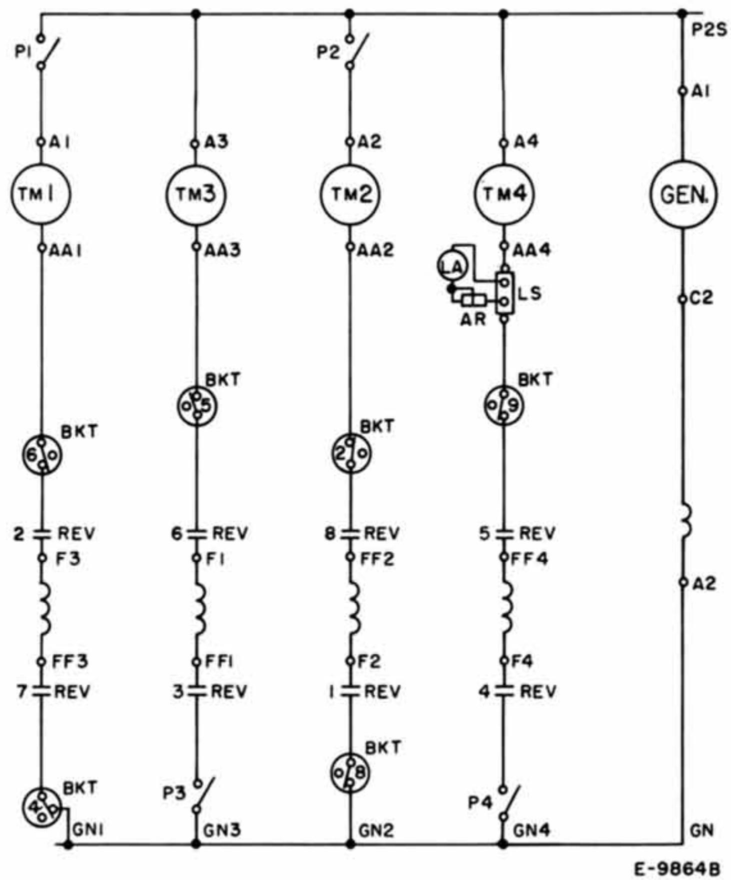



MOTOR FIELD SHUNTING AND CONTROL

FIG. 10-10



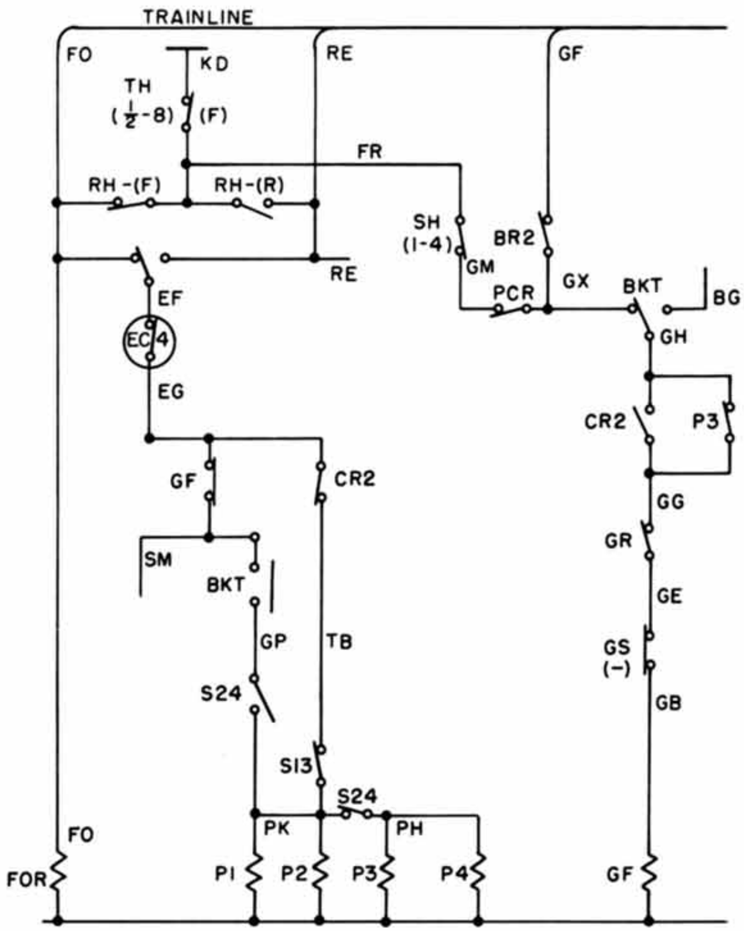
## CIRCUIT OPERATION




PARALLEL MOTOR CONNECTION

FIG. 10-11

# CIRCUIT OPERATION




PROPULSION CONTROL CIRCUITS, PARALLEL
(CIRCUIT DRAWN IN ENERGIZED POSITION)

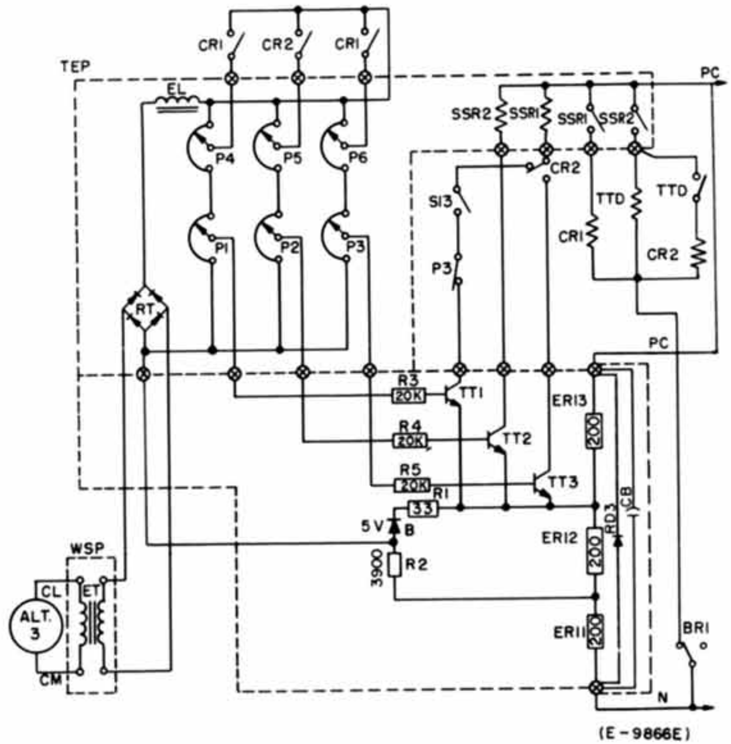
FIG. 10-12

The traction motors are now connected in full parallel. If the locomotive continues to accelerate, the CR1 relay will be energized again to shunt motor fields in the same manner as before.

Locomotive speeds at which field shunting and transition occur are included in a table in the pertinent schematic diagram.



# CIRCUIT OPERATION




AUTOMATIC TRANSITION CONTROL

FIG. 10-13

## AUTOMATIC TRANSITION CONTROL

The traction-motor circuit transitions previously described occur automatically at predetermined locomotive speeds. An axle-driven alternator supplies a frequency signal to the transition panel. The transition panel uses a saturating transformer to convert the alternator frequency to a voltage which is proportional to axle or locomotive speed. The output of the saturating transformer is fed into three calibrated circuits which control three transistors. Each transistor circuit is calibrated to turn on and off at a particular locomotive speed. When a transistor is turned on, it permits current to energize a speed-sensitive relay

(SSR1 or SSR2) which, in turn, energizes CR1 or CR2 (through TTD) relay. The SSR1 and CR1 relays control field shunting, while SSR2, TTD and CR2 relays control parallel transition. The TTD (time delay) relay delays the pickup of CR2. This is to prevent parallel transitions at speeds below normal due to wheel slip.

FIG. 10-13 shows an automatic transition circuit for the operation of the CR1 and CR2 relays. The panel wiring diagram should be consulted for details. Note that the saturating transformer previously mentioned is actually located in the wheel-slip control panel.

## DYNAMIC BRAKING

At the railroad's option, dynamic braking equipment may be installed. On locomotives with dynamic braking, the traction motors are connected as generators with the main generator supplying the exciting current for the traction motor fields. The power output of the traction motors is delivered to grid-type resistors where it is dissipated as heat. The generator action in the traction motors retards the movement of the locomotive and train. FIG. 10-14 shows the dynamic-braking power circuits.

Each traction motor armature is connected across a portion of the braking grids (BRG). All the traction motor fields are connected in series across the main-generator armature.

The braking effort is controlled by the throttle handle. As it is moved through the 16 positions, excitation is increased on the exciter battery field, the main generator, and the traction motors.

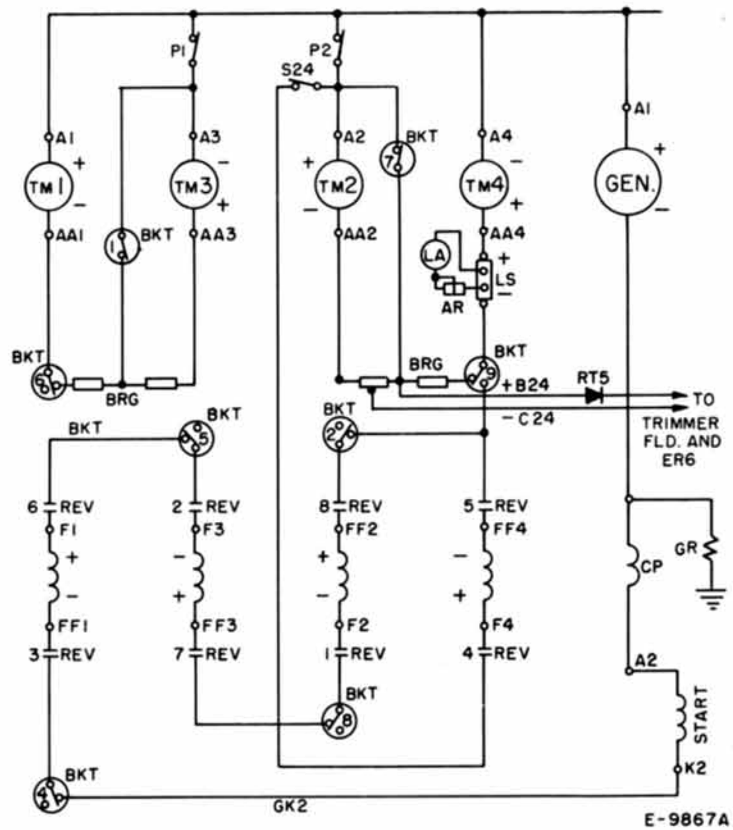
When it is desired to change from motoring to dynamic-braking operation, the following steps are taken:

1. Return throttle to IDLE.

2. Move slector handle to OFF and then to BRAKING (B).

3. Advance throttle slowly to the notch which gives the desired braking effort.





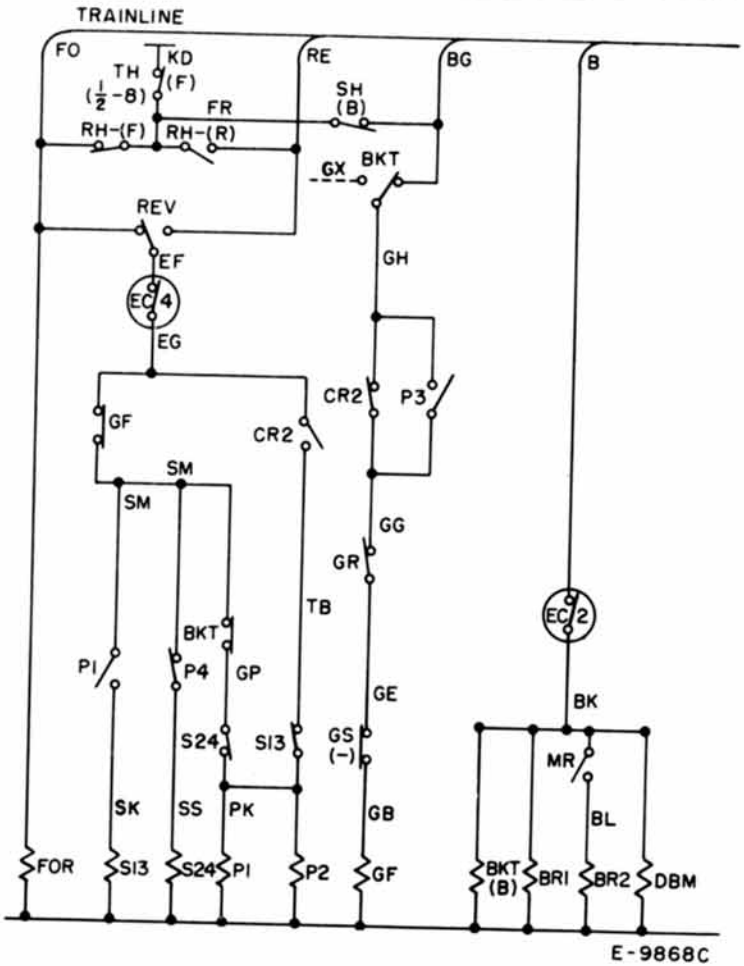

(CONTACTS SHOWN CONNECTED FOR BRAKING.)
DYNAMIC-BRAKING POWER CIRCUITS

FIG. 10-14

## DYNAMIC BRAKING EXCITATION (G-E UNIT LEADING)

The contactors, relays, and braking switch used for dynamic braking are energized when the selector handle (SH) is moved to "B" position. The following sequence takes place. See FIG. 10-15 for the dynamic-braking control circuit.

## CIRCUIT OPERATION




DYNAMIC BRAKING U-25B LEADING
(CIRCUIT DRAWN IN ENERGIZED POSITION)

FIG. 10-15

1. Braking switch (BKT) moves to braking position as BKT-B is energized.
2. Braking relays (BR1 and BR2) are energized.
3. Braking magnet valve (DBM) is energized.



## CIRCUIT OPERATION

4. Since ER relay is de-energized, the AV, BV, and CV governor solenoids are energized and engine speed increases to 8th notch speed.
5. If unit selector switch (USS) is closed (see OPERATING MANUAL), the field loop relay (FLR) is energized.

When the throttle is advanced to notch 1/2 or higher, the following occurs:

1. S24, P1 and P2 contactors are energized.
2. GF contactor is energized.
3. MR relay is energized, thereby de-energizing BR2.
4. Load ammeter indicates braking current.

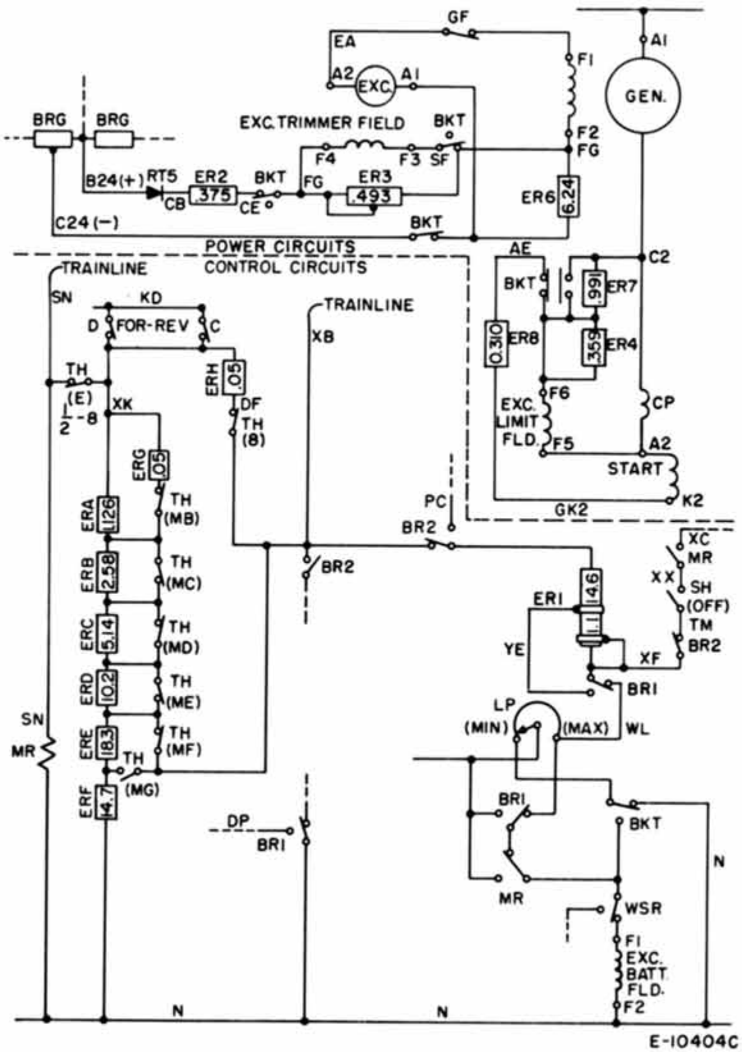
FIG. 10-16 shows the excitation control circuit for dynamic braking when the General Electric unit is leading or operating as a single unit.

The exciter battery field is controlled and establishes a level of excitation for each throttle position. When the throttle handle is moved to notch 1/2, connection is made and voltage established on the XB wire. This is accomplished in the following manner:

1. BR2 relay is not energized because MR interlock contact between wires BK and BL is open.
2. Throttle contact TH (MG) is closed and allows voltage to be applied to wire XB.

As the throttle handle is advanced, the throttle contacts (TH-MB, TH-MC, etc.) close, cutting out resistance to increase voltage on wire XB. This produces a higher current flow in the exciter battery field to give a higher level of excitation current.

When two or more General Electric locomotives are connected in multiple, excitation control for trailing locomotives is through the XB wire. See FIG. 10-16.




U-25B BRAKING AT MAXIMUM EXCITATION
(CIRCUIT DRAWN IN ENERGIZED POSITION)

FIG. 10-16



## EXCITER FIELD CONTROL

The EXC. TRIMMER of the exciter is connected across a portion of the dynamic-braking grids. See FIG. 10-16. This field (current F4 to F3) opposes the F1-F2 field (EXC. BATT. FIELD) and sets a braking grid current-limit for each throttle position, thus automatically protecting against excessive current at any throttle-notch or speed.

The F5-F6 field (EXC. LIMIT FIELD) of the exciter is connected in a circuit with resistors ER8 and ER7 so that it is effectively neutralized during dynamic braking and has no effect on exciter output.

At the railroad's option field loop control braking may be applied. Locomotives are provided with field loop control of braking when leading in multiple with a locomotive using such a system. The field loop relay (FLR) is energized when operating as lead unit and control current flows from XB wire through BSR2 resistor, FLR contacts, to BSR1 and out the FB wire to trail units and returns through FC and FF wires through FLR contacts to N wire. See FIG. 10-17.

## DYNAMIC BRAKING EXCITATION
## (NON G-E UNIT LEADING)

When the lead unit (of another manufacturer) is moved to set up dynamic braking, the following sequence takes place:

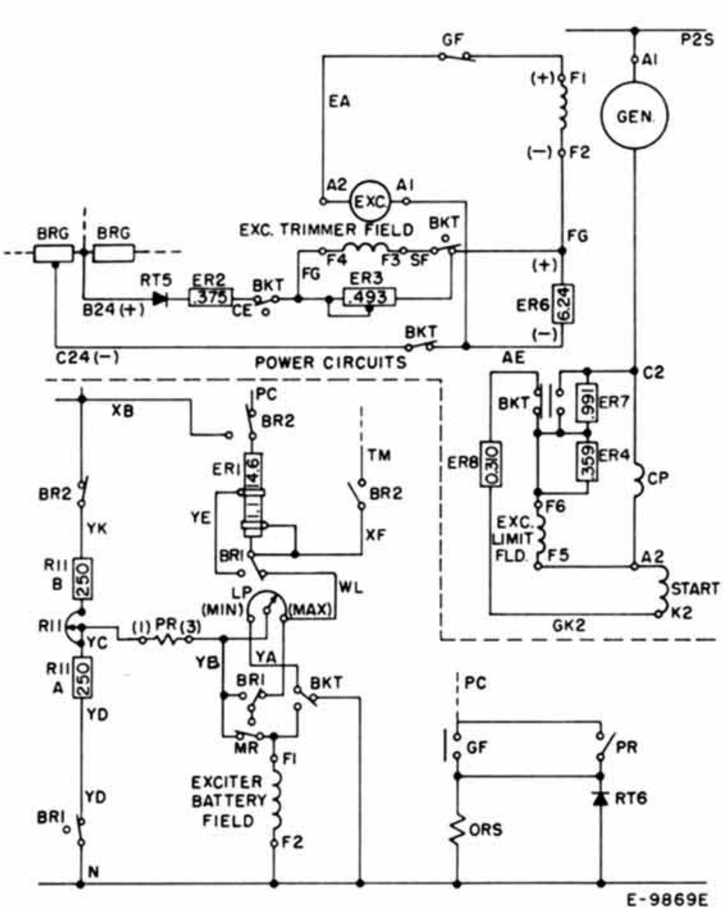
1. Braking switch (BKT) moves to braking position as BKT-B is energized.

2. Braking relays (BR1, BR2) are energized.

3. Braking magnet valve (DBM) is energized.

4. Since ER relay is de-energized, the AV, BV, and CV governor solenoids are energized and engine speed increases to 8th notch speed.

# CIRCUIT OPERATION




NON G-E DYNAMIC BRAKING
(CIRCUIT DRAWN IN ENERGIZED POSITION)

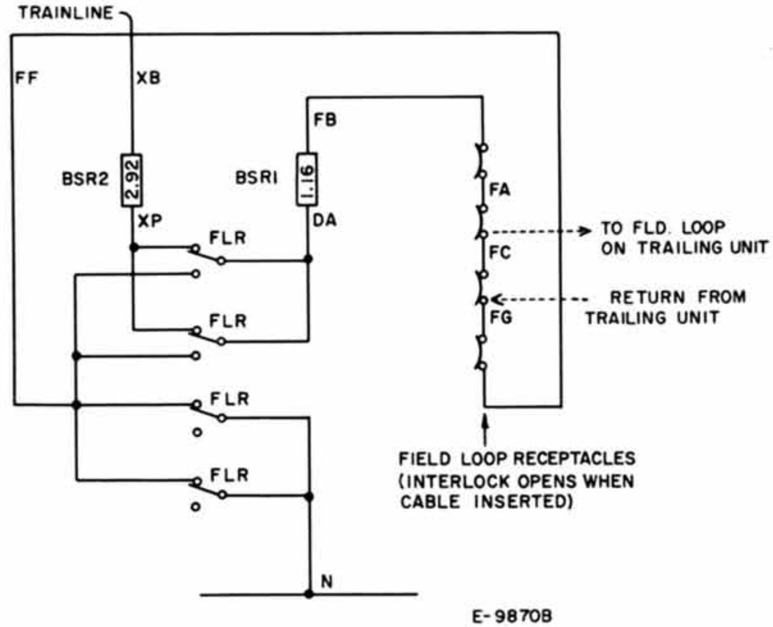
FIG. 10-16A

When the throttle or selector handle (whichever is used for braking) is advanced to notch 1/2 (or higher) the following occurs:

1. S24, P1 and P2 contactors are energized.



# CIRCUIT OPERATION




CIRCUIT SHOWN IN ENERGIZED POSITION

FIG. 10-17

2. GF contactor is energized.

3. Micro-positioner relay (PR) is connected in the circuit since both BR1 and BR2 are up. See FIG. 10-16A.

4. Load ammeter indicates braking current starting from zero current and increasing slowly.

FIG. 10-16A shows the excitation control circuits for dynamic braking. The exciter battery field is controlled and establishes a level of excitation for each braking position. When the handle is moved to notch 1, there is a difference in potential across the PR relay. The PR relay is polarized and picks up only when the current flows from YB to YC wire. When PR relay is energized, YB is at higher voltage than YC, the ORS solenoid is energized, and the governor load control potentiometer moves toward

# CIRCUIT OPERATION

minimum field. This decreases the voltage at YB with respect to YC and drops out PR and ORS. By normal governor action the load control potentiometer moves toward maximum field position to increase excitation and eventually PR relay will be picked up again. Then the same action will be repeated. With the throttle in Notch 1, this action keeps the load control potentiometer (LP) operating near minimum position and excitation is very low.

## ENGINE SHUTDOWN

The following steps are taken in shutting down the diesel engine:

1. Return throttle handle to IDLE.
2. Return selector handle to OFF.
3. Open generator field breaker.
4. Return reverse handle to OFF.
5. Move engine-control switch to START.
6. Push and hold STOP switch. See FIG. 10-8.
   a. The DV solenoid is energized (not AV, BV, or CV).
   b. Governor action removes fuel from engine.
7. Release STOP switch when engine has shut down.
8. Open all circuit breakers and battery knife switch.

## ALARMS AND SAFEGUARDS

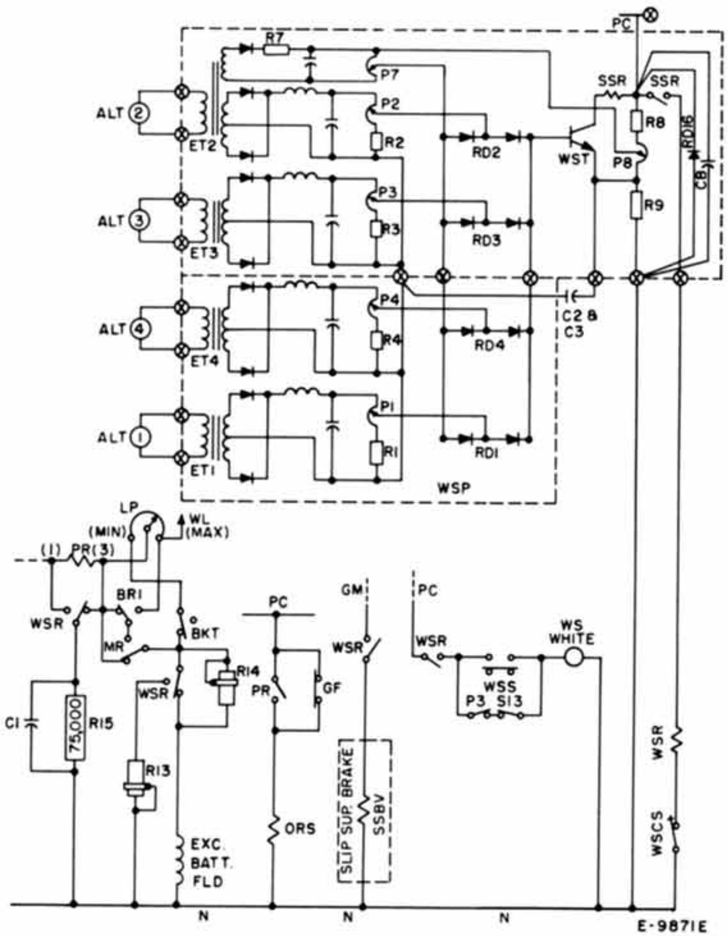
Various devices or systems are included to safeguard the equipment and give suitable alarm in event of trouble. The following explains the operation of each:

### WHEEL-SLIP CONTROL

If a pair of wheels slip or slide without corrective action, severe damage can result. A sliding wheel causes



# CIRCUIT OPERATION




WHEEL SLIP CONTROL CIRCUITS

FIG. 10-18

flat spots, while a slipping wheel can overspeed the traction motor. In addition, the slipping wheel reduces traction.

Each axle is fitted with a small permanent-magnet field axle-alternator which supplies a frequency proportional to locomotive speed. The output of each axle-alternator is fed

# CIRCUIT OPERATION

into the wheel-slip panel (WSP), where the frequency signal is converted to a voltage signal. See FIG. 10-18. This is done by saturating transformers, which are loaded through a resistor and potentiometer. The potentiometers are factory adjusted to obtain equal voltage at each brush arm for equal axle speeds.

The output of each potentiometer is connected to a rectifier network and transistor circuit. The only time current flows through the rectifiers and transistor is when there is sufficient differential in axle-alternator speeds. When sufficient differential exists, the transistor operates to energize the sensitive relay (SSR). The amount of differential required to operate the transistor and relay varies over the speed range of the locomotive.

Voltage from the PC wire to R8, P8, R9 is used to help operate the transistor. This circuit increases the sensitivity of the system.

Because of the variations in wheel diameter, the sensitivity must be decreased at higher speeds. This is accomplished by voltage from another secondary winding on ET2 transformer. Voltage from this winding increases with locomotive speed and decreases the sensitivity of detection as speed increases.

When the SSR relay is energized, it, in turn, energizes the WSR relay. Four WSR relay contacts operate to correct the slip and give an alarm. FIG. 10-18 shows the circuits controlled by WSR.

Wheel-slip correction is accomplished primarily by a prompt light air-brake application. When the WSR relay is energized, the slip suppression brake valve (SSBV) is energized to give the light brake application. At the same time, the R14 resistor is put in series with the exciter separate field and the R13 resistor is placed in parallel with R14 and the exciter separate field. This reduces the exciter field current as the magnetic flux in the exciter decays and, in turn, reduces the main-generator field current as the magnetic flux in the main-generator decays.

Automatic sanding (pneumatically controlled) takes place on the slipping unit after a brief time delay if slip



CIRCUIT OPERATION

persists. Simultaneously, during prolonged slipping, there is a gradual continued reduction of generator excitation. The circuits are set up so that the gradual discharge of the capacitor C1 through R15 causes the PR relay to energize the ORS solenoid in the governor in such a way that it moves the load-control potentiometer toward minimum field. The travel from the maximum field position to the minimum field position takes about 20 seconds. Generally, the prompt application of the slip suppression brake together with automatic sanding after about three seconds corrects slips so promptly that there is very little reduction in engine output. Capacitors C2 and C3 protect against synchronous slips and improve sensitivity.

Slips of a very few seconds duration will not operate the wheel-slip warning. As shown in FIG. 10-18, the WSR contact sets up the circuit to the wheel-slip indicator. During motoring, contacts P3 or S13 are open. The WSS pneumatic switch closes when the air pressure in an air reservoir reaches a predetermined value. This takes several seconds following the starting of a continuous slip. Successive slips of short duration may eventually operate the WSS switch. For air circuit refer to FIG. 10-19.

When a slip occurs during coasting or dynamic braking (WSS switch is shorted by P3 and S13 contacts), the warning light operates immediately when WSR is energized.

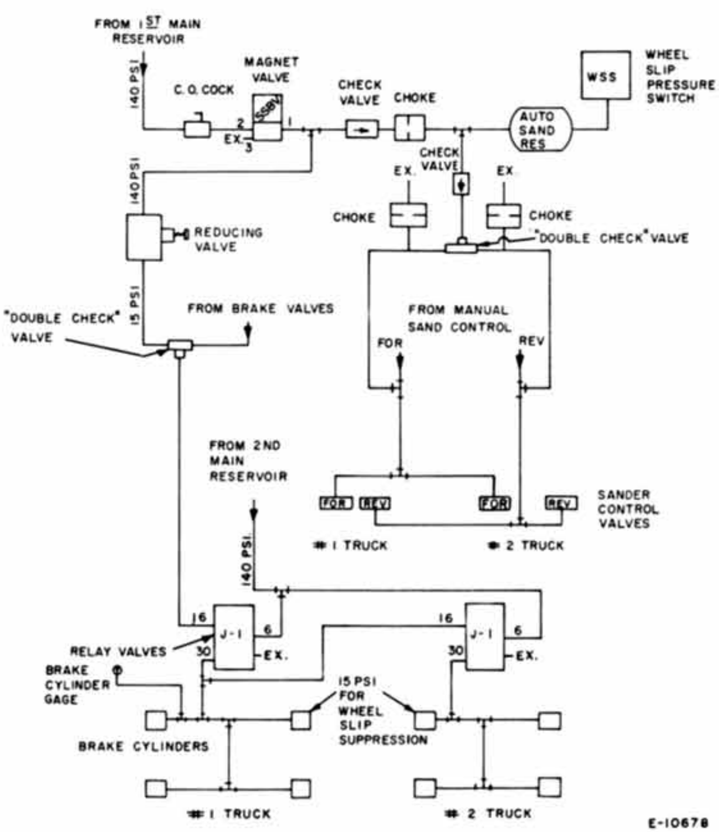
## GROUND RELAY

As shown in FIG. 10-20, a ground relay (GR) is connected into the power circuit to detect grounds. When a ground exists, the GR relay is energized and mechanically locks itself in energized position. A GR contact opens the GF contactor circuit, which removes excitation. A second GR contact de-energizes the ER relay, which returns the engine to idle speed. It also rings the alarm bell. The throttle should be returned to IDLE before resetting GR.

## HOT ENGINE

An engine temperature switch (ETS) closes at a predetermined engine water temperature. The switch contacts operate the red, HOT ENGINE light. See FIG. 10-21.

## CIRCUIT OPERATION

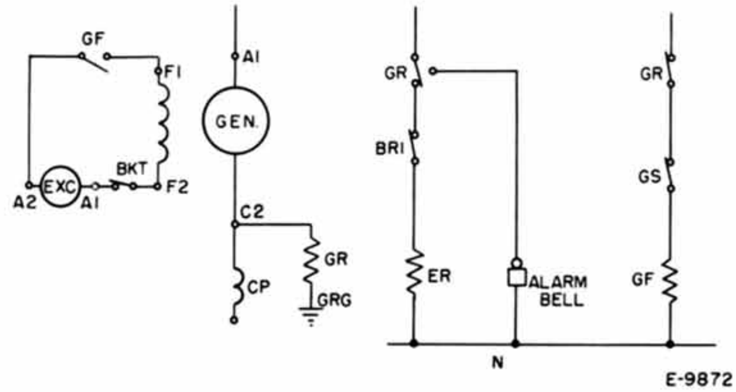



TYPICAL AIR PIPING SCHEMATIC WHEEL SLIP SUPPRESSION AND SANDING EQUIPMENT

FIG. 10-19



CIRCUIT OPERATION




GROUND RELAY CIRCUITS

FIG. 10-20

### LOW ENGINE OIL PRESSURE

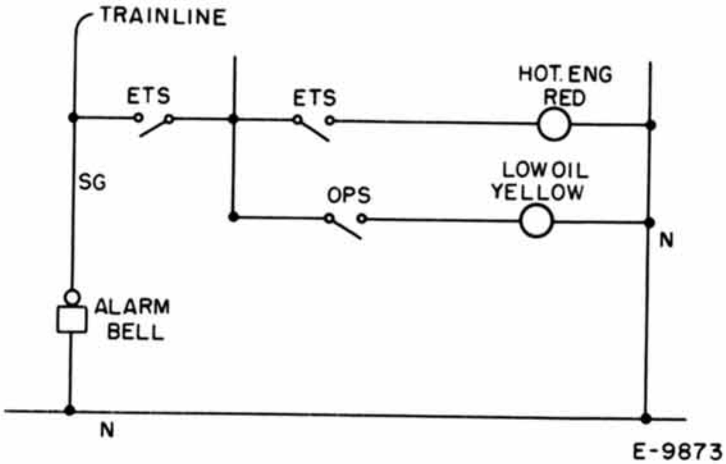
Engine lubrication - oil pressure is supplied to the engine governor. The oil-pressure switch (OPS) operates on a difference in pressure between the engine and governor oil pressures. If engine oil pressure drops sufficiently, the OPS switch closes to operate yellow LOW OIL light. See FIG. 10-21. Governor action will shut down engine.

### NO BATTERY CHARGING

The no-battery-charging relay (HR) coil is connected across the reverse-current contactor and charging circuit breaker in series with the auxiliary-generator armature. When the engine is shut down (no auxiliary-generator voltage), the HR relay is energized. The HR contacts operate the No-Battery-Charging light (blue) and the alarm bell if the EC switch is moved to RUN. No alarm will appear during cranking, since the EC switch is in START.

During cranking, the auxiliary-generator voltage rises causing HR coil current to decrease. Eventually HR will drop out. When auxiliary-generator voltage rises above battery volts, the RC contactor picks up and shorts out the HR coil. The auxiliary generator charges the battery.

# CIRCUIT OPERATION




HOT ENGINE AND LOW OIL PRESSURE

FIG. 10-21

When the engine is idling, the EC switch can be moved to RUN. If the HR relay is not de-energized, the alarm light and bell operate. See FIG. 10-22. This means the voltage regulator is not functioning properly.

EMERGENCY SHUTDOWN

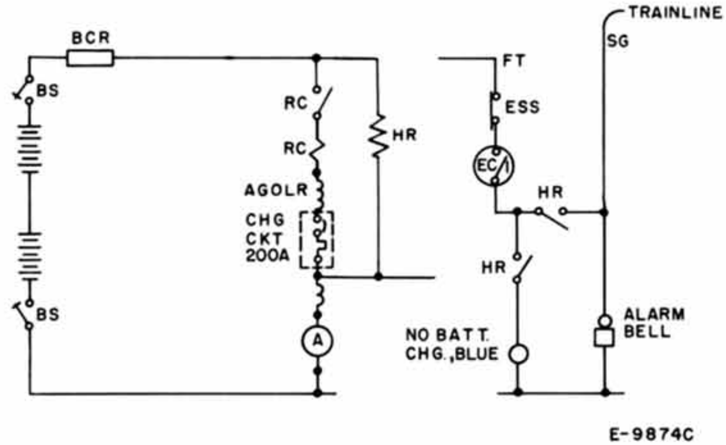
An occasion may arise when it is desirable to shut down all engines operating in multiple unit. This can be accomplished by operating the emergency shut-down switch (ESS). FIG. 10-8 shows the results of operating ESS. One set of contacts will de-energize the AV, BV, and CV governor solenoids on all units. Another set of ESS contacts energize the DV solenoid (and DR relay) on all units. This action shuts down all engines. The ESS switch must be reset before the engines can be restarted.

LOCOMOTIVE OVERSPEED

At the railroad's option locomotive overspeed is applied. The locomotive overspeed magnet valve (OSV) is normally energized during locomotive operation. If the locomotive speed increases to a predetermined value (near or above



CIRCUIT OPERATION




NO BATTERY CHARGING ALARM

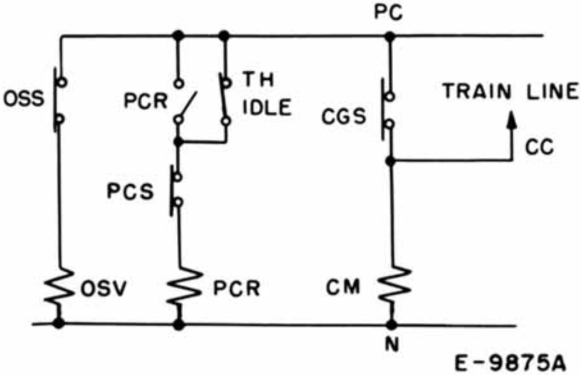
FIG. 10-22

maximum), the overspeed switch (OSS) opens to de-energize OSV. When OSV is de-energized, an air-operated whistle warns the operator. If the operator does not apply brakes within a few seconds the brakes are automatically applied and power is removed.

AIR COMPRESSOR SYNCHRONIZATION

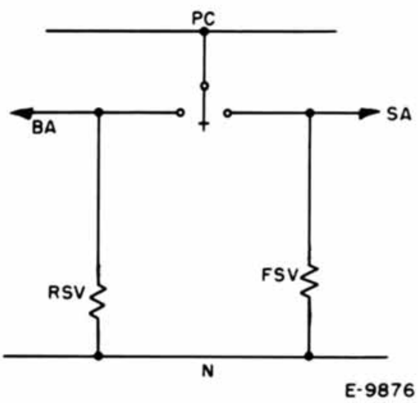
Each unit operating in multiple has an air compressor that supplies main air reservoir pressure. When main-reservoir air is used to control the locomotive and train, the air pressure decreases. When it drops to 130 psi on any unit, the compressor governor switch (CGS) closes and energizes the compressor magnet valve (CM) on all units. This operates a compressor unloader valve to cause compressor to pump air into reservoirs. This forces the air compressor on each unit to share the load. The CGS switch opens when main-reservoir pressure reaches 140 psi to unload compressor out to atmosphere. See FIG. 10-23.

# CIRCUIT OPERATION




AIR COMPRESSOR SYNCHRONIZATION SAFETY CONTROL
LOCOMOTIVE OVERSPEED

FIG. 10-23



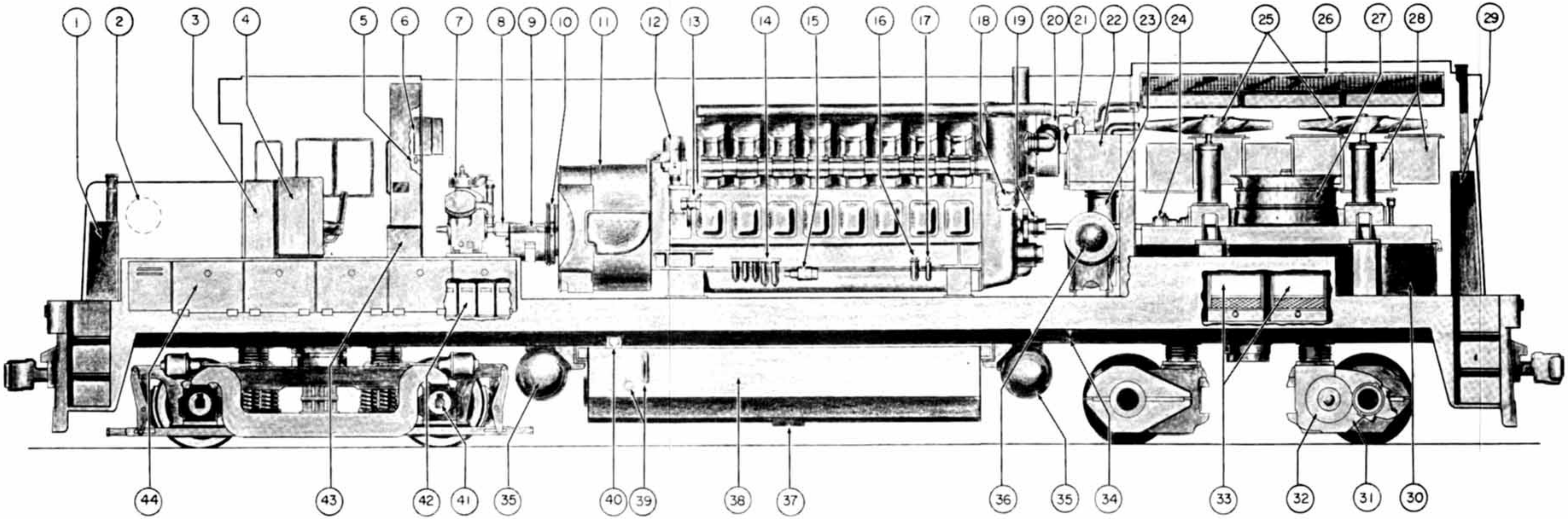

ELECTRIC SANDING CONTROL

FIG. 10-24

## SANDING

FIG. 10-24 shows the electric sanding control. A sanding switch with a forward and reverse position energizes the forward or reverse sander magnet valves (FSV, RSV). The magnet valves control the application of sand on all units operating in multiple.

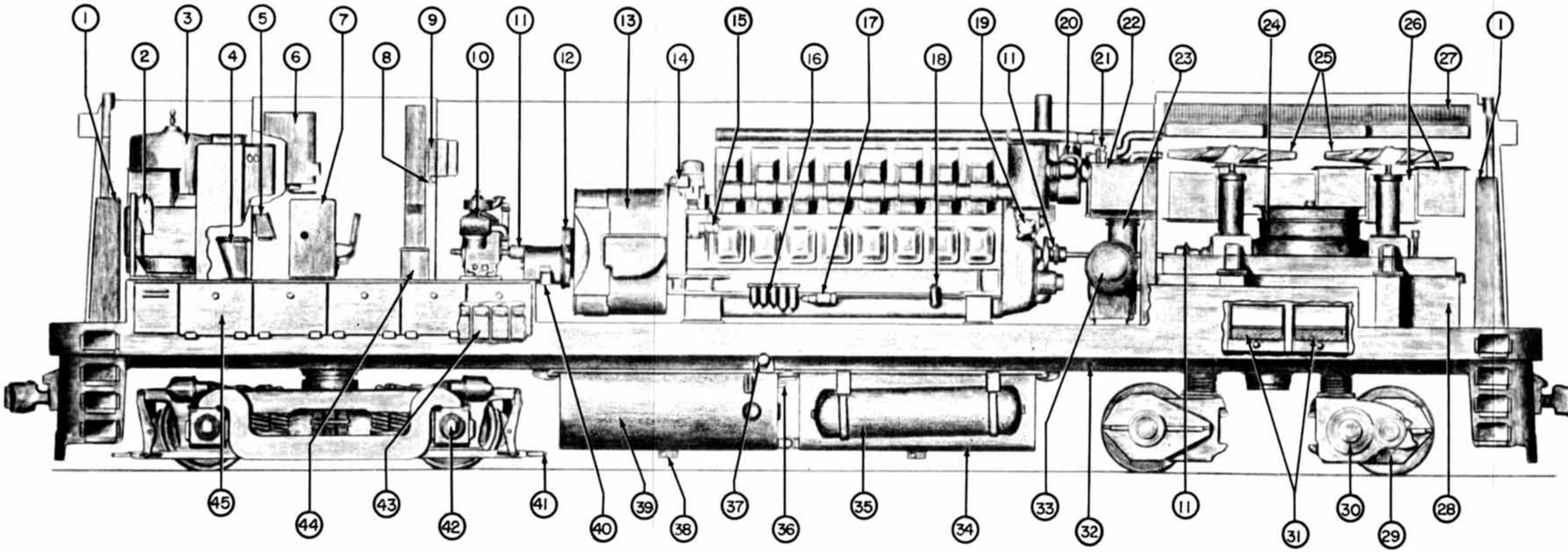
Some models have pneumatic controls instead of electric.




1. SAND BOX
2. HANDBRAKE
3. OPERATING CONTROLS AND GAGE PANEL
4. AIR BRAKE CONTROLS
5. EMERGENCY FUEL TRIP
6. ENGINE CONTROL PANEL
7. AIR COMPRESSOR
8. FLEXIBLE COUPLING
9. AUXILIARY GENERATOR (LEFT SIDE)
   EXCITER (RIGHT SIDE)
10. TRACTION GENERATOR GEAR CASE
11. TRACTION GENERATOR
12. ENGINE CONTROL GOVERNOR
13. OVERSPEED GOVERNOR
14. FUEL FILTERS
15. FUEL BOOSTER PUMP
16. LUBE OIL FILLER
17. LUBE OIL DIP-STICK (BOTH SIDES)
18. LUBE OIL STRAINER
19. FLEXIBLE COUPLING
20. TURBOCHARGER
21. WATER FILL (GRAVITY)
22. WATER STORAGE TANK
23. LUBE OIL COOLER
24. FLEXIBLE COUPLING
25. RADIATOR FANS
26. RADIATOR
27. EQUIPMENT BLOWER
28. BRAKING RESISTORS
29. SAND BOX
30. PRIMARY AIR CLEANER
31. TRACTION MOTOR GEAR CASE
32. TRACTION MOTOR
33. ENGINE AIR FILTERS
34. WATER FILL (PRESSURE) (BOTH SIDES)
35. MAIN AIR RESERVOIR
36. LUBE OIL FILTER
37. FUEL TANK SUMP
38. FUEL TANK
39. FUEL LEVEL GAGES
40. FUEL TANK FILL (BOTH SIDES)
41. AXLE ALTERNATOR (ALL AXLES)
42. BATTERIES (RIGHT SIDE)
43. CAB HEATER
44. CONTROL COMPARTMENT (LEFT SIDE)
    AIR BRAKE COMPARTMENT (RIGHT SIDE)

APPARATUS LOCATION (E-11662)

(LOW NOSE LOCOMOTIVE)



1. SAND BOX
2. HAND BRAKE
3. STEAM GENERATOR (IF USED)
4. HOPPER
5. ENGINEMAN'S GAGE PANEL
6. MASTER CONTROLLER
7. AIR BRAKE STAND
8. EMERGENCY FUEL TRIP
9. ENGINE CONTROL PANEL
10. AIR COMPRESSOR
11. FLEXIBLE COUPLING
12. TRACTION GENERATOR GEAR CASE
13. TRACTION GENERATOR
14. ENGINE CONTROL GOVERNOR
15. OVERSPEED GOVERNOR
16. FUEL FILTERS
17. FUEL BOOSTER PUMP
18. LUBE OIL FILL AND DIP-STICK
19. LUBE OIL STRAINER
20. TURBOCHARGER
21. WATER FILL (GRAVITY)
22. WATER STORAGE TANK
23. LUBE OIL COOLER
24. EQUIPMENT BLOWER
25. RADIATOR FANS
26. BRAKING RESISTORS
27. RADIATOR
28. PRIMARY AIR CLEANER
29. TRACTION MOTOR GEAR CASE
30. TRACTION MOTOR
31. ENGINE AIR FILTERS
32. WATER FILL (PRESSURE)
33. LUBE OIL FILTER
34. AUXILIARY FUEL TANK
35. MAIN AIR RESERVOIR
36. EMERGENCY FUEL TRIP (BOTH SIDES)
37. FUEL TANK FILLER
38. FUEL TANK SUMP
39. MAIN FUEL TANK
40. AUXILIARY GENERATOR (LEFT SIDE) EXCITER (RIGHT SIDE)
41. SLACK ADJUSTER
42. AXLE ALTERNATOR (ALL AXLES)
43. BATTERIES (RIGHT SIDE)
44. CAB HEATER
45. CONTROL COMPARTMENT (LEFT SIDE) AIR BRAKE COMPARTMENT (RIGHT SIDE)

APPARATUS LOCATION (E-10093)

(HIGH NOSE LOCOMOTIVE)