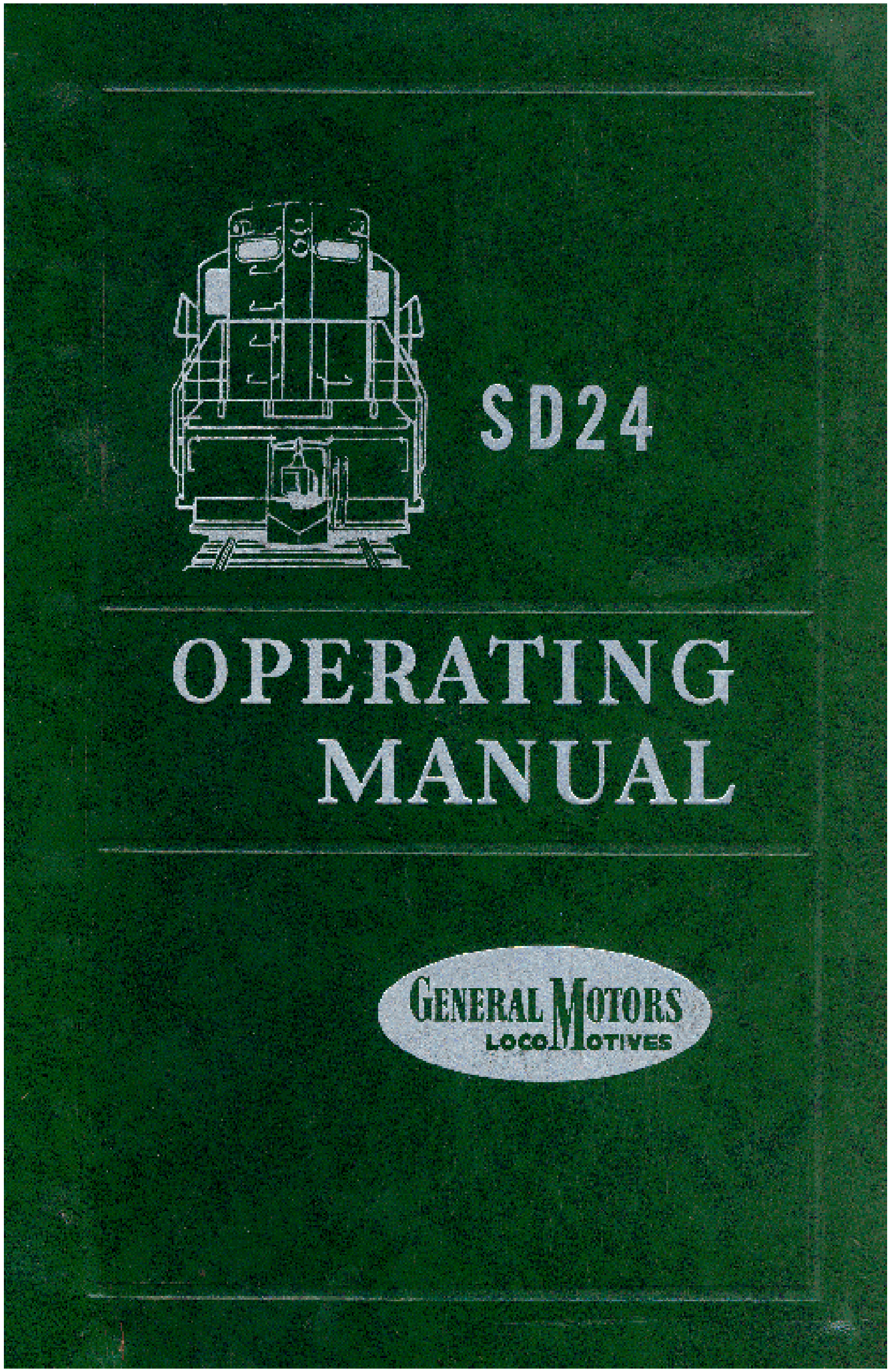

DIESEL LOCOMOTIVE

OPERATING MANUAL

for

MODEL SD24

2nd Edition
July, 1959

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

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INTRODUCTION

This manual has been prepared to serve as a guide to railroad personnel engaged in the operation of the 2400 horsepower General Motors Model SD24 turbocharged diesel-electric locomotive.

The information in this manual is divided into seven sections. which feature the following information:

1 - General Description - Provides general description of principal equipment components.

2 - Cab Controls - Explains functions of cab control equipment used in operating the locomotive.

3 - Operation - Outlines procedures for operation of the locomotive.

4 - Mechanical Systems - Describes the fuel, cooling, lubricating oil and air system functions during locomotive operation.

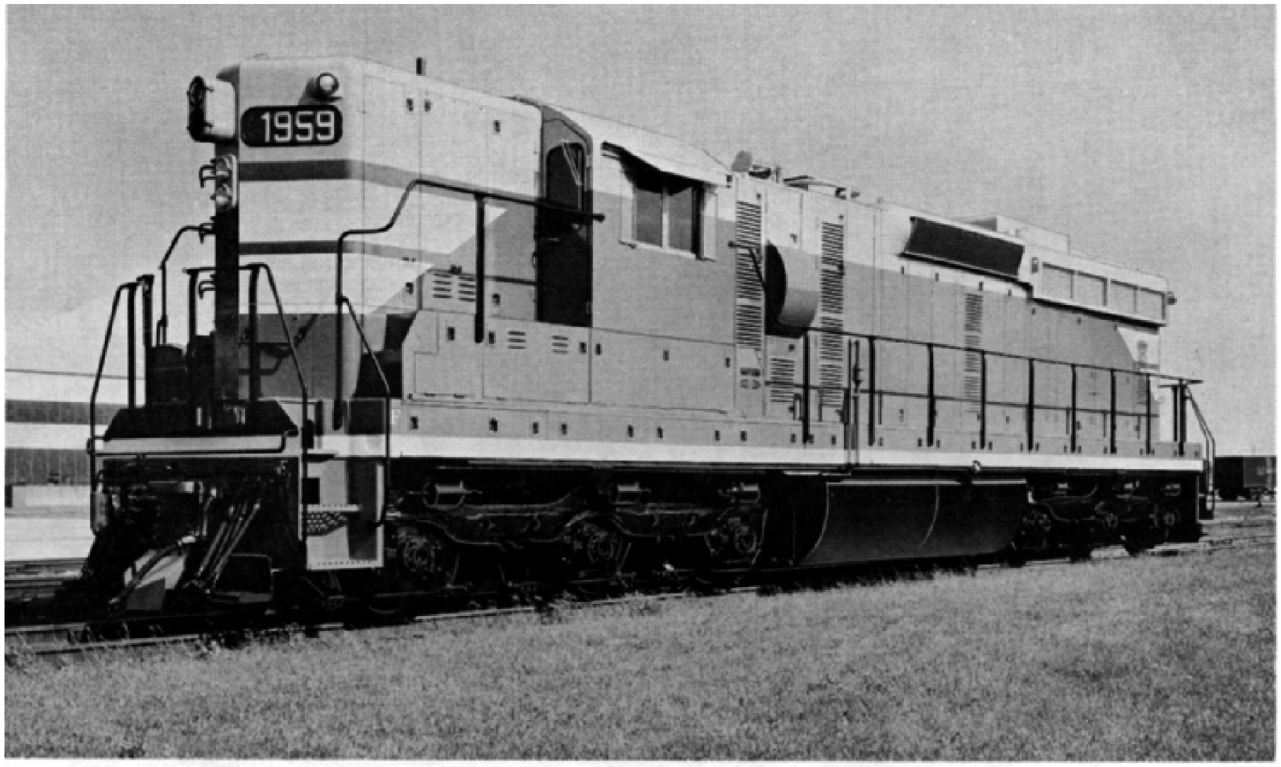
5 - Electrical Equipment - Explains functions of principal electrical equipment components.

6 - Electrical Systems - Explains electrical systems and circuit functions.

7 - Trouble Shooting - Describes cause, location and correction of possible troubles occurring during operation.

The sections are numbered in the 100 series type of numbering. Thus Section 1 starts with page 100, Section 2 with 200, and the others following in this manner. Figures are identified by section and sequence thus Fig. 2-3 is the third figure used in Section 2.

For a thorough understanding of the operation of the SD24 locomotive, it is strongly recommended that all sections of this manual are read in the sequence in which they appear.



General Motors Model SD24 Locomotive
Fig. 0-1

General Motors Model SD24 Locomotive
Fig. 0-1

GENERAL DATA

Model Designation	SD24
Locomotive Type	0660
Locomotive Horsepower	2400
Diesel Engine	
Model	567D3
Type	Turbocharged
Number of Cylinders	16
Cylinder Arrangement	45° "V"
Cylinder Bore and Stroke	8-1/2" x 10"
Operating Principle	2 cycle
Full Speed	835 RPM
Idle Speed	275 RPM
Starting Speed	75-100 RPM
Main Generator	
Model	D22
Nominal Voltage (DC)	600
Number of Fields	6
Alternator	
Model	D14
Type	3 phase
Poles	16
Nominal Voltage (AC)	170
Frequency (At 835 RPM)	111-1/3 cps
Auxiliary Generator	
Rating (Basic)	10 KW
*Rating (With Steam Generator)	18 KW
Voltage (DC)	74
Traction Motors	
Model	D47
Number	6
Type	Series wound
Driving Wheels	
Number	6 pair
Diameter	40"
*Gear Ratio - Maximum	
Speed Options	62/15 - 65 MPH
	61/16 - 71 MPH
	60/17 - 77 MPH
	59/18 - 83 MPH
	58/19 - 89 MPH

GENERAL DATA (Cont'd)

Air Compressor	
Model	WBG
Type	2 stage
Number of Cylinders	6
Capacity (At 835 RPM)	371 cu. ft. per min.
Cooling	Water
Air Reservoir Capacity	50,000 cu. in.
Storage Battery	
Number of Cells	32
Voltage	64
Rating (8 hour)	420 ampere hours
Supplies	
Lubricating Oil Capacity	220 gallons
Cooling Water Capacity	260 gallons
Fuel Capacity (Basic)	1200 gallons
* Fuel Capacity (Extra)	3000 gallons
*Water Capacity (Steam Generator)	1200 gallons
Sand Capacity	46 cu. ft.
Locomotive Weight (Fully Loaded)	328,000 lbs. max.
*Locomotive Weight (Ballasted)	390,000 lbs. max.
Weight On Drivers	100%
Major Dimensions	
Overall Length Between Coupler Faces	60' 8"
Distance Between Truck Bolster Centers	35' 0"
Width Over Grab Irons	10' 8"
Overall Height Between Top of Rail & Cab	15' 1"
Minimum Curve Radius	250' 0"
Truck Rigid Wheel Base	13' 7"
*Steam Generator Rating	2750 lbs. per hour
Air Brakes	
Schedule (Basic)	26L
*Schedule (Optional)	6BL or 24RL

*Indicates optional features

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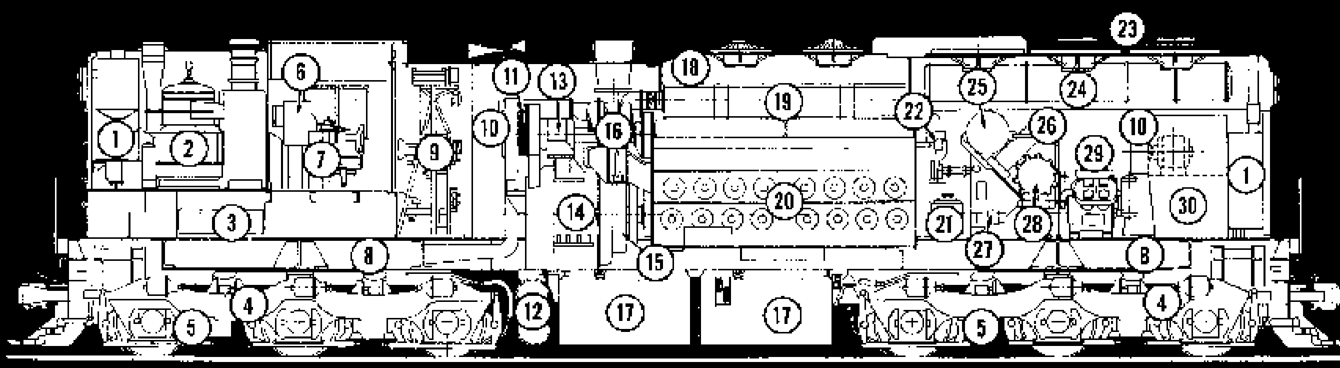
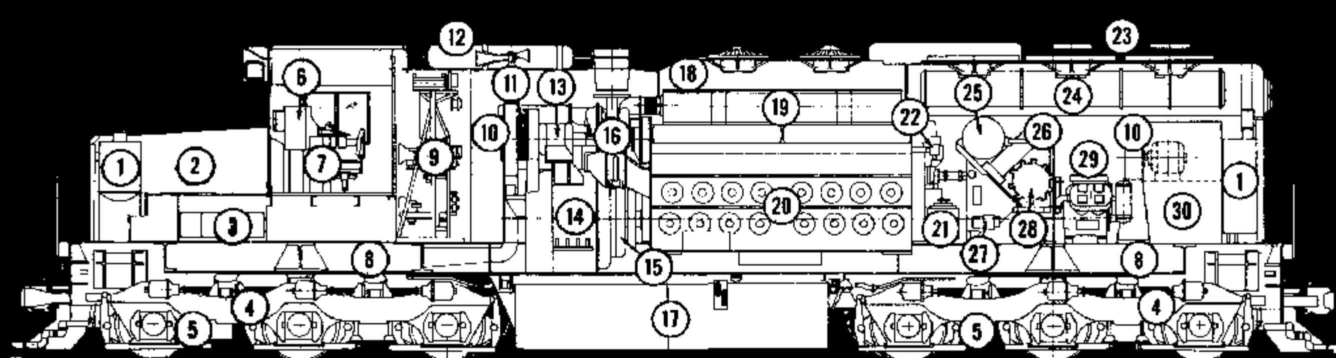


1. Sand Box
2. Steam Generator
3. Storage Battery
4. Truck
5. Traction Motor
6. Locomotive Controller
7. Air Brake Controls
8. Air Duct
9. No. 1 Electrical Cabinet
10. Traction Motor Blower
11. Generator Blower
12. Air Reservoirs
13. Auxiliary Generator
14. Main Generator
15. Alternator
16. Turbocharger
17. Fuel And Water Tanks
18. Dynamic Brake Hatch
19. Exhaust Manifold
20. Diesel Engine
21. Lube Oil Strainer
22. Governor
23. Engine Cooling Fans
24. Radiators
25. Engine Water Tank
26. Lube Oil Cooler
27. Fuel Pump
28. Lube Oil Filter
29. Air Compressor
30. No. 2 Electrical Cabinet

General Arrangement Of Equipment
Fig. 1-1



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General Arrangement Of Equipment
Fig. 1-1

SECTION 1

GENERAL DESCRIPTION

INTRODUCTION

The General Motors Model SD24 locomotive, illustrated in Fig. 0-1, is equipped with a turbocharged diesel engine that delivers 2400 horsepower to the main generator for tractive purposes. This power is then distributed to six traction motors each of which is directly geared to a pair of driving wheels.

The basic locomotive is arranged and equipped so (that the short hood or cab end is considered the front or forward part of the unit. All information in this manual pertaining to equipment location or identification is based on this arrangement. Thus the number 1, 2 and 3 traction motors are located in that order in the No. 1 truck which is under the cab or short hood end of the locomotive. On special order, however, this basic designation could be changed so that the long hood end would be forward. In addition to this possibility, dual controls are sometimes ordered thus permitting either end of the locomotive to be considered the front end depending on direction of travel.

The locomotive may consist of one or more individual units each of which is a completely functional power plant. When coupled together for multiple unit operation, all can be simultaneously controlled from a single set of controls located in the cab of the lead unit. This is accomplished electrically by circuits established through jumper cables connected between the units.

This section of the manual describes the functions of the major equipment components and provides a brief I description of how the SD24 locomotive operates.

PRINCIPAL EQUIPMENT COMPONENTS, Fig. 1-1

The general arrangement of equipment used on the SD24 locomotive is shown in Fig. 1-1. Each of the more important equipment components are numbered and identified both in this illustration and in the descriptions that follow. Some of the items are covered in greater detail in other sections of the manual. The Table of Contents should be consulted for such additional information.

1. SAND BOX

Two sand boxes are used on the SD24 locomotive each having a capacity of 23 cu. ft. of sand. One is located at the extreme front end of the locomotive to supply sand to the No. 1 truck while the other is at the rear end to serve the No. 2 truck. They can be readily filled through roof openings.

Sanding to prevent or correct wheel slipping can be initiated manually by sanding valves in the cab or electrically by automatic sanding features operating in conjunction with wheel slip relays. In either instance main reservoir air pressure actuates sand traps to release sand in front of the leading pair of wheels in each truck. Sanding is equally effective for both forward or reverse locomotive operation.

2. STEAM GENERATOR

When used, a steam generator is installed in the front or short hood end of the locomotive unit. Its purpose is to generate steam which is piped back into the cars for train heating purposes. Installation of a steam generator is optional and required only in instances where the locomotive unit is to be suitable for passenger train purposes.

In operation, water is pumped from the storage tank, Item 17, Fig. 1-1, to coils within the steam generator. Diesel fuel oil is then spark ignited to provide an intense fire which evaporates the water into steam. Once started, operation of the steam generator is entirely automatic.

3. STORAGE BATTERY

A 32 cell, 64 volt storage battery is located in two battery boxes under the catwalk along each side of the short hood of the locomotive. Doors are provided to facilitate inspecting and servicing the battery.

The storage battery supplies power to run the fuel pump and to start the engine through motorizing of the main generator. It also supplies power for the lights and control circuits. Once the engine is running, the auxiliary generator provides all low voltage needs and it charges the battery as well.

An ammeter is provided on the rear cab wall above the electrical cabinet to indicate whether the storage battery is being charged or discharged.

4. TRUCKS

Two fully flexible three axle trucks are used on the SD24 locomotive. The truck supports three traction motors each of which is directly geared to an axle and pair of driving wheels.

Full floating action between the bolster and truck frame is obtained through the use of four sets of double coil springs, one set in each corner of the H-shaped bolster. Relative movement between the bolster and truck frame is controlled by rubber cushioned bolster stops and spring loaded snubbers.

Equalization between axles and additional vertical springing is provided by two sets of triple coil helical springs mounted between each journal box and the truck frame.

All axles are equipped with Hyatt roller bearing journal boxes. A recess in the journal box casting holds a stench bomb which is designed to release a pungent odor should the journal box ever become heated to approximately 220° F. Provision is made for application of a smoke bomb which would also serve to warn of a hot journal.

For purposes of lubrication, the journal box is provided with fill and drain plugs that should be kept securely wired in place to prevent loss of lubricants or entrance of contaminants.

5. TRACTION MOTOR

Each pair of wheels is powered by one of the six heavy-duty traction motors used on the SD24 locomotive. These motors are electrically connected to the main generator by means of cables and switches to provide the necessary circuits for operation.

Each motor is mounted in the truck so that one side is supported by a nest of springs in the truck frame and the other side rides directly on the wheel axle. A gear on the wheel axle meshes directly with a pinion at the end of the motor armature shaft. The gear ratio of the locomotive and its range of operation is determined by the sizes of these gears. The gears are protected by a gear case containing a heavy grease lubricant.

6. LOCOMOTIVE CONTROLLER

The controller is located in the cab and contains the levers, switches and gauges that the engineman will be using during locomotive operation.

This device is used to establish low voltage control circuits throughout the locomotive for proper operation.

All units of a multiple unit locomotive may be operated simultaneously from the controller in the lead unit. In such instances, jumper cables are installed between units to "trainline" the necessary electrical circuits.

7. AIR BRAKE CONTROLS

The type 26L air brake schedule is installed as basic equipment on the SD24 locomotive. In instances of customer preference, types 6BL or 24RL could be installed.

Regardless of which type is used, located in the cab adjacent to the controller will be an independent and an automatic brake valve with actuating handles for each. The independent brake valve applies brakes to the locomotive alone. The automatic brake valve applies brakes to both train and locomotive.

8. COOLING AIR DUCT

A cooling air duct is built into the locomotive underframe at both front and rear ends to provide cooling air for the traction motors.

These ducts are charged with air by traction motor blowers (Item 10). A mechanically driven blower supplies air to the front truck while an electrically driven blower is used at the rear.

Openings are provided in the traction motors for passage of the cooling air. Air is admitted through the top opening which is connected to the duct by means of a flexible bellows type arrangement. Passing through the motor, the cooling air picks up heat which is discharged to atmosphere through side openings in the motor. This method of forced air cooling is also effective in keeping dust and dirt from entering the motor during operation.

9. ELECTRICAL CONTROL CABINET NO. 1

Forming the rear wall of the cab is electrical cabinet No. 1. It is accessible from both the cab and engineroom sides. Within the cabinet are the majority of electrical devices required to control locomotive operation. These consist of fuses, circuit breakers, switches, relays and contactors.

The function of these many devices is entirely automatic. Some of them are used in high voltage circuits for the transmission of power to the traction motors in the No. 1 truck, while others are for low voltage control purposes. All of the contactors and relays having moving parts are electro-magnetically actuated.

Cabinet access doors are provided for purposes of equipment inspection and maintenance. They should be always kept closed during locomotive operation.

10. **TRACTION MOTOR BLOWER**

Two blowers are used to provide cooling air for the traction motors. The one near the cab end of the locomotive is mechanically driven by a shaft from the rear gear train of the diesel engine. It charges a duct in the locomotive underframe to provide cooling air to the three traction motors in the No. 1 truck.

The second traction motor blower, located at the long hood end of the locomotive, is electrically driven by a 25 horsepower alternating current motor. It supplies air to a duct in the underframe for the No. 2 truck and its traction motors. Both blowers operate automatically and will be running whenever the diesel engine is in operation. Blower speed will vary directly with the engine speed. They will be running fastest when the engine is running at full throttle thus providing maximum air when it is most needed.

11. GENERATOR BLOWER

The generator blower is driven by a shaft from the rear gear train of the diesel engine and it supplies ventilation and cooling for the main generator. It operates whenever the diesel engine is running and at speeds in direct proportion to the engine speed.

12. AIR RESERVOIRS

Compressed air received from the air compressor must be stored to maintain a sufficient volume or reserve for locomotive and train operation. Although primarily used for the air brakes, compressed air is also used for operation of the bell ringer, signal horn, sanders, windshield wipers and temperature control shutters.

The air system should be drained periodically to prevent accumulations of moisture from condensation.

Main reservoir air pressure is approximately 140 pounds psi. This pressure is automatically maintained by pressure sensitive electrical devices that control air compressor pumping action. An air pressure gauge is located above the controller in front of the engineman.

13. AUXILIARY GENERATOR

The auxiliary generator is mounted on top of the main generator and is directly driven by a shaft extending from the rear gear train of the diesel engine. Its purpose is to supply power for the low voltage electrical system of the locomotive.

This low voltage direct current electricity is used for such important functions as actuating electrical control circuits and equipment, excitation of the main generator and alternator, charging the storage battery, lighting, operating the steam generator, fuel pump, cab heater and defroster.

Since the auxiliary generator will be operating at speeds that vary directly with engine speed, a voltage regulator is employed to maintain a constant 74 volt output regardless of engine speed. The basic generator has a rating of 10 kilowatts. An 18 KW generator is used on locomotives equipped with steam generators since such equipment requires considerable electrical power. Depending on the generator size, either a 150 ampere or 250 ampere fuse is used to prevent generator output from exceeding design limitations.

14. MAIN GENERATOR

The main generator is directly connected to the diesel engine crankshaft by means of a flexible coupling arrangement. This coupling is often called the engine flywheel but does not actually serve this purpose. It does however feature a timing disc on which numbers are marked for purposes of engine timing and inspection. The opposite end of the generator features a single self-aligning roller bearing on the armature shaft.

The main generator functions to convert the mechanical power developed by the diesel engine into high voltage direct current electrical power for locomotive traction purposes. It is also used to crank and start the diesel engine by temporarily functioning as a motor in such instances.

Inspection covers are provided on the generator for maintenance purposes. These covers should always be securely in place during locomotive operation.

15. ALTERNATOR

An alternator or alternating current generator is provided to supply AC power to induction motors that drive such important auxiliaries as the engine cooling fans and the traction motor blower. Direct drives of this type are very efficient and eliminate the need for "vee" belts.

The alternator stator is bolted directly to the main generator frame and the 16-pole rotor is connected to the generator armature. The alternator assembly thus becomes an integral part of the main generator. It is located at the end of the main generator that is adjacent to the diesel engine and flexible coupling.

16. **TURBOCHARGER**

A turbocharger is used to provide the large volume of air required by the diesel engine for cylinder scavenging and combustion. This device is mounted at the rear end of the engine and consists of a turbine unit and a centrifugal air compressor contained within a single housing. The turbine and compressor portions of the turbocharger are mounted on a common shaft.

Exhaust gases are ducted from the diesel engine exhaust manifold to the turbine portion of the turbocharger. The gases strike the turbine blades causing rotation of the turbine shaft. Going through the turbine, the gases expand to atmospheric pressure then through additional ducting, are expelled through the roof of the locomotive.

Being driven by the rotating turbine shaft, the centrifugal compressor takes clean filtered air, compresses it and delivers it to the airbox in both banks of the engine. Prior to entering the engine, the air is cooled by passing through a water cooled aftercooler which increases air density and improves efficiency.

When starting the engine and during operation at the lower throttle positions or light loading, the turbocharger is driven directly by the diesel engine. This provides the necessary combustion air during the period when engine exhaust gases have insufficient energy to drive the turbine and compressor at desired speeds. When the engine reaches about 2/3 of rated power, an overrunning clutch disengages the turbocharger from its engine drive and it then becomes "free wheeling." At this time, the exhaust gas energy is sufficient to power the turbine unit and drive the compressor without help from the engine.

17. FUEL AND WATER TANKS

The basic locomotive is equipped with a single 1200 gallon fuel tank suspended beneath the underframe between the trucks of the locomotive. Space is available at this location however for additional fuel storage or water tanks to serve specific customer needs.

When the locomotive is equipped with a steam generator, a 1200 gallon water tank is installed adjacent to the basic fuel tank. If a steam generator and its attendant water tank are not used, the space could then be occupied by an additional 1200 gallon fuel tank. Such an installation would increase fuel carrying capacity to 2400 gallons. Also available on special order is a single 3000 gallon fuel tank that could be installed in place of the preceding tank arrangements.

Suitable high capacity filler openings are provided on both sides of water and fuel tanks. Also installed are gauges that accurately indicate the level of the liquids in the tanks.

18. DYNAMIC BRAKE BLOWER

On locomotives equipped with dynamic braking, the electrical power generated by the traction motors when operating in dynamic braking, is dissipated in the form of heat by the braking resistor grids. These grids are located in a hatch forming the roof of the locomotive above the engine. Two blower fans are installed in the hatch for purposes of forcing air through the grids to prevent excessive heating.

The blowers are electrically connected to the grids so that they will receive power from the grids any time the locomotive operates in dynamic braking. In this way they operate automatically and at speeds directly in proportion to generated energy and dynamic braking strength.

The blowers draw air from the sides of the locomotive through the grids after which it is discharged through the roof of the locomotive.

The dynamic braking grid hatch is removable as a complete assembly. This feature is of importance in instances where it is necessary to gain access to the engine from above during overhauls.

19. EXHAUST MANIFOLD

Located directly above the diesel engine is an exhaust manifold which receives the combustion gases from each of the engine's 16 cylinders. This manifold is connected by ducting to the turbocharger located at the rear of the diesel engine. Since the exhaust gases have considerable energy, they are thus directed to drive the turbocharger before being exhausted through the roof of the locomotive.

20. DIESEL ENGINE

The General Motors 16 cylinder Model 567D3 diesel engine is used as the source of power for the SD24 locomotive. At full operating speed of 835 RPM, this turbocharged engine delivers 2400 horsepower to the generator for traction purposes.

Engine starting speed when being cranked by the motorized main generator is 75 to 100 RPM. Idling speed is 275 RPM. Engine speed and power is advanced in 8 increments (by the throttle) of 80 RPM each until the full speed of 835 RPM is reached.

The FRONT end of the engine is also known as the accessory end since it contains the water and lubricating oil pumps, the governor and an overspeed trip mechanism. Engine power is transmitted from the crankshaft to the direct coupled main generator which is located at the REAR end of the engine.

The engine has 16 cylinders, 8 in each bank of the 45° "V" arrangement. The cylinders are numbered 1 through 8 starting at the right front corner of the engine and 9 through 16 starting at the left front corner.

Each cylinder has an 8-1/21, bore and a 10" stroke providing a 567 cu. in. piston displacement from which the engine model designation is derived. Operation is on the highly efficient two stroke cycle principle.

Engine overspeed protection is provided by a mechanical tripping device located in the camshaft counterweight housing at the upper front portion of the engine. A lever extends from this housing and is in the SET position when facing the right side of the engine. At speeds exceeding approximately 915 RPM, the overspeed trip device functions to stop the injection

of fuel which stops the diesel engine. When TRIPPED, the lever faces the left side of the engine and must be manually reset before the engine can be started.

21. LUBE OIL STRAINER

The engine lubricating oil is constantly being strained, filtered and cooled during engine operation. The strainer is located at the front of the engine on the right side. The housing contains screens to strain all oil as it circulates in and out of the engine.

The covers provided on top of the strainer housing are for maintenance purposes. They should be securely tightened and kept in place at all times during engine operation.

22. ENGINE GOVERNOR

The governor on the front end of the engine, performs the function of controlling the speed of the diesel engine, as directed by the position of the throttle at the control stand. The speed of the engine is controlled from 275 RPM at IDLE to 835 RPM in Run 8. The "orders" of the throttle are transmitted to the electro-hydraulic governor through electrical circuits. The governor is connected through a linkage to the injector control shafts on each bank of the engine. By regulating the position of the injector racks, and consequently the fuel injected to each cylinder, the speed of the engine is controlled. The governor performs its job of seeing that the engine rotates at the speed ordered by the throttle, regardless of how much or how little fuel is needed.

A device called the load regulator is actuated by oil pressure controlled by the load control pilot valve in the governor.

The regulator acts to cause the governor to allow injection of no more or no less fuel to each cylinder than that which will result in a predetermined power output for each throttle position. This prevents undesired overloading or underloading of the diesel engine and insures stable operation at all throttle positions.

A low oil pressure device built into the governor protects the engine in case of low oil pressure or high vacuum on the suction side of the main lubricating oil pump or in the event of low oil pressure at the turbocharger oil system. If such lubricating oil trouble occurs, the governor will act to stop the engine and actuate the alarm bell. When the engine stops, the no power light will also be on in the unit affected.

23. ENGINE COOLING FANS

Three alternating current motor driven cooling fans are mounted in the roof at the long hood end of the locomotive. Their function is to draw air through the radiator assemblies beneath them in order to maintain proper temperatures of the engine cooling water.

Each of these fans are 48" in diameter and are driven by 35 horsepower motors. They are designed for heavy duty service to provide the air flow volume needed for engine cooling. They will function automatically in response to thermostat control.

24. RADIATORS

The radiator assemblies for engine cooling are located in the roof hatch beneath the cooling fans at the long hood end of the locomotive.

Two banks of radiators are used, each having six sections. All of the engine cooling water is circulated through the radiators

during operation. Regulation of water temperature is by means of shutters and cooling fans which control air flow through the radiator cores. The function of the temperature control system is entirely automatic.

25. ENGINE WATER TANK

Located in the upper portion of the engine equipment rack is the cooling water tank. This tank is connected into the engine cooling water system and serves as a storage reservoir and expansion area. Water levels are indicated by a sight glass and stenciled markings on the tank.

The system may be filled through piping provided on either side of the locomotive. An overflow ("G" valve) is installed on the water tank for purposes of achieving a proper operating level for the water in the cooling system.

26. LUBE OIL COOLER

A lube oil cooler is mounted in the engine equipment rack for purposes of cooling the engine lubricating oil. In operation, the oil flowing through the engine picks up heat which is dissipated by the cooler thus keeping the oil temperature within desired limits.

The oil is cooled by water which flows through a radiator arrangement within the oil cooler housing. The water had been previously cooled by air flowing through the radiators in the cooling system.

27. FUEL PUMP

A small direct current electric motor is used to drive the fuel pump. The motor operates on battery current in order to supply fuel to the engine for starting purposes.

The fuel pump runs continuously during operation thus providing a constant supply of fuel to the diesel engine. The fuel supplied is in excess of the maximum requirements of the engine. Excess fuel not burned by the engine circulates through the injectors for purposes of cooling and lubrication, then returns to the fuel tank.

28. LUBE OIL FILTER

A lubricating oil filter arrangement is mounted in the engine equipment rack. All of the engine lubricating oil flows through the filter unit which operates on the bypass principle. The purpose of the filter is to keep the engine oil clean and thus provide efficient engine operation and long service life to all parts requiring lubrication.

Replaceable type filter cartridges are employed which are changed periodically. This procedure maintains the desired cleanliness of the oil.

29. AIR COMPRESSOR

To provide the compressed air requirements of the locomotive, a heavy-duty, 6-cylinder, two stage, water cooled air compressor is used. This machine is driven directly by the diesel engine through a flexible coupling from the front end of the engine crankshaft.

When driven at the full engine speed of 835 RPM, the air compressor delivers 370 cu. ft. of air per minute. Although the air compressor is being driven at all times the engine is running, it may not be pumping air due to the functioning of the compressor control system. This system automatically maintains proper pressures in the air system through use of electro-pneumatic control devices.

30. ELECTRICAL CONTROL CABINET NO. 2

To house the necessary electrical control equipment, a second electrical cabinet is used on the SD24 locomotive. This cabinet is located at the long hood end of the unit and contains the electrical switchgear for operation of the traction motors in the No. 2 truck.

This cabinet also houses the alternating current (AC) cooling fan contactors. These contactors are thermostatically controlled to connect the cooling fans to the alternator supply in response to cooling requirements.

Access doors are provided for purposes of maintenance and inspection. These doors should be kept closed at all times during locomotive operation.

HOW THE MODEL SD24 LOCOMOTIVE OPERATES

1. The fuel pump is driven by an electric motor using current from the storage battery. It transfers fuel from the tank under the locomotive to the engine injectors.

2. The diesel engine is started by means of the direct coupled main generator which is temporarily used as a starting motor. The storage battery supplies the electric current to rotate the generator and start the engine.

3. When the engine is running, it supplies mechanical power through shafts and couplings to directly drive three electrical generators, the air compressor and a traction motor blower.

4. The auxiliary generator charges the storage batteries and supplies low voltage direct current for the control, lighting and generator excitation circuits. The alternating current

generator furnishes power to drive a traction motor blower and three radiator cooling fans. The main generator supplies high voltage direct current electricity to the traction motors for locomotive pulling power.

5. By means of the cab controls, low voltage circuits are established to actuate the engine governor as well as the various contactors, switches, and relays in the electrical cabinets. These electrical devices function to complete other circuits or cause action desired for locomotive operation.

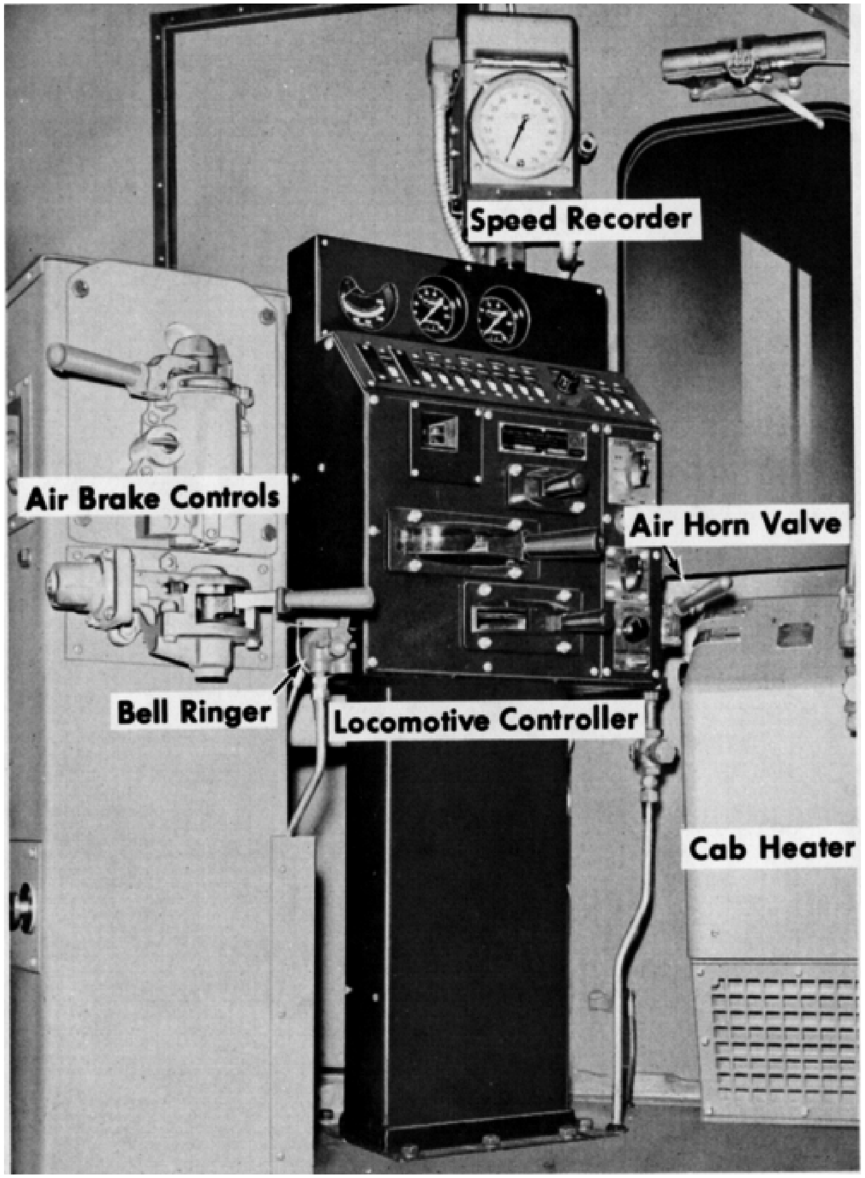
6. Six traction motors are under the locomotive, each of which is directly geared to an axle and pair of driving wheels. These motors are located in two trucks which support and distribute the locomotive weight on the driving wheels.

7. The throttle electrically actuates a governor mounted on the engine and controls engine speed and power. The main generator converts the engine's mechanical power to electrical power which is then distributed to the traction motors through circuits established by the various switchgear components in the electrical cabinet.

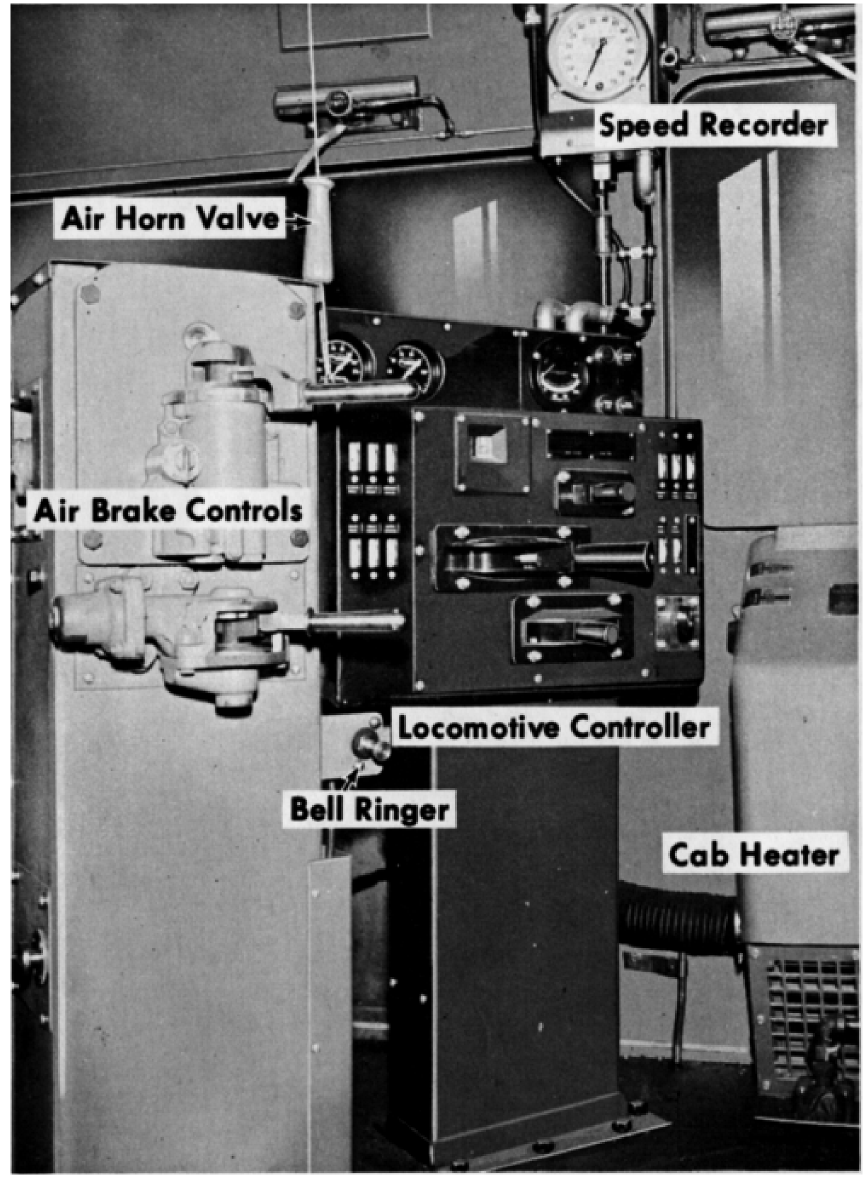
8. A load regulator is used to prevent the engine from being over or underloaded, and thus provide power uniformly in accordance with each throttle position.

9. The air compressor supplies air pressure to the reservoirs which is then used primarily for the air brakes which are controlled by the engineman through suitable equipment in the cab.

10. Other than manual operation of the cab controls, the locomotive operation is otherwise completely automatic. Various alarms and safety devices will alert the engineman should any operating difficulties occur.



Locomotive Control Station
Fig. 2-1



Locomotive Control Station
Fig. 2-1

SECTION 2

CAB CONTROLS

INTRODUCTION

All of the control equipment used during locomotive operation is located in four separate areas within the cab. These are the (1) distribution panel, (2) the engine control panel, (3) the locomotive controller and (4) the air brake pedestal. Each of these areas contains various devices the engineman should be familiar with as most of them will be used at one time or another during operation.

The first two areas are panels on which are mounted switches and circuit breakers that must be properly positioned to establish electrical circuits for operation. Once set, these devices need no further attention since actual operation of the locomotive is then controlled from the control station shown in Fig. 2-1. This location contains the locomotive controller and air brake pedestal which are the remaining control areas.

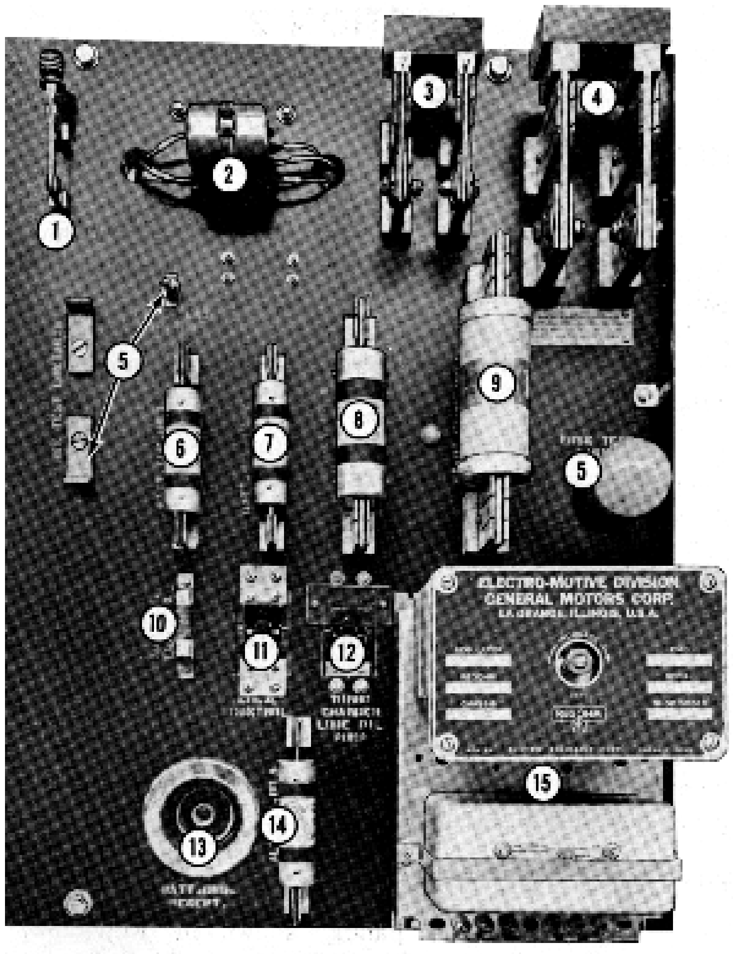
Each of the control areas and the equipment they contain are fully described in the following articles. The paragraph number corresponds with the numbers given on the illustrations.

DISTRIBUTION PANEL, Fig. 2-2

The distribution panel, shown in Fig. 2-2, is located within electrical cabinet No. 1 which forms the rear wall of the locomotive cab. Its position is in the upper left hand corner. Upon opening the cabinet door, the following items will be observed.

1. GROUND RELAY KNIFE SWITCH

   The purpose of the ground relay knife switch is to eliminate the ground protective relay from the locomotive circuits during certain shop maintenance inspections. It MUST ALWAYS BE KEPT CLOSED in normal operation otherwise the protection offered by the ground relay would be nullified and



1. Ground Relay Switch
2. Reverse Current Relay
3. Auxiliary Generator Switch
4. Main Battery Switch
5. Fuse Test Equipment
6. Battery Field Fuse
7 . Battery Charging Fuse
8. Auxiliary Generator Fuse
9. Starting Fuse
10. Auxiliary Generator Field Fuse
11. Local Control Circuit Breaker
12. Turbocharger Lube Pump Circuit Breaker
13. Battery Charging Receptacle
14. Alternator Field Fuse
15. Voltage Regulator

Distribution Panel
Fig. 2-2

possible serious equipment damage could occur. It may be opened however in the event of extreme emergency upon receipt of definite instruction to that effect from a responsible officer of the railroad.

2. REVERSE CURRENT RELAY

The reverse current relay (RCR) functions in response to auxiliary generator voltage output to control the operation of battery charging contactor (BC). When the auxiliary generator voltage approaches its normal value of 74 volts, the RCR causes the BC contactor to close thus connecting the auxiliary generator to the storage battery and low voltage system of the locomotive. The battery will then be charged since the auxiliary generator's 74 volts potential is greater than the storage battery's 64 volts. .

In instances where the auxiliary generator voltage falls below normal operating value or that of the battery, the RCR again functions causing the BC contactor to open and disconnect the generator from the battery. This prevents a reversal of current from the storage battery attempting to motorize the auxiliary generator. The RCR and the rectifier beneath it (to prevent contact arcing) needs no attention and should not be disturbed during operation.

3. AUXILIARY GENERATOR KNIFE SWITCH

The double pole, single throw auxiliary generator knife switch is kept closed at all times during operation. This connects the auxiliary generator to the locomotive low voltage electrical system. It thus provides power for the control circuits, main generator and alternator excitation, fuel pump operation, lights and other low voltage requirements.

The switch is to be opened only when it is desired to disconnect the auxiliary generator from the low voltage system during certain shop maintenance procedures. It may also be opened when a locomotive is taken out of service and the engine shut down for an extended layover.

4. MAIN BATTERY KNIFE SWITCH

The large double pole, single throw knife switch at the upper right hand corner of the distribution panel is the main battery switch and is used to connect the battery to the locomotive low voltage system. It should be kept closed at all times during operation.

If this switch were left open, the fuel pump could not be started, the lights would not function and the engine could not be started. If the switch were opened after the engine was started and the auxiliary generator was supplying the low voltage needs, then the batteries could not be charged.

This switch may be opened during certain shop maintenance procedures and in instances where the engine is shut down and the locomotive taken out of service for an extended layover. This will prevent the battery from being discharged in the event the lights or other low voltage devices are inadvertently left operating during the layover. Particular attention should be given to the notation below the switch which cautions against opening the switch immediately after engine shutdown. At least 15 minutes should be allowed after engine shutdown before the switch is opened which will permit the turbocharger lube oil pump to function properly. This motor driven pump operates automatically upon engine shutdown (providing the main battery switch is closed) to circulate oil to the turbocharger, thus permitting a gradual cooling of this device.

5. FUSE TEST EQUIPMENT

To facilitate the testing of fuses, a pair of fuse test blocks, a test light and a test light toggle switch are installed on the distribution panel.

Fuses may be readily tested as follows. First, move the toggle switch ON to make sure the fuse test light is not burned out. Extinguish the light by moving the toggle switch OFF. Place a fuse across the test blocks so that the metal ends of the fuse are in firm contact with the blocks. If the fuse is good, the light will come on. If the fuse is burned out, the light will not come on and a new fuse is required.

It is advisable to always test fuses before installing them in their circuits. Always isolate the circuits in question by opening their switches before changing or replacing fuses.

6. BATTERY FIELD 80-AMPERE FUSE

The battery field windings of the main generator are excited with current received from the locomotive low voltage system. This circuit is established by means of the battery field (BF) contactor. The 80-ampere battery field fuse is used in this circuit for protection against possible overload or short circuit damage.

The fuse must be in good condition, since if it is blown, the locomotive unit concerned will not develop normal power due to lack of main generator excitation. In such instances, no alarms would occur but the trouble would be recognized due to loss of locomotive power.

7. EXTERNAL BATTERY CHARGING 100-AMPERE FUSE

In the event that the locomotive storage battery is to be charged from an external source, a plug receptacle, Item 13,

Fig. 2-2, is provided. The 100-ampere charging fuse is in the circuit between the receptacle and battery to prevent charging current in excess of equipment and wiring capacity.

This fuse is required only during instances of external battery charging. It does not affect locomotive operation in any way.

8. AUXILIARY GENERATOR 150-AMPERE FUSE

During locomotive operation, the auxiliary generator supplies all of the locomotive low voltage requirements. This generator is rated at 10 kilowatt capacity. To prevent overloading and possible damage due to excessive current demands, a 150-ampere fuse is installed in the circuit connecting the generator to the low voltage system.

NOTE: On units equipped with a steam generator, a higher capacity 18 KW auxiliary generator is used in place of the basic 10 KW machine. The fuse used in such instances has a capacity of 250 amperes. Care should be taken to make sure that this larger capacity fuse is never installed on units equipped with the smaller generator.

The auxiliary generator fuse must be installed and in good condition at all times during locomotive operation. In the event that the fuse blows out, the circuit for alternator excitation will be open with the result the AC current output will cease. This causes the no AC voltage relay (NVR) to drop out which de-energizes the ER relay and brings the engine to IDLE speed. The no power alarm would also occur and be indicated on the unit affected.

9. STARTING 400-AMPERE FUSE

The starting fuse is in use only during the period that the diesel engine is actually being started. At this time, battery

current flows through the fuse and starting contactor to motorize the main generator and crank the engine.

Although this fuse should be in good condition and always left in place, it has no affect on locomotive operation other than for engine starting. A defective fuse can be determined when attempting to start the engine since at that time, even though the starting contactor closes, the circuit is open preventing the generator from cranking the engine.

10. AUXILIARY GENERATOR FIELD 30-AMPERE FUSE

The field excitation circuit of the auxiliary generator is protected by a 30-ampere fuse. This fuse must be good and in place at all times during locomotive operation.

In the event that this fuse is burned out, it opens the generator excitation circuit which stops generator output to the low voltage system. An alternator failure (no power) alarm would then occur due to the functioning of the no AC voltage relay (NVR) since the auxiliary generator could no longer provide excitation current for the alternator. The NVR also opens the circuit to the ER relay which causes the engine speed in the unit affected to be reduced to IDLE.

11. LOCAL CONTROL 30-AMPERE CIRCUIT BREAKER

This circuit breaker must be in the ON position in order for the locomotive to be operated. It establishes "local" power from the auxiliary generator to operate certain of the heavy-duty electro-magnetic switchgear components contained in that particular unit.

This switch is necessary since the circuits energizing such equipment could not be trainlined in a multiple unit consist due to the excessive power requirements from the lead unit auxiliary generator. Thus the lead unit simply establishes control or pilot circuits in trailing units which in turn bring in the actual equipment components using local control power.

12. TURBOCHARGER LUBE OIL PUMP
15-AMPERE CIRCUIT BREAKER

It is important for the turbocharger to be gradually cooled when it and the diesel engine are stopped after being in operation. This is accomplished by the external motor driven lube oil pump which circulates engine oil through the turbocharger to absorb the residual heat and provide a gradual cooling.

Whenever the diesel engine is stopped, this motor driven pump starts automatically through circuits established by the no AC voltage relay (NVR). Time delay relays are used to keep the pump running for approximately 15 minutes after the engine is stopped. This provides sufficient oil circulation to gradually cool the turbocharger.

NOTE: For this pump to function as intended, the main battery switch and turbocharger oil pump 15ampere breaker must remain closed for 15 minutes after the engine stops.

13. BATTERY CHARGING RECEPTACLE

Whenever it is considered necessary, the locomotive storage battery may be charged from an external source through means of the charging receptacle provided. A fuse, discussed in preceding paragraph 7, is provided to protect the charging circuit.

14. ALTERNATOR FIELD 40-AMPERE FUSE

The alternator receives its excitation through a pair of slip rings connected to the low voltage DC auxiliary generator output. To protect these windings, a 40-ampere fuse is provided in the excitation circuit. This fuse must be good and in place at all times during locomotive operation.

In the event that the fuse is blown, alternator excitation and resulting AC power output will cease. This causes the no AC voltage relay (NVR) to function setting off the no power alarms and reducing engine speed to idle in the unit affected.

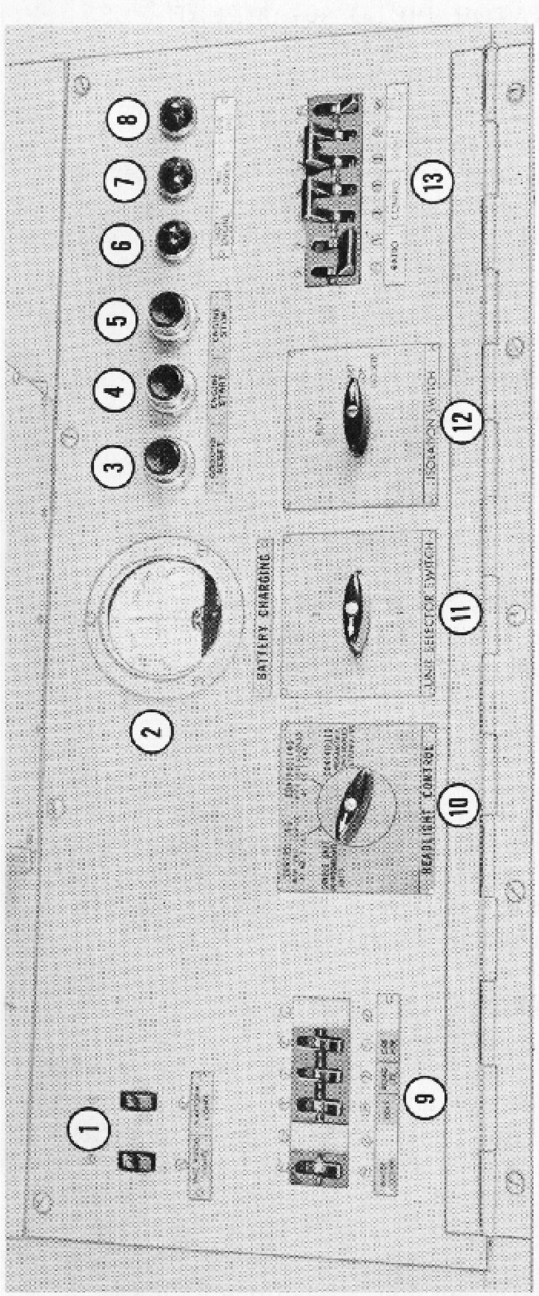
15. AUXILIARY GENERATOR VOLTAGE REGULATOR

The locomotive low voltage system and equipment are designed for operation on 74 volt DC power supplied by the auxiliary generator. This voltage must be kept constant regardless of changes in engine (and generator) speed.

The voltage regulator is used in the auxiliary generator field excitation circuit and functions to vary excitation as needed to hold output voltage constant despite speed changes. This device functions entirely automatically and should never be disturbed in operation.

ENGINE CONTROL PANEL, Fig. 2-3

The engine control panel, Fig. 2-3, is mounted in the rear wall of the cab above the number one electrical cabinet. This panel contains several switches, circuit breakers and alarm lights, along with engine start, stop and ground relay buttons and a battery charging ammeter. Since all of these items will be used at one time or another during operation, a brief description of their individual functions follows:



1. Light Switches
2. Battery Charging Ammeter
3. Ground Relay Reset
4. Engine Start Button
5. Engine Stop Button
6. Hot Engine Alarm Light
7. No Power Alarm Light
8. Low Oil Alarm Light
9. Miscellaneous Circuit Breakers
10. Headlight Control Switch
11. Unit Selector Switch
12. Isolation Switch
13. Control And Fuel Pump Circuit Breakers

Engine Control Panel
Fig. 2-3

1. LIGHT SWITCHES

Individual switches are provided for platform and engineroom lights. In order for these switches to be functional, the 30-ampere "lights" circuit breaker at Item 13 location must be ON.

2. BATTERY CHARGING AMMETER

With the main battery and auxiliary generator knife switches closed, the battery charging ammeter is connected into the low voltage circuit to indicate the extent of current flowing to or from the storage battery. This meter does not indicate the output current of the auxiliary generator. Since the storage battery is usually well charged, the meter in normal operation should read zero or a slight charge.

When the engine and auxiliary generator are stopped, all low voltage current requirements such as for lights, fuel pump motor and cab heaters are supplied by the storage battery. In such instances, current would be coming from the battery which would be discharging. The meter pointer would be reading to the left of the center-zero position to indicate the extent of discharge.

When the diesel engine is started, the auxiliary generator is in operation and will be supplying all low voltage current needs. In addition, the generator will also be charging the storage battery. In such instances, current will be flowing to the storage battery and would be indicated by the meter pointer being to the right of center-zero or charge side of the meter.

During normal operation, the meter should always be indicating either zero or a slight charge. A zero indication would mean that the battery was fully charged. The meter should never indicate discharge with the diesel engine running, even at idle speed. Such a reading would indicate that the battery was discharging, which if allowed to continue, could possibly lead to ultimate failure of the locomotive unit.

3. GROUND RELAY RESET PUSH BUTTON

The ground relay can detect a low voltage ground when starting the engine or a high voltage ground during operation under power. In either instance, it would trip to set off the alarm and illuminate the ground relay light on the controller. In addition, the diesel engine speed could not be advanced above IDLE in the unit affected.

To reset the ground relay and restore locomotive power, it is first necessary to isolate the unit affected or place the throttle in idle. The ground relay reset button may then be depressed to reset the relay and restore the locomotive circuits for normal operation.

NOTE: The button should not be held in as this will not keep relay from tripping. Repeated tripping of the ground relay under power is cause for isolation of the unit concerned. In instances where tripping is accompanied by wheel slip light indications, the locomotive should be stopped and all wheels inspected to make sure that none are sliding.

4. ENGINE START PUSH BUTTON

In order to start the diesel engine, the fuel pump must be running, the isolation switch must be in the START position and then the START push button may be depressed. Doing so establishes circuits to close the starting contactor (GS) which allows battery current to flow through the armature and starting field windings of the main generator. This motorizes the generator to crank the engine.

CAB CONTROLS

In starting the engine, the push button should be depressed firmly and held in until the engine starts (no more than 15 seconds). If the engine does not start, refer to the trouble shooting section of this manual for likely causes.

5. ENGINE STOP PUSH BUTTON

To stop the diesel engine, the isolation switch must first be placed in the START position after which the engine STOP push button may be depressed. Doing so energizes the "D" or shutdown solenoid in the engine governor. The governor then functions to move all of the injector racks to the no fuel position which causes the diesel engine to stop.

When stopping the engine, the button must be depressed firmly and held IN until the engine is completely stopped. Releasing it prematurely will allow the engine to regain fuel and return to idle speed.

NOTE: Main battery switch and turbocharger circuit breaker must remain closed for 15 minutes after engine stops.

6. HOT ENGINE ALARM LIGHT

The red hot engine alarm light operates in conjunction with the alarm bell to warn the engineman that the engine cooling water has reached an excessive temperature. This alarm light will be illuminated only in the unit affected although the alarm bell will ring on all units in the locomotive consist.

The hot engine alarm will not affect locomotive speed or power. It simply serves as a warning. The alarm will not cease functioning until engine temperature is reduced to a normal value. The bell cannot be silenced by isolating the unit as is true with other types of alarms. Refer to the trouble shooting section for causes and correction of a hot engine.

7. NO POWER ALARM LIGHT

The green no power light will come on and the alarm bell will ring any time the no AC voltage relay (NVR) is open with the isolation switch in RUN position. This would occur if the engine stopped for any reason or an alternator failure occurred during operation.

When this alarm occurs, the engine will be either running at idle or stopped. If it occurred with the engine running, it indicates a true alternator failure or electrical difficulty. If, on the other hand it occurs when the engine stops, the cause of such stopping may be the cause of the alarm.

Refer to the trouble shooting section for possible cause and the corrective action to be taken.

8. LOW OIL ALARM LIGHT

Built into the diesel engine governor is a mechanism to detect low engine lubricating oil pressure or high suction. In either event, a small button will pop out of the governor to stop the diesel engine and establish the alarms through movement of a switch.

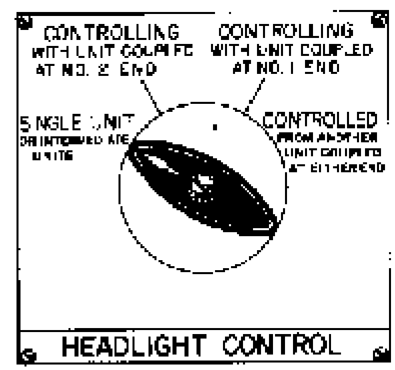
The yellow low oil alarm light will come on and the alarm bell will ring through circuits established by this tripped switch. Isolating the unit or resetting the governor button will extinguish the alarm light and silence the bell. Refer to the trouble shooting section for details of causes and corrections.

9. MISCELLANEOUS CIRCUIT BREAKERS

Provision is made for the installation of several circuit breakers in the lower left hand portion of the engine control panel. These would include one each for the water cooler (if used), the headlight, road lights, and cab heater. The headlight circuit breaker is rated at 30amperes while the others have 15-ampere capacities. These circuit breakers should be turned ON to obtain operation of desired features.

10. HEADLIGHT CONTROL SWITCH

The twin sealed-beam front and rear headlights are controlled by the front and rear headlight switches on the locomotive control panel. A dimming switch is mounted on the right side of the controller. Before these switches will function, the 30-ampere headlight circuit breaker on the engine control panel must be placed ON. On locomotives equipped for multiple unit operation, a remote headlight control switch is mounted on the engine control panel. This remote headlight control switch permits operation of the headlight of the rear unit to be controlled from the lead unit.



Remote Headlight Switch
Fig. 2-4

The switch is shown in Fig. 2-4 and its positions are set on each unit as follows:

A. On Lead Units If only a single locomotive unit is being used, place the switch in the "SINGLE UNIT" position.

In multiple unit service, if trailing units are coupled to the No. 2 or long hood end of the lead unit then place the switch in the "CONTROLLING - coupled at No. 2 end position." In multiple unit service, if trailing units are coupled to the No. 1 or short hood end of the lead unit, place switch in "CONTROLLING - coupled at No. 1 end position."

B. On Intermediate Units

On units operating in between other units in a multiple unit consist, place the switch in the "SINGLE UNIT" position.

C. On Trailing Units

The last unit in a multiple unit consist should have the headlight control switch placed in the "CONTROLLED" from other unit position.

11. UNIT SELECTOR SWITCH

The unit selector switch is used only on locomotives equipped with dynamic brakes. Its purpose is to adjust circuit resistance for uniform dynamic brake operation regardless of the number of units in the locomotive consist.

This switch should be set to the No. 1, 2, 3 or 4 position depending on the number of locomotive units physically and electrically connected together. The switch position should not be changed for any reason other than to correspond to a change in number of units being operated. For example, it should not be changed if one of the units is isolated or shut down yet remains in the locomotive consist.

This switch position is of importance only in the lead or controlling locomotive unit during operation in dynamic braking. It has no function on intermediate or trailing units.

NOTE: Switch position may be changed only while the throttle is in IDLE or locomotive is at rest. It should never be moved while operating in dynamic braking.

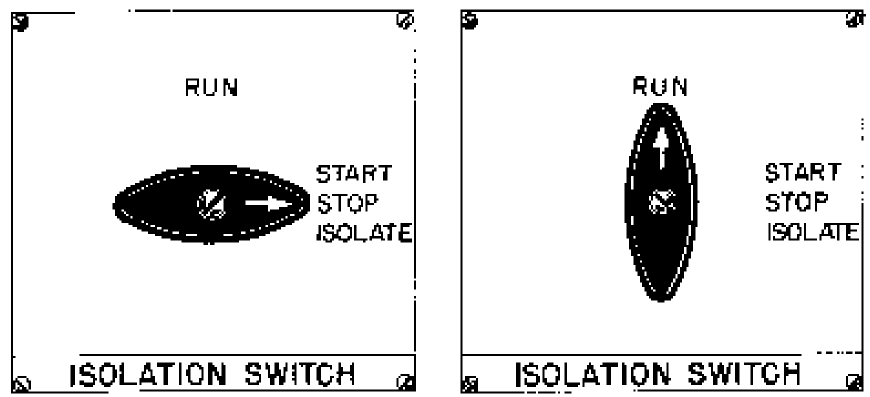
12. ISOLATION SWITCH

The isolation switch has two positions, namely START (or isolate) and RUN. The function of these two positions, shown in Fig. 2-5, are as follows:

A. Start Position

The isolation switch is placed in this position whenever the diesel engine is to be started or stopped. The START and STOP push buttons are effective only in this switch position.

The START position is also used to isolate the unit which will prevent it from developing power and responding to controls. In such instances, the engine would be running at idle speed regardless of throttle position.



Isolation Switch Positions Fig. 2-5

This position would also silence the alarm bell in the event of a no power or low lube oil alarm. It would not, however, stop the alarm in the event of a hot engine.

B. Run Position

After the engine has been started, the unit maybe placed "on the line" by moving the isolation switch to the RUN position. The unit will then respond to control and will develop power in normal operation.

NOTE: The isolation switch should never be moved from one position to another while operating in dynamic braking. Dynamic braking should be temporarily terminated (by placing throttle in idle) whenever it is desired to place the unit on or off the line. It is also good practice while operating under power to first return the throttle to idle before changing isolation switch position.

13. CONTROL AND FUEL PUMP CIRCUIT BREAKERS

Located at the lower right hand corner of the engine control panel is another group of circuit breakers. They include double-pole 30-ampere circuit breakers for the RADIO (if used), CONTROL and LIGHTS. Also included is a single pole 15-ampere FUEL PUMP circuit breaker. The control and the fuel pump circuit breakers must be ON for normal operation. The others may be placed on to meet operating requirements.

The fuel pump circuit breaker must be ON in all units of the locomotive consist in order for the individual fuel pumps to operate. The other circuit breakers may be placed off on all trailing units without affecting operation.

LOCOMOTIVE CONTROLLER, Fig. 2-6

The locomotive controller is shown in Fig. 2-6. It contains the necessary switches, gauges and operating levers that are used by the engineman during operation of the locomotive. The individual components of the controller are described, together with their functions, in the following paragraphs.

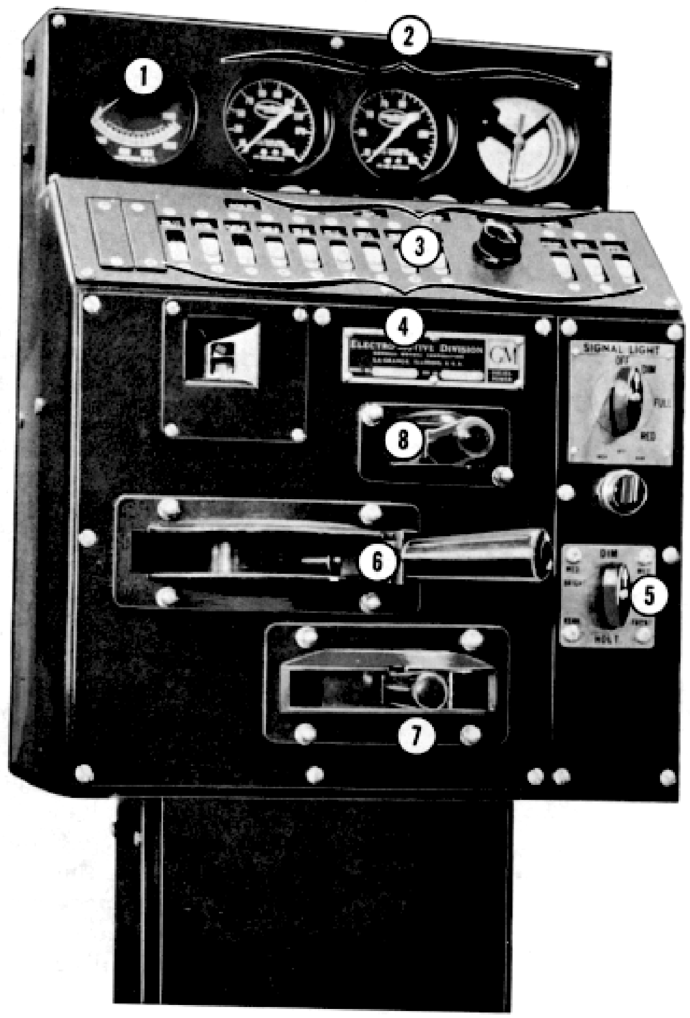
1. LOAD INDICATING METER

The locomotive pulling force is indicated by the load indicating meter located at the upper left hand corner of the controller. This meter is graduated to read amperes of electrical current with 1500 being the maximum reading on the scale.

The meter is connected so as to indicate the current flowing through the No. 2 traction motor. Since the amperage is the same in all motors, each motor will be receiving the amount shown on the meter.

Since the traction motors receive their power from the main generator, the meter readings may be multiplied to determine the approximate generator current output. The multiplying factor will depend, however, on the particular transition circuit in effect at the time the reading is taken. For example, when operating in a series circuit, the multiplying factor is 2. In series-parallel it is 3 and in full parallel it is 6.

Thus a meter reading of 200 amperes would indicate a generator output of 400 amperes when operating in series, 600 in series-parallel or 1200 in straight parallel. The generator load can thus be readily determined.



1. Load Indicating Meter
2. Air Gauges
3. Indicating Lights
4. Operating Switches
5. Headlight Dimming Switch
6. Throttle Lever
7. Reverse Lever
8. Selector Lever

Locomotive Controller
Fig. 2-6

2. AIR GAUGES

Air gauges to indicate main reservoir air pressure as well as various pressures concerned with the air brakes are prominently located along the top of the controller. These gauges are indirectly illuminated for night visibility.

3. INDICATING LIGHTS

Three or more indicating lights are installed to provide a visual warning of operating difficulties. The three basic lights are wheel slip, PC open, and ground relay. Additional lights would be used for specially installed equipment such as dynamic braking and train control. The function of these lights are as follows:

A. Wheel Slip Light

In the event that a pair of wheels should slip on any unit in the locomotive consist, it will be detected by the wheel slip relays in the unit concerned. The wheel slip relay initiates corrective action at the same time that it lights the warning light. The light will normally flash on and off as the wheel slip control system functions to correct the slip (through sand application or unloading). Since wheel slip control is automatic, the throttle and locomotive power need not be reduced unless slippage is continuous.

NOTE: A steady burning wheel slip light during operation may indicate a pair of sliding wheels or circuit difficulty. In such instances, the locomotive should be stopped for a careful inspection to ascertain that there are no locked-sliding wheels.

1. Load Indicating Meter
2. Air Gauges
3. Indicating Lights
4. Operating Switches
5. Headlight Dimming Switch
6. Throttle Lever
7. Reverse Lever
8. Selector Lever

Locomotive Controller
Fig. 2-6

B. PC Open Light

The PC or pneumatic control switch functions to automatically reduce locomotive power in the event that an emergency or safety control air brake application occurs. It does so by reducing the speed of ALL engines to idle regardless of throttle position. When tripped, the PC open indicating light on the controller would be illuminated. This light is extinguished and locomotive power restored by resetting the PC switch. This occurs automatically provided that:

(1) control of the air brake is recovered and
(2) the throttle is returned to IDLE position.

C. Ground Relay Light

The ground relay light will be illuminated whenever the ground relay trips. In such instances the unit concerned will not develop power and the engine will remain at idle and not respond to throttle.

The light is extinguished and power restored by resetting the ground relay. This is done by isolating the unit or placing the throttle in idle, then momentarily depressing the reset button on the engine control panel.

D. Brake Warning

A brake warning light is installed on units equipped with dynamic brakes and functions in conjunction with a brake warning relay. The purpose of the relay and light is to indicate excessive braking current when operating in dynamic braking.

Due to the use of an automatic brake limiting regulator, the warning light should seldom if ever be illuminated and then only momentarily. Correction for

excessive current generally occurs automatically and quite rapidly.

In the event that the brake warning light comes on and does not go out quickly, the braking strength should be immediately reduced to prevent possible equipment damage. By moving the throttle towards IDLE, the excessive braking strength should be removed and the warning light will be quickly extinguished.

4. OPERATING SWITCHES

Along the front face of the controller are a group of switches. At each switch is an identifying nameplate indicating switch function. The switches are in the ON position when moved upward.

Before the engine can be started, the CONTROL AND FUEL PUMP switch must be placed ON. After being started, the engine speed can be controlled by the throttle providing the ENGINE RUN switch is placed ON. To obtain power from the locomotive, the GENERATOR FIELD switch must be placed ON. These three important switches are grouped together at the extreme right side of the controller. They should be placed in "OFF" position on controllers of trailing units.

Other switches control operation of the automatic sanding feature and various lights. They are placed on as needed.

5. HEADLIGHT DIMMING SWITCH

A three position switch is located on the controller to the right of the throttle. It may be set for DIM headlights on both ends of the locomotive or BRIGHT, for the lights at either front or rear of the unit.

For this switch to function, the two headlight switches on the controller as well as the headlight circuit breaker on the engine control panel must be placed "ON."

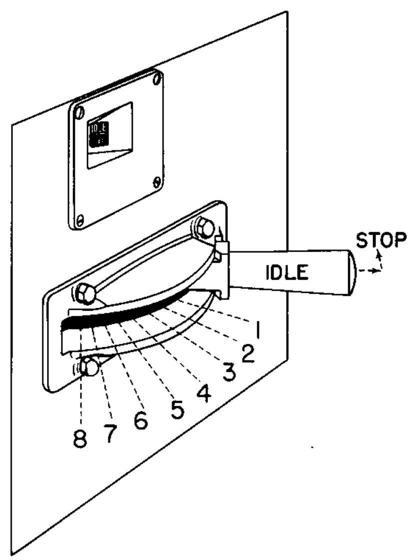
6. THROTTLE LEVER

The throttle lever actuates switches within the controller to establish low voltage electrical circuits to the engine governor for purposes of controlling engine speed. The throttle has ten positions namely, STOP, IDLE and running speeds 1 through 8 as shown in Fig. 2-7. Each of these positions are shown in the illuminated indicator in the upper left hand corner of the controller.

To stop all engines, the throttle lever is pulled out away from the controller and then moved one step beyond IDLE to the STOP position. The IDLE position is as far forward as the throttle lever can be moved without pulling it away from the controller. Each running notch on the throttle increases the engine speed from 275 RPM at IDLE and Run 1 to 835 RPM at full throttle. The engine speed increases in 80 RPM increments from position 1 to 8.

7. REVERSE LEVER

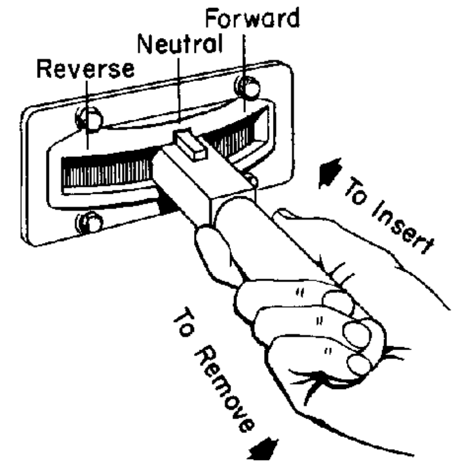
The reverse lever, Fig. 2-8, has three positions: FORWARD,



Throttle Positions Fig. 2-7

NEUTRAL and REVERSE. Direction in which the locomotive moves is controlled by movement of this lever to the FORWARD or REVERSE position. With the lever in NEUTRAL, no power will be developed if the throttle is opened. The reverse lever should be moved ONLY when the locomotive is standing still.

The reverse lever can be removed from the controller only when the lever is in NEUTRAL position, the throttle is in IDLE and the selector lever is in OFF. Removal of the reverse lever locks the operating controls in t h e controller. The reverse lever should be removed from the controllers in all but the lead unit of a multiple unit locomotive consist.



Reverse Lever Positions Fig. 2-8

8. SELECTOR LEVER

A selector lever is applied to the controller in instances where the locomotive unit is equipped with dynamic brakes or when it would be necessary to manually control transition on trailing units not equipped with automatic transition. When used, this lever would thus serve to establish proper circuits for either or both of these functions.

The position of the lever is indicated by the lower indicating band illuminated through the opening at the upper left corner

of the controller front panel. The lever is spring loaded I so that movement all the way in one direction will index the selector cam one notch only in that direction. It must be allowed to return to I center position before indexing again in either direction.

When the selector lever is indexed to the "B" or braking position, the electro-magnetic contactors for dynamic braking are energized. In this position the throttle lever moves freely (without notching) to control a 500-ohm braking rheostat and dynamic braking strength.

When the lever is moved to the center or "OFF" position, all circuits are open. This position is used for locking the controller in unattended or trailing units.

For operation under power, the lever would be indexed to the No. 1 position. Succeeding positions such as Nos. 2, 3 and 4 would be used only when it is necessary to cause transition on non-automatic trailing units operating in the locomotive consist.

MECHANICAL INTERLOCKS ON THECONTROLLEF

The levers on the controller are interlocked so that:

1. Reverse lever in NEUTRAL.
   a. Throttle may be moved to any position.
   b. Selector may be moved between OFF and 1 (or the 1-4 range).

2. Reverse lever in FORWARD or REVERSE.
   a. Throttle may be moved to any position.
   b. Selector may be moved to any position.

3. Throttle in IDLE or STOP.
   a. Reverse lever may be moved to any position.
   b. Selector may be moved to any position.

CAB CONTROLS

4. Throttle above IDLE.
   a. Reverse lever position cannot be changed.
   b. Selector cannot be moved out of B to OFF or from 1 to OFF. It may, however, be moved in the 1-4 range.

5. Selector in OFF.
   a. Reverse lever may be moved to any position.
   b. Throttle may be moved between IDLE and STOP only.

6. Selector in "B."
   a. Reverse lever cannot be moved.
   b. Throttle may be moved to any position.

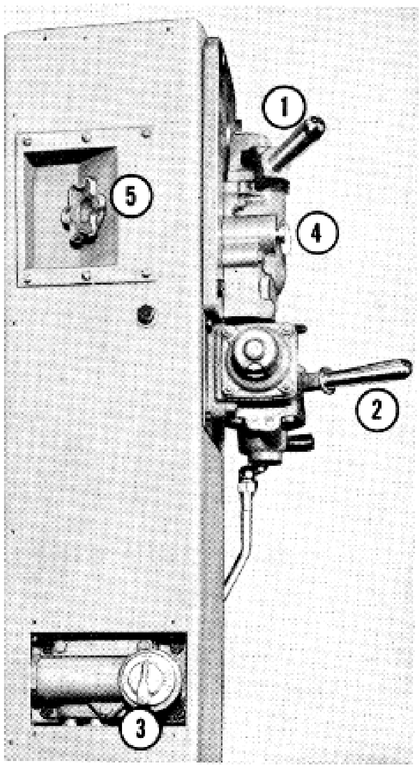
7. Selector in 1 (or the 1-4 range).
   a. Reverse lever may be moved to any position.
   b. Throttle may be moved to any position.

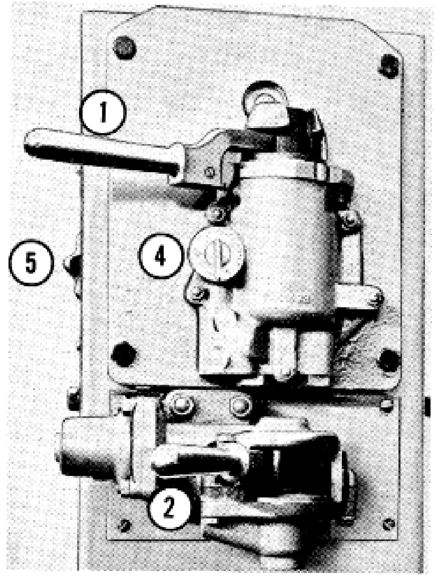
   Where positions 2, 3 and 4 for manual transition are incorporated in the selector, this handle may be moved from 1 to these positions if the reverse lever is in FORWARD or REVERSE, and with the throttle in any position. Permissible movement of the throttle and reverse levers with the selector in 2, 3 or 4 is the same as with the selector in 1.

AIR BRAKE EQUIPMENT, Fig. 2-9

Basic SD24 locomotives are equipped with the type 26L air brakes. Available as optional equipment are type 24RL or 6BL air brakes which may be installed to meet customer preference. Since the type 26L is basic or "standard" equipment, only that type of air brake will be discussed in this manual.

The 26L air brake control equipment is located on a pedestal to the left of the controller. As shown in Fig. 2-9, this equipment consists of an automatic brake, independent brake, multiple unit valve (when MU control is installed), cut-off valve and a trainline air pressure adjustment device. Not shown is the dead engine feature.





1. Automatic Air Brake Handle
2. Independent Brake Handle
3. Multiple Unit Valve
4. Cut-Out Valve
5. Trainline Air Pressure Knob

Side View Front View

26L Air Brake Pedestal
Fig. 2-9

1. AUTOMATIC BRAKE VALVE

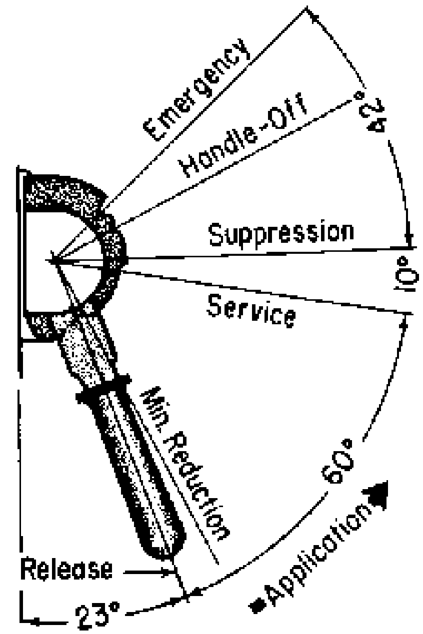
The automatic brake valve handle maybe placed in six (6) operating positions as shown in Fig. 2-10 and identified below.

(1) Release
(2) Minimum reduction
(3) Service
(4) Suppression (train and safety control reset position)
(5) Handle off
(6) Emergency

2. INDEPENDENT AIR BRAKE

The independent air brake handle is located directly below the automatic brake handle. It has two positions namely, RELEASE and FULL APPLICATION. Between these two positions is the application zone. Since this is a self-lapping brake, it automatically laps off the flow of air and maintains brake cylinder pressure corresponding to the position of the handle in the application zone.

Depression of the independent brake valve handle when in the RELEASE position causes release of any automatic brake application existing on the locomotive.



Automatic Brake Handle Positions
Fig. 2-10

3. MULTIPLE UNIT VALVE

The multiple unit, MU-2 valve is located on the left hand side of the air brake pedestal, as shown in Fig. 2-9. Its purpose is to pilot the F1 selector valve which is a device that enables the air brake equipment of one locomotive unit to be controlled by that of another unit.

The MU-2 valve has three positions which axe:

(1) LEAD or DEAD
(2) TRAIL 6 or 26
(3) TRAIL 24

The valve is positioned by pushing in and turning to the desired setting.

*Whenever the MU-2 valve is in the TRAIL 6 or 26 position and if actuating trainline is not used then the actuating end connection cutout cock must be opened to atmosphere. This is necessary to prevent the inadvertent loss of air brakes due to possible pressure build-up in the actuating line.

4. CUT-OFF VALVE

The cut-off valve is located on the automatic brake valve housing directly beneath the automatic brake valve handle. This valve has the following three positions:

(1) CUT-OUT
(2) PASS (Passenger)
(3) FRT (Freight)

5. TRAINLINE PRESSURE ADJUSTMENT

The trainline air pressure adjusting knob is located behind the automatic brake valve at the upper portion of the brake pedestal. It may be seen by referring to Fig. 2-9.

DEAD ENGINE FEATURE

The SD24 locomotive is equipped with a dead engine feature which is a part of the 26L braking equipment. This feature is located beneath the cab floor and is accessible from the outside of the locomotive through side doors provided.

BRAKE EQUIPMENT POSITIONS

When operating SD24 locomotives equipped with 26L air brakes, the brake equipment should be positioned according to the information given in Fig. 2-11.

Type Of Service	Automatic Brake Valve	Independent Brake Valve	Cutoff Valve	Dead Engine Cutout Cock	26D Control Valve	26F Control Valve	MU2 Valve	Overspeed Cutout Cock	Deadman Cutout Cock
SINGLE LOCOMOTIVE EQUIPMENT									
Lead	Release	Release	Passenger Freight	Closed	No Relief Valve In Control Reservoir				
Double Heading	Release	Release	Cutout	Closed	No Relief Valve In Control Reservoir				
Shipping Dead In Train	Handle Off Position	Release	Cutout	Open	Relief Valve In Control Reservoir 75 ± 2#				
MULTIPLE LOCOMOTIVE EQUIPMENT AND EXTRAS									
Lead	Release	Release	Passenger Freight	Closed		Graduated Direct	Lead	Open	Open
Trail	Handle Off Position	Release	Cutout	Closed		Graduated Direct	Trail 6 or 26 Trail 24	Open	Open
Shipping Dead In Train	Handle Off Position	Release	Cutout	Open		Direct Release	Dead	Closed	Closed
Double Heading	Release	Release	Cutout	Closed		Graduated Direct	Lead	Open	Open
Dual Control:									
Operative Station	Release	Release	Passenger Freight	Closed					
Non-Operative Station	Handle Off Position	Release	Cutout						

26L Air Brake Equipment Positions
Fig. 2-11

SECTION 3

OPERATION

INTRODUCTION

This section of the manual covers recommended procedures for operation of the Model SD24 locomotive. These procedures are outlined without detailed explanations of equipment location or function which are covered in other sections of this manual.

The information is arranged in a sequence commencing with inspections in preparation for service, starting the engine, running light, coupling to train, and then through routine operating phases. Special operating situations are also discussed as are special features such as dynamic braking.

PREPARATION FOR SERVICE

A. GROUND INSPECTION

Check locomotive exterior and running gear for:

1. Leakage of fuel oil, lube oil, water or air.
2. Loose or dragging parts.
3. Proper hose connections between units in multiple.
4. Proper positioning of all angle cocks and shutoff valves.
5. Air cut in to truck brake cylinders.
6. Satisfactory condition of brake shoes.
7. Condensation in main air reservoir.
8. Adequate supply of fuel.
9. Adequate supply of water (on units with steam generators operating in passenger service).

B. ENGINEROOM INSPECTION

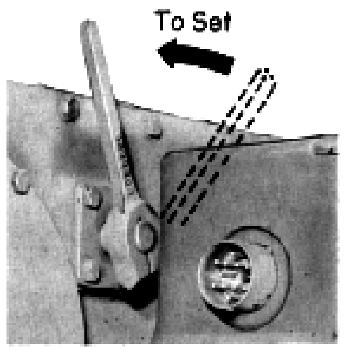
By opening the access doors along the sides of the long hood end of the locomotive, the engineroom may be readily inspected. Observe the following items:

1. Check air compressor for proper lubricating oil supply.
2. Observe for proper water level on tank sight glass.
3. Check all valves for proper positioning.
4. Observe for leakage of fuel oil, lubricating oil, water or air.
5. Observe that control (and dynamic braking) jumper cables are installed between units operating in multiple.
6. Perform the following engine inspection, then close all engineroom access doors and latch them securely.

C. ENGINE INSPECTION

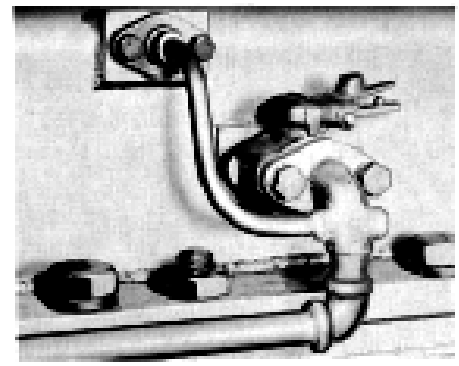
The engine should be inspected before as well as after starting as follows:

1. Check oil pan dipstick for proper lubricating oil supply.
2. Check governor for proper oil supply.
3. Check to see that engine overspeed lever is set, Fig. 3-1.
4. Make sure governor low oil pressure trip button is set.
5. Observe that engine top deck, air box and oil pan inspection covers are in place and securely closed.



Engine Overspeed Trip
Fig. 3-1

6. Open air box drains, Fig. 3-2, and allow accumulation to drain. Report any observance of water draining when valve is opened. Draining will occur faster if engine is running. Close drain valves before operating locomotive.



Air Box Drains
Fig. 3-2

7. If fuel pump is running, check fuel system condition by observing fuel flow through sight glasses on engine mounted filter.
8. If engine is running, observe lube oil gauge for proper operating pressure.

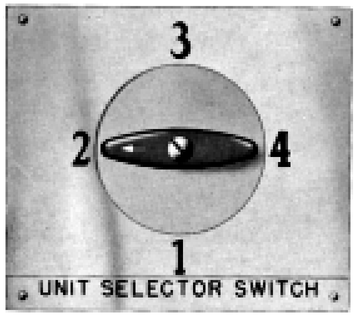
D. LEAD UNIT CAB INSPECTION

On the lead or control unit, the four control areas described in Section 2 should be checked and the equipment positioned for operation as follows:

DISTRIBUTION PANEL

1. Main battery switch closed.
2. Auxiliary generator knife switch closed.
3. Ground relay knife switch closed.
4. All fuses installed and in good condition.
5. Local control circuit breaker ON.
6. Turbocharger lube oil pump circuit breaker ON.

ENGINE CONTROL PANEL



Unit Selector Switch
Fig. 3-3

1. Control circuit breaker ON.
2. Fuel pump circuit breaker ON.
3. Isolation switch in START position.
4. Lights circuit breaker ON.
5. Unit selector switch (where used), Fig. 3-3, in position to correspond with total number of units in locomotive consist.
6. Headlight control switch in proper position for lead unit operation.
7. Miscellaneous switches and circuit breakers, lights, cab heater, water cooler ON as required. 8. If engine is running, observe that battery charging ammeter reads zero or charge.

LOCOMOTIVE CONTROLLER

At the locomotive controller, the switches and operating levers should be positioned for operation as follows:

1. Place control and fuel pump switch ON.
2. Place engine run switch ON.
3. Install reverse lever.
4. Make sure throttle is in IDLE.

AIR BRAKES - TYPE 26L

1. Insert automatic brake valve handle (if removed) and place in SUPPRESSION position. This will nullify any safety control application if used.

2. Insert independent brake valve handle (if removed) and move to FULL APPLICATION position.
3. Position cutoff valve to either FRGT or PASS depending on make-up of train.
4. Place MU valve in LEAD position.

E. TRAILING UNIT CAB INSPECTION

Switches, circuit breakers and control equipment located in the cab of a trailing unit should be checked for proper positioning as follows:

DISTRIBUTION PANEL

1. All knife switches closed.
2. All circuit breakers closed.
3. All fuses installed and in good condition.

ENGINE CONTROL PANEL

1. Fuel pump circuit breaker ON.
2. Isolation switch in START position.
3. Headlight control switch in position to correspond with unit position in consist.
4. Other switches and circuit breakers may be placed ON as needed or left off, as they do not affect locomotive operation.

LOCOMOTIVE CONTROLLER

The controller switches and operating levers should be positioned as follows:

1. All switches should be OFF.
2. Throttle should be in IDLE.
3. Selector lever should be in OFF.

4. Reverse lever should be placed in NEUTRAL then REMOVED from the controller to lock the other levers.

AIR BRAKES - TYPE 26L

1. Place automatic brake valve handle in HANDLE OFF position. Remove handle if so equipped.

2. Place independent brake valve handle in FULL RELEASE position. Remove handle if so equipped.

3. Place MU valve in desired position for trailing unit operation.

4. Place cutoff valve in CUTOUT position.

TO START DIESEL ENGINE

After completing the preceding inspections, the diesel engine may be started as follows:

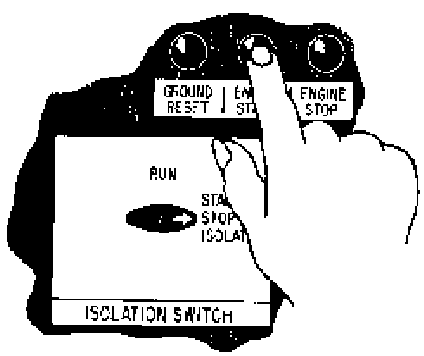
1. Make sure the isolation switch is in START, fuel pump circuit breaker is ON, and the control and fuel pump switch is ON.

2. Firmly press start push button IN as shown in Fig. 3-4, and hold (not more than 15 seconds) until engine starts and runs. If engine fails to start, consult "Trouble Shooting" section for possible causes.

3. After starting engine, check for ground relay tripping. Depress reset button.

4. Observe that engine oil pressure is satisfactory.

5. Place unit "on-the line" by moving isolation switch to RUN position as shown in Fig. 3-5.

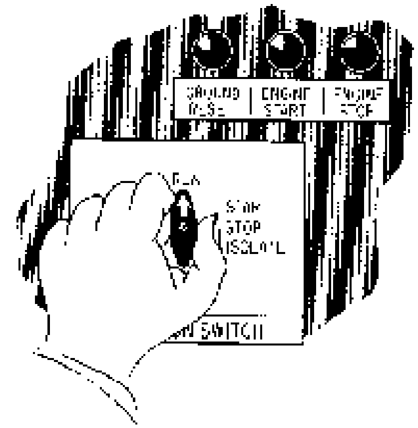


Starting Engine
Fig. 3-4

PRECAUTIONS BEFORE MOVING LOCOMOTIVE

The following points should be carefully checked before attempting to move the locomotive under its own power.

1. MAKE SURE THAT MAIN RESERVOIR AIR PRESSURE IS NORMAL (approximately 130-140 pounds). This is very important since the locomotive is equipped with electro-magnetic switchgear which would function in response to control and permit operation without air pressure required for this function.



Placing Engine On The Line
Fig. 3-5

2. Check for proper application and release of air brakes.

3. Release hand brake and remove any blocking of the wheels.

HANDLING LIGHT LOCOMOTIVE

With the engine started and placed "on-the-line" and the preceding inspections and precautions completed, the locomotive is handled as follows:

1. Place generator field switch ON.

2. Place headlight and other lights ON as needed.

3. Move reverse lever to desired direction of motion, either FORWARD or REVERSE.

4. Place selector lever in No. 1 position.

5. Depress safety control foot pedal (if used).

6. Release air brakes.

7. Open throttle to Run 1, 2 or 3 as needed to move locomotive at desired speed.

NOTE: Engine should not be operated above throttle position No. 3 until water temperature is greater than 130° F.

8. Throttle should be in IDLE before coming to a dead stop.

9. Reverse lever should not be moved except when locomotive is completely stopped.

COUPLING LOCOMOTIVE UNITS TOGETHER

When coupling units together for multiple unit operation, the procedure below should be followed:

1. Couple and stretch units to insure couplers are locked.

2. Install control and dynamic braking jumper cables between units.

3. Attach platform safety chains between units.

4. Perform ground, engineroom and engine inspections as outlined in preceding articles.

5. Position cab controls for trailing unit operation as outlined in preceding articles.

6. Connect air brake hoses between units as follows Unit equipped with 26L brake equipment to operate in multiple (lead or trail) with 24RL or 6BL units.

6BL		26L		24RL
Brake pipe	to	Brake pipe	to	Brake pipe
MR equalizing pipe	to	MR equalizing pipe	to	MR equalizing pipe
-		Actuating pipe	to	Actuating pipe
BC equalizing pipe	to	BC equalizing pipe	to	Indep. applic.& rel. pipe
Sanding pipe	to	Sanding pipe	to	Sanding pipe

7. Open required air hose cutout cocks on both units.

NOTE: Units with 26L brake equipment must have the actuating pipe end hose cutout cock CLOSED at the rear of the locomotive when they are leading units with 6SL or 6BL brake equipment. If two or more units of 26L brake equipment are connected together and leading the consist, the end hoses must be coupled together between units and the cutout cocks on the actuating pipe line OPENED on each unit. Units with 26L brake equipment must have the actuating pipe cutout cock OPEN at both ends when attached to, but trailing units with 6SL or 6BL brake equipment. (This is required to eliminate an inoperative brake action occurring on the locomotive.)

A setup of the brakes must then be made on the consist to determine if brakes apply on each unit. Brakes then must be released to determine if all brakes release. The same procedure must be followed to check the independent brake application. Also, release an automatic service application by depressing the independent brake valve handle downward. Inspect all brakes in the consist to determine if released.

COUPLING LOCOMOTIVE TO TRAIN

Locomotive should be coupled to train with the same care taken as when coupling cars together. After coupling, make the following checks:

1. Test to see that couplers are locked by stretching connection.

2. Connect air brake hoses.

3. Slowly open air valves on locomotive and train to cut in brakes.

4. Pump up air if necessary by following procedure below.

PUMPING UP AIR

After cutting in air brakes on train, note the reaction of the main reservoir air gauge. If pressure falls below trainline pressure, pump up air as follows:

1. Place generator field switch OFF.
2. Move reverse lever to NEUTRAL.
3. Open throttle as needed to speed up engine and thus increase air compressor output.

NOTE: Throttle may be advanced to RUN 4, 5 or 6 if necessary. Engine should not, however, be run unloaded (as in pumping up air) at speeds beyond throttle No. 6 position.

BRAKE PIPE LEAKAGE TEST

Prior to operating the 26L brake equipment, a leakage test must be performed. This is accomplished in the following manner.

1. The cutoff valve is positioned in either **FRGT or PASS, depending** on the equipment make up of the train.
2. Move the automatic brake valve handle gradually into service position and the equalizing reservoir gauge should be observed until a 15 psi reduction is obtained.
3. Without any further movement of the automatic brake valve handle, observe the brake pipe gauge until this pressure has dropped 15 psi and exhaust has stopped blowing.
4. At this moment turn the cutoff valve to CUT OFF position. This cuts out the maintaining function of the brake valve.
5. From the instant the cutoff valve is turned to CUT OFF position, the brake pipe gauge should be observed and any possible drop in brake pipe pressure should be timed for one minute.

Brake pipe leakage must not exceed 1 psi per minute.

6. After checking trainline leakage for one minute and the results are within required limits, return the cutoff indicator to the required position FRGT or PASS and proceed to reduce the equalizing gauge pressure until the pressure is the same as brake pipe gauge pressure. This is accomplished by moving the automatic brake valve handle gradually to the right until a full service application has been obtained.
7. After pipe leakage test has been completed, return the automatic brake valve handle to RELEASE position.

STARTINGA TRAIN

The method to be used in starting a train depends upon many factors such as, the type of locomotive being used; the type, weight, length and amount of slack in the train; as well as the weather, grade and track conditions. Since all of these factors are variable, specific train starting instructions cannot be provided and it will therefore be up to the engineman to use good judgment in properly applying the power to suit requirements. There are, however, certain general considerations that should be observed and they are discussed in the following paragraphs.

A basic characteristic of the diesel locomotive is its VERY HIGH STARTING TRACTIVE EFFORT. It is therefore imperative that the air brakes are COMPLETELY RELEASED before any attempt is made to start a train. On an average 100 car freight train having uniformly distributed leakage, it may take 10 minutes or more to completely release the brakes after a reduction has been made. It is therefore important that sufficient time is allowed after stopping, or otherwise applying brakes, to allow them to be fully released before attempting to start the train.

The Model SD24 locomotive possesses sufficiently high tractive effort to enable it to start most trains without taking slack. The indiscriminate practice of taking slack should thus be avoided. There will, however, be instances in which it would be advisable (and sometimes necessary) to take slack in starting a train. Care should be taken in such cases to prevent excessive locomotive acceleration which would cause undue shock to draft gear and couplers and lading.

Throttle handling in starting trains is of importance since it has a direct bearing on the power being developed. As the throttle is advanced, a power increase occurs at a rate dependent upon characteristics of the governor and load regulator. This rate of increase may be noted by observing the load indicating meter. Although factors are present to regulate the rate of power build-up, it is still largely controlled by changes in throttle position.

It is therefore advisable to advance the throttle one notch at a time when starting a train. A train should be started in as low a throttle position as possible, thus keeping the speed of the locomotive at a minimum until all slack has been removed and the train completely stretched. Sometimes it is advisable to reduce the throttle a notch or two at the moment the locomotive begins to move in order to prevent stretching slack too quickly or to avoid slipping.

When ready to start, the following general procedure is recommended:

1. Place the selector lever (if used) in the No. 1 or RUN position.

2. Move reverse lever to the desired direction, either FORWARD or REVERSE.

3. Place generator field switch in ON position.

4. Place automatic sanding switch ON if desired. 5. Release both automatic and independent air brakes.

6. Open the throttle one notch every 1 to 2 seconds as follows:

   a. To Run 1 - Note the load meter pointer start moving to the right.

   b. To Run 2 - Note engine speed increase. At an easy starting place, the locomotive may start the train in Run 1 to 2.

   c. To Run 3 or higher (experience and the demands of the schedule will determine this) until the locomotive moves.

7. Reduce throttle one or more notches if acceleration is too rapid.

8. After the train is stretched, advance throttle as desired.

NOTE: If the wheel slip indicator flashes continuously, reduce the throttle one notch. Reopen the throttle when rail conditions improve. It is seldom if ever necessary to manually apply sand with the automatic sanding feature "cut in."

ACCELERATION OF A TRAIN

After the train has been started, the throttle may be advanced as rapidly as desired to accelerate the train. The speed with which the throttle is advanced depends upon demands of the schedule and the type of locomotive and train involved. In general however, advancing the throttle one notch at a time is desired to prevent slipping.

The load indicating meter provides the best guide for throttle handling when accelerating a train. By observing this meter it will be noted that the pointer moves towards the right (increased amperage) as the throttle is advanced. As soon as the increased power is absorbed, the meter pointer begins moving towards the left. At that time, the throttle may again be advanced. Thus for maximum acceleration without slipping, the throttle should be advanced one notch each time the meter pointer begins moving towards the left until full power is reached in throttle position 8.

Additional train acceleration is provided by forward transition taking place automatically during throttle changes or after reaching full throttle. This transition or change of electrical circuits takes place automatically without any attention or action required on the part of the engineman.

NOTE: In the event that trailing locomotive units are not equipped with automatic transition, manual shifting of the lead unit selector lever will be necessary to cause transition on such units. The shift points (1 through 4) are based on speed. Such information is provided by the railroad or maybe obtained from Electro-Motive on request.

SLOWING DOWN BECAUSE OF A GRADE

When entering upon an ascending grade, the locomotive and train will slow down and the increased load will be noted by the indicating meter pointer moving towards the right. Backward transition will take place automatically (see preceding note).

AIR BRAKING WITH POWER

The method of handling the air brake equipment is left to the discretion of the individual railroad. However, when braking with power, it must be remembered that for any given throttle position, the draw bar pull rapidly increases as the train speed decreases. This pull might become great enough to part the train unless the throttle is reduced as the train speed drops. Since the pull of the locomotive is indicated by the amperage on the load meter, the engineman can maintain a constant pull on the train during a slow down, by keeping a steady amperage on the load meter. This is accomplished by reducing the throttle a notch whenever the amperage starts to increase. It is recommended that the independent brakes be kept fully released during power braking. The throttle MUST be in Idle before the locomotive comes to a stop.

OPERATION OVER RAILROAD CROSSING

When approaching railroad crossings, the throttle should be reduced to Run 5 just before the lead unit reaches the crossing. It should be left reduced until all units have passed over the crossing, then reopened as required. Following this procedure will reduce arcing from the brushes to the traction motor commutators.

RUNNING THROUGH WATER

Under ABSOLUTELY NO CIRCUMSTANCES should the locomotive be operated through water deep enough to touch the bottom of the traction motors. Water any deeper than 3" above the rail is likely to cause traction motor damage.

When passing through any water on the rails, exercise every precaution under such circumstances and always go very slowly, never exceeding 2 to 3 MPH.

WHEEL SLIP LIGHT INDICATIONS

The momentary flashing of the wheel slip light on and off generally indicates a pair of wheels are slipping. Corrective action is seldom necessary particularly if the automatic sanding feature is cut in.

Automatic sanding together with the electrical wheel creep and slip relays function to prevent wheel slips and to quickly correct those that do occur. Where necessary, the power of the locomotive is automatically and gradually reduced to overcome a slip. Power is then gradually reapplied after slipping has stopped. This wheel slip control equipment thus functions to maintain the maximum locomotive tractive effort possible during operation. Manual sanding is seldom if ever necessary.

In instances where the wheel slip light flashes on and off when starting a train then stays on more or less continuously as speed increases indicates some electrical difficulty or a SLIDING PAIR OF WHEELS.

Due to the seriousness of sliding wheels, under such indications, the locomotive should be IMMEDIATELY STOPPED and an investigation made to determine the cause. The wheels may be sliding due to a locked brake, damaged traction motor bearings, or broken pinion or gear teeth.

Repeated ground relay tripping accompanied by unusual noises such as thumping or squealing may also be an indication of serious traction motor trouble that should be investigated at once.
Do not allow any unit to remain in a locomotive consist that must be isolated due to repeated wheel slip or ground relay action UNLESS IT IS ABSOLUTELY CERTAIN THAT ALL OF ITS WHEELS ROTATE FREELY.

LOCOMOTIVE SPEED LIMIT

The maximum speed at which the locomotive may be safely operated is determined by the gear ratio. This ratio is expressed as a double number such as 62-15. The 62 indicates the number of teeth on the axle gear while the 15 represents the number of teeth on the traction motor pinion gear.

Since the two gears are meshed together, it can be seen that for this particular ratio, the motor armature turns approximately four times for every one revolution of the driving wheels. The locomotive speed limit is therefore determined by the maximum permissible rotation speed of the motor armature. Exceeding this maximum could result in serious damage to the traction motors.

Various gear ratios are available to suit specific locomotive operating requirements. For each gear ratio, there is a maximum operating speed. This information is given in the "General Data" section at the beginning of this manual.

Although not basically applied, overspeed protective equipment is available for installation on locomotives. This consists of an electro-pneumatic arrangement with many possible variations to suit specific requirements. In general however, an electrical microswitch in the speed recorder is used to detect the overspeed. This switch in turn causes certain air brake functions to occur to reduce the train speed.

MIXED GEAR RATIO OPERATION

If the units of the consist are of different gear ratios, the locomotive should not be operated at speeds in excess of that recommended for the unit having the lowest maximum permissible speed. Similarly, operation should never be slower than the minimum continuous speed (or maximum motor amperage) of units having established overload short time ratings.

To obtain a maximum tonnage rating for any single application, Electro-Motive will, upon request, analyze the actual operation and make specific tonnage rating recommendations.

DYNAMIC BRAKING

Dynamic braking, on locomotives so equipped, can prove extremely valuable in retarding train speed in many phases of locomotive operation. It is particularly valuable while descending grades, thus reducing the necessity for using air brakes.

Depending on locomotive gear ratio, the maximum braking strength is obtained between 15 and 25 MPH. It should also be remembered that dynamic brake function is primarily to hold train speed constant and is not too effective in slowing down or stopping trains. It is thus important that dynamic braking is started BEFORE train speed becomes excessive. While in braking, the speed should not be allowed to "creep" up by careless handling of the brake.

To operate dynamic brakes, proceed as follows:

1. Observe that the unit selector switch position in the lead unit corresponds to the number of units in the locomotive consist.

2. The reverse lever should be positioned in the direction of locomotive movement.

3. Throttle must be reduced to Idle.

4. Move selector lever from No. 1 to OFF position. Pause 10 seconds before proceeding.

5. Move the selector lever to the "B" or braking position. This establishes the dynamic braking circuits. It will also be noted that a slight amount of braking effort occurs as evidenced by the load indicating meter.

6. After the slack is bunched, the throttle is used to control dynamic braking strength. As it is advanced about 13° away from IDLE it will be noted that the engine speed automatically increases from 275 RPM (idle) to 435 RPM.

7. Braking effort may be increased by slowly advancing the throttle to the full 8th notch position if desired. Maximum braking effort is automatically limited to 700 amperes by a dynamic brake current limiting regulator.

8. With automatic regulation of maximum braking strength, the brake warning light on the controller should seldom give indication of excessive braking current. If the brake warning light does flash on however, movement of the throttle handle should be stopped until the light goes out. If the light fails to go out after several seconds, move the throttle handle back towards IDLE slowly until the light does go out. After the light goes out, throttle may again be advanced to increase braking effort.

NOTE: The brake warning light circuit is "trainlined" so that a warning will be given in the lead unit if any unit in the consist is generating excessive current in dynamic braking. Thus regardless of the load indicating meter reading (which may be less than brake rating) whenever the warning light comes on, it should not be allowed to remain for any longer than several seconds before steps are taken to reduce braking strength.

9. When necessary, the automatic brake may be used in conjunction with the dynamic brake. However, the independent brake must be KEPT FULLY RELEASED whenever the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 MPH the dynamic brake becomes less effective. When the speed further decreases, it is permissible to completely release the dynamic brake by placing the selector lever in the OFF or No. 1 position, applying the independent brake simultaneously to prevent the slack from running out.

SD24 locomotives can be operated in dynamic braking coupled to older units that are not equipped with brake current limiting regulators. If all the units are of the same gear ratio, the unit having the lowest maximum brake current rating should be placed as the lead unit in the consist. The engineman can then operate and control the braking effort up to the limit of the unit having the lowest brake current rating, without overloading the dynamic brake system of a trailing unit. The locomotive consist MUST always be operated so as not to exceed the braking current of the unit having the lowest maximum brake current rating.

Units equipped with dynamic brake current limiting regulators can be operated in multiple with SD24 locomotives in dynamic braking regardless of the gear ratio, or difference in the maximum brake current ratings.

Units not equipped with dynamic brake current limiting regulators and of different gear ratios will require special operating instructions when used in multiple with a SD24 locomotive in dynamic braking.

DYNAMIC BRAKE WHEEL SLIDE CONTROL

The electrical relays used to correct a wheel slip while under power are also used to correct the tendency of one pair of wheels to rotate slower while in dynamic braking due to an unusual rail condition.

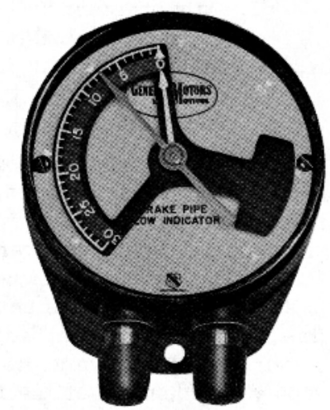
When a pair of wheels is detected tending to rotate at a slower speed, the retarding effort of the traction motors in the unit affected is reduced (main generator battery field excitation is reduced in the unit affected) and sand is automatically applied to the rails (automatic sanding switch on the controller must be in ON position). When the retarding effort of the traction motors in the unit is reduced, the tendency of the wheel set to rotate at a slower speed is overcome. After the wheel set resumes normal rotation, the retarding effort of the traction motors returns (increases) to its former value. Automatic sanding continues for approximately 20 seconds after the wheel slide tendency is corrected.

HUMP SPEED CONTROL

When applied, the electrical hump speed control circuit controls the positioning of the load regulator, thereby controlling the excitation to the main generator.

From this it can be seen that a combination of throttle setting (i.e., engine RPM) and applied voltage (main generator excitation voltage) produces the power to move the train. Locomotive power can be reduced by reducing the throttle setting. However, reducing power in smaller increments better suits the operating conditions peculiar to humping service. Reducing the excitation as the load lessens makes possible a fine balance between power output and power required.

BRAKE PIPE FLOW INDICATOR



Brake Pipe Flow Indicator
Fig. 3-6

When applied, a brake pipe flow indicator, Fig. 3-6, is a very useful supplement to locomotive air brake equipment. The indicator provides the following desirable indications:

1. It indicates a trainline that is sufficiently charged to start the initial brake test when the differential between the pointer hand and sector hand reaches 7 pounds or less.

2. It indicates the continuous system leakage of the particular train being handled. This indication is the lowest number reached after the train is fully charged, the reading should be 5 or less.

3. A change in reading from the number indicated as a normal continuous system leakage indicates one of the following conditions:

   a. Conductor initiated Service Reduction from the caboose.

   b. Conductor initiated Emergency Application from the caboose.

   c. An application caused by a break-in-two or separation of the train.

4. This indicator provides readings in service position of the brake valve as well as differential indication in running position of the brake valve.

5. Only practice and experience will bring out all the many valuable uses of this indicator. The indication shown in Fig. 3-6, for example, is that which would be noted with brakes released and train charged, ready for initial brake test.

The flow indicator consists of a duplex gauge case and bezel with a special movement, and employs bourdon tubes with enough sensitivity to indicate differentials encountered during the various brake operating conditions. This is accomplished by measurement of differential pressures across an orifice in the main reservoir line to the brake valve, which would indicate the degree of work the brake valve was required to do in order to supply the demand of the brake pipe.

DOUBLE HEADING

Prior to double heading behind another locomotive, make a full service brake pipe reduction with the automatic brake valve, and place the cutoff valve in CUT OUT position. Return the automatic brake valve handle to the RELEASE position and place the independent brake valve in RELEASE position. On 26L equipment place the MU valve in LEAD position.

The operation of the throttle is normal, but the brakes are controlled from the lead locomotive. An emergency air brake application may be made however, from the automatic brake valve of the second unit. Also, the brakes on this unit may be released by depressing the independent brake valve handle in the RELEASE position.

OPERATION I N HELPER SERVICE

Basically, there is no difference in the instructions for operating the SD24 locomotive as a helper or with a helper. In most instances it is desirable to get over a grade in the shortest possible time. Thus, wherever possible, operation on grades should be in full throttle 8 position. The throttle may be reduced however, in instances when

excessive wheel slips are occurring. For proper traction motor cooling, the locomotive should never be operated on grades below the 5th throttle position.

TO ISOLATE A UNIT

When the occasion arises that it becomes advisable to isolate a locomotive unit, the following precautions should be observed.

1. When operating under power, the throttle should be reduced to IDLE, the isolation switch may then be moved from RUN to START, thus isolating the unit. The throttle may be reopened and the train operated by power from remaining locomotive units.

2. When operating in dynamic braking, it is important to get out of dynamic braking before attempting to isolate unit. This is done by reducing the throttle to IDLE. The isolation switch can now be moved to START position, thus eliminating the braking of that unit. If the braking is resumed, other units will function normally.

NOTE: Unit should not be placed "on-the-line" while operating in dynamic braking without first placing throttle in IDLE to stop braking effort.

CHANGING OPERATING ENDS

When the consist of the locomotive includes two or more units with operating controls, the following procedure is recommended in changing from one operating end to the opposite end on locomotives equipped with 26L brakes.

A. On End Being Cut Out

1. Move the automatic brake valve handle to service position and make a 20 pound reduction.

2. After brake pipe exhaust stops, place cutoff valve in CUT OUT position by pushing dial indicator handle in and turning to the desired position.

3. Place independent brake in fully released position.

4. Place MU valve in the desired TRAIL position depending on brake equipment on trailing units. (MU valve is located in the left hand side of the air pedestal. Push dial indicator inward and turn to desired position.)

5. Position automatic brake valve in HANDLE OFF position. (Handle maybe removed if so equipped.)

6. Place selector lever in OFF.

7. Place reverse lever in NEUTRAL position and REMOVE to lock controller.

8. At the engine control panel, place headlight control switch in proper position for trailing operation.

9. At the controller, place all switches in the OFF position. Be absolutely sure that the fuel pump and control, generator field, and engine run switches are OFF.

10. After placing preceding switches OFF, move immediately to cab of new lead unit.

    Since fuel pumps will be inoperative, engines will starve of fuel unless control circuit is quickly re-established on unit being cut in.

B. On End Being Cut In

1. At the controller, place the fuel pump and control switch ON. This will re-establish control circuit and fuel pumps will again be running.

2. Make certain the throttle lever is in IDLE, selector lever is in OFF, and the generator field switch is OFF.

3. Insert reverse lever and leave in NEUTRAL position.

4. Insert automatic brake valve handle (if removed) and place in SUPPRESSION position to nullify any safety control, overspeed or train control, if used.

5. Insert independent brake valve handle (if removed) and move handle to full independent application position.

6. Position cutoff valve in either FRGT or PASS position depending on make-up of the train. 7. Place MU valve in LEAD position.

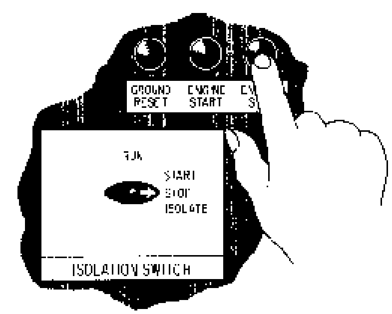
8. At the engine control panel, place headlight control switch in proper position. Other switches and circuit breakers may be placed ON as needed.

9. At the controller, move engine run switch ON. Generator field and other switches may be placed ON as needed.

TO STOP ENGINE

There are three ways of stopping the engine: (1) normal, (2) under power, and (3) emergency.

1. Normally stopping an engine applies when the locomotive is standing still. In this case, place isolation switch in START position and press in on Stop button, Fig. 3-7, holding it until engine stops.



Stopping Engine
Fig. 3-7

2. Under power or while operating in dynamic braking, an engine can be taken "off-the-line" by first reducing the throttle to IDLE, then placing the isolation switch in the START position. After being isolated the engine may be stopped in the normal manner using the stop push button.

3. In an emergency, all engines "on-the-line" are simultaneously stopped by pulling the throttle lever out away from the controller, then pushing it one step beyond IDLE to the STOP position.

NOTE: The diesel engine may also be stopped by manually taking control away from the governor by means of the layshaft lever. Moving this lever towards "no fuel," will move all injector racks out and stop the engine by stopping fuel injection.

SECURING LOCOMOTIVE FOR LAYOVER

1. Place the reverse lever in NEUTRAL position and the throttle in IDLE.
2. Place the selector lever in the OFF position and remove the reverse lever from controller.
3. Place isolation switch in START and press Stop button IN until engine stops.
4. Place all switches on the controller panel in the OFF position (down).
5. Open all knife switches in the electrical cabinet. Place all the circuit breakers and switches on the engine control panel in the OFF position.
6. Apply hand brake and block wheels, if necessary.
7. Cover exhaust stacks, if there is danger of a severe rain.
8. Drain or otherwise protect engine if there is any danger of freezing.

TOWING DEAD IN TRAIN

In instances where an SD24 locomotive unit equipped with 26L air brakes is placed within a train consist to be towed, its control and air brake equipment should be set as follows:

1. Drain all air from main reservoirs and air brake equipment.
2. Place the MU valve in DEAD position.
3. Place cutout valve in CUT OUT position.
4. Place independent brake valve handle in RELEASE position.
5. Place automatic brake valve handle in HANDLE OFF position.
6. Cut in dead engine feature by turning cutout cock to OPEN position. Dead engine feature is located beneath cab floor and may be reached through an access door at side of locomotive.
7. If engine is to remain IDLING, switches should be positioned as follows:
   a. Isolation switch in START position.
   b. All knife switches CLOSED.
   c. Local control and turbocharger lube oil pump circuit breakers ON.
   d. Battery field 80-ampere fuse should be removed. Other fuses should be left in place.
   e. Place the control and fuel pump switch ON.
   f. Place control circuit breaker ON.
   g. Place fuel pump circuit breaker ON.
   h. Place throttle in IDLE, selector in OFF, reverser in NEUTRAL. REMOVE REVERSE LEVER FROM CONTROLLER to lock controls.

8. If locomotive is to be towed DEAD in a train, switches should be positioned as follows:

   a. All knife switches OPEN.

   b. All circuit breakers OFF.

   c. All control switches OFF. d. Throttle should be in IDLE, selector in OFF. REVERSE LEVER SHOULD BE REMOVED FROM CONTROLLER.

NOTE: If there is danger of freezing, the engine cooling system should be drained according to the procedure outlined below.

FREEZING WEATHER PRECAUTIONS

As long as the diesel engine is running, the cooling system will be kept adequately warm regardless of temperatures encountered in freezing weather. It is only when the engine is shut down or stops for any reason that the cooling system requires protection against freezing.

In instances where such danger of freezing is present, the cooling system should be completely drained or have steam admitted where possible. Further information on these methods of protection may be found in the section on engine systems.

SECTION 4

COOLING, LUBRICATING, FUEL, AND AIR SYSTEMS

COOLING SYSTEM

ENGINE COOLING

A schematic flow diagram of the engine cooling system is shown in Fig. 4-1. Water is circulated throughout the system by means of two centrifugal pumps mounted on the front of the engine. The pumps are gear driven from the front or accessory drive gear train of the engine.

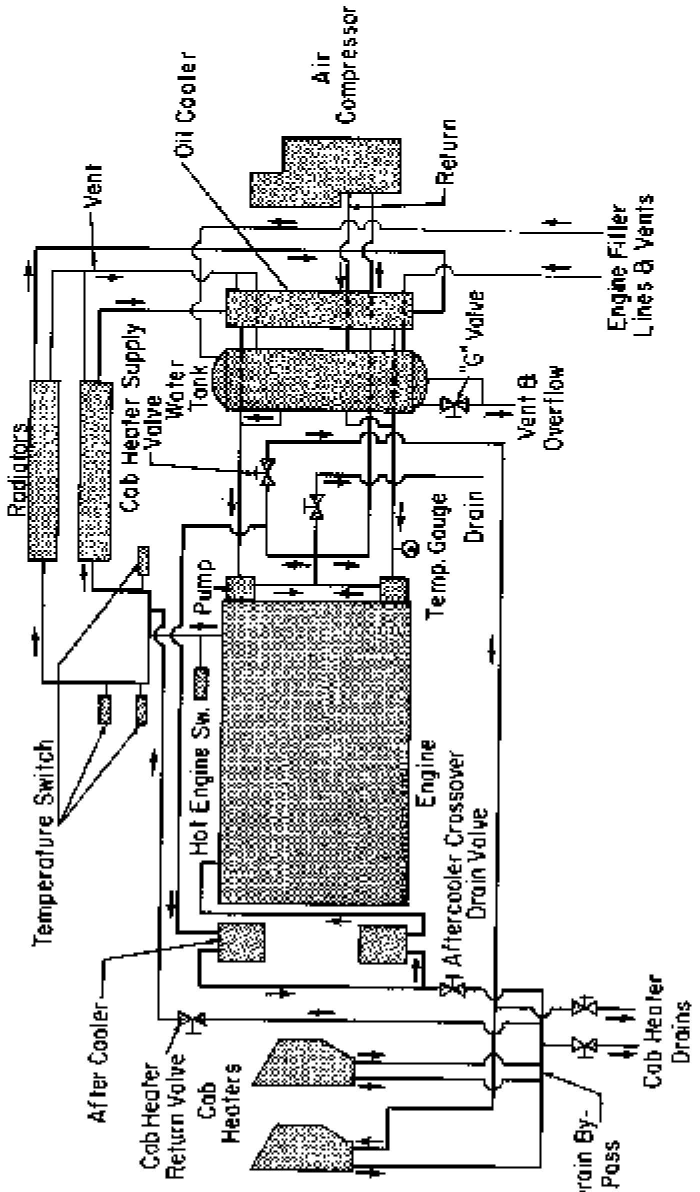
Water, drawn from the engine cooling water tank and lubricating oil cooler assembly by the pumps, is forced into manifolds extending through the airbox in each bank of the engine. Jumpers connect this manifold to the individual cylinder liners. Water flows through the liners and cylinder heads providing the necessary cooling. The heated water leaves the engine and flows through the radiator assembly where it is cooled. Leaving the radiators the cooled water returns to the oil cooler to repeat the cycle.

AIR COMPRESSOR COOLING

The water cooled air compressor receives its cooling water supply directly from the pumps on the diesel engine as shown in Fig. 4-1. There are no valves in this line thus cooling will be provided whenever the engine is running. Upon leaving the air compressor, the water is then piped back to the tank for recirculation.

TURBOCHARGER AFTERCOOLER

Aftercoolers are located on the discharge side of the turbocharger to cool the air before it enters each bank of the diesel engine. Their purpose is to reduce the temperature of the compressed air thus increasing air density and improving engine operating efficiency.



Cooling System Schematic Diagram
Fig. 4-1

The turbocharger aftercoolers receive water directly from the cross connection on the discharge side of the engine water pumps. As shown in Fig. 4-1, the flow of water goes through one aftercooler then the other before returning to the upper discharge manifold in the engine. The water then leaves the engine and flows to the radiators for cooling and recirculation. There are no valves in this system thus cooling is provided whenever the engine is running.

TEMPERATURE CONTROL

During circulation through the diesel engine, air compressor and turbocharger aftercoolers, the cooling system water picks up heat which must be dissipated. This heat is dissipated and the water temperature controlled by means of a radiator assembly and AC motor driven cooling fans.

The radiator is made up of two banks, each containing six radiator sections. They are located in a hatch at the rear or long hood end of the locomotive. Above the radiators and located in the roof are the three AC motor driven cooling fans. They are numbered from 1 to 3 from front to rear with the No. 1 fan being closest to the cab. Shutters operated by air pressure which is controlled by the shutter magnet valve (SMV) are located along the sides of the hood, adjacent to the radiators.

Control of the fans and shutters and thus the water temperature is entirely automatic.

In operation, outside air comes in through the shutters and is drawn up through finned sections of the radiators by the cooling fans. This flow of air through the radiators picks up heat from the circulating water. The heat is then discharged through the roof of the locomotive.

The temperature control switches are designated TA, TB and TC. A capillary tube connects each switch to a thermal element which is installed in the cooling system piping as shown in Fig. 4-1.

As the heated water discharges from the engine, it acts upon the thermal elements which in turn cause their switches to respond and establish electrical circuits to bring in the cooling fan contactors.

The cooling fan contactors are designated AC1, AC2 and AC3. They are located in the No. 2 electrical cabinet in the long hood end of the locomotive. When energized, they electrically connect their respective AC cooling fans to alternating current supply from the alternator. Thus powered, the fans commence operating.

The temperature control is as follows:

TA picks up at 180 ± 1° F. This energizes AC1 which starts No. 1 cooling fan. Since the shutters are closed, this fan receives its air by reverse flow through the other non-operating cooling fans. TA drops out at 165 ± 2° F. to stop No. 1 fan.

TB picks up at 185 ± 1° F. This energizes AC3 to start up No. 3 cooling fan. It simultaneously energizes the shutter magnet valve (SMV) and the shutters open to provide the necessary cooling air. TB drops out to stop No. 3 fan at 170 ± 2° F.

TC picks up at 190 ± 1° F. to start No. 2 fan by energizing AC2. It also establishes a circuit to energize SMV. TC and the No. 2 cooling fan drop out at 175 ± 2° F.

HOT ENGINE ALARM

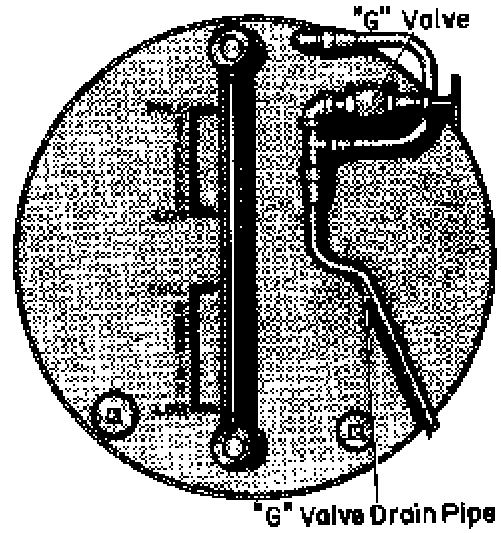
A hot engine alarm switch will close when the water in the cooling system reaches a temperature of approximately 208° F. This will cause the alarm bells to ring in all units and will light the red HOT ENGINE light on the engine control panel of the unit affected. The alarm can be silenced only by reduction of the cooling system temperature below 198° F. at which point the switch contacts open.

Engine water temperature may be readily checked by a gauge installed in the water inlet line leading to the right bank water pump.

The gauge is color coded to indicate COLD (Blue), NORMAL (Green), and HOT (Red) engine temperatures.

OPERATING WATER LEVELS

Operating water levels are stencilled on the water tank, Fig. 4-2, to indicate minimum and maximum water level in the gauge glass with the engine running or stopped. The water level should not be permitted to go below the "low" mark for either the engine running or stopped positions. Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system, and should be reported. Normally, there should be no need of adding water to the cooling system except at extended intervals and then only to make up for the small evaporation losses.



Cooling Water Levels
Fig. 4-2

FILLING COOLING SYSTEM

The engine cooling system is filled through the filler pipe on either side of the locomotive, just under the catwalk.

Another fill line, capped by a knurled edge cap, is located near the top of the water tank inside the carbody. This filler pipe is used when adding inhibitor to the cooling water. The engine should be running at idle speed when adding inhibitor.

To fill the cooling system proceed as follows:

1. Stop engine.

2. Open "G" (overflow) valve.

3. Fill slowly until water runs out the "G" valve drain pipe.

4. Close "G" valve.

If filling a dry or nearly dry engine also follow these additional steps:

5. Start engine and run several minutes. This will eliminate any air pockets in the system.

6. Shut down engine and open "G" valve and wait 3 minutes.

7. Add water until it runs out "G"valve drain pipe.

8. Close "G" valve.

CAUTION: 1. If the cooling system of a hot engine has been drained, do not refill immediately with cold water. If this is done, the sudden change in temperature might crack or warp the cylinder liners and heads.

2. Do not attempt to fill the cooling system through the drain pipe located underneath the locomotive.

3. The system should not be filled above the maximum water level indicated on the water tank to prevent:

a. Freezing of radiators in winter when engine is shut down.

b. Loss of rust inhibitor when draining back to "G" valve level.

DRAINING COOLING SYSTEM

Draining of the engine cooling system may become necessary in the event that the diesel engine is stopped and a danger of freezing exists. By referring to Fig. 4-1, the draining procedure is as follows:

1. Open the main drain valve located at the floor in front of the engine. This will drain the engine, radiators, water tank, oil cooler, and air compressor.

2. The water pump on the right side of the engine will not drain completely in the preceding step. To drain remaining water trapped in the pump, open the drain provided at the bottom of the housing.

3. With the cab heater supply and return valves open, the cab heaters and associated piping are drained by opening two valves located under the locomotive frame at the left side of the cab.

4. Turbocharger aftercoolers are drained by opening the cross-over drain valve. Also open pet cocks on the individual after-coolers where such are installed.

CAB HEATING AND VENTILATING

Cab heaters are complete with defroster and fresh air ventilators. Fresh air is taken in through a louver in the cab wall and is controlled by a fresh air damper within the heater.

Controlled by a rheostat type switch, a 1/12th HP variable speed fan motor draws in fresh air or recirculates cab air. The fan forces air through a hot water radiator and exhausts the heated air out onto the cab floor.

The defroster is a simple nonadjustable baffle and duct arrangement and the volume, temperature, and velocity of discharge air is dependent upon the setting of the fresh air damper, outlet damper, and speed of the fan motors.

Fresh air is controlled by the knob nearest the cab wall while the fan motor OFF-ON and speed control knob is farthest from the cab wall. A small knob located on the outlet damper controls the amount of air entering the cab through this outlet.

Cab heater water is taken from the water pump discharge at the front end of the engine, as shown in Fig. 4-1. To obtain circulation of water through the cab heaters, the supply and return valves must be opened.

ENGINE WINTERIZATION

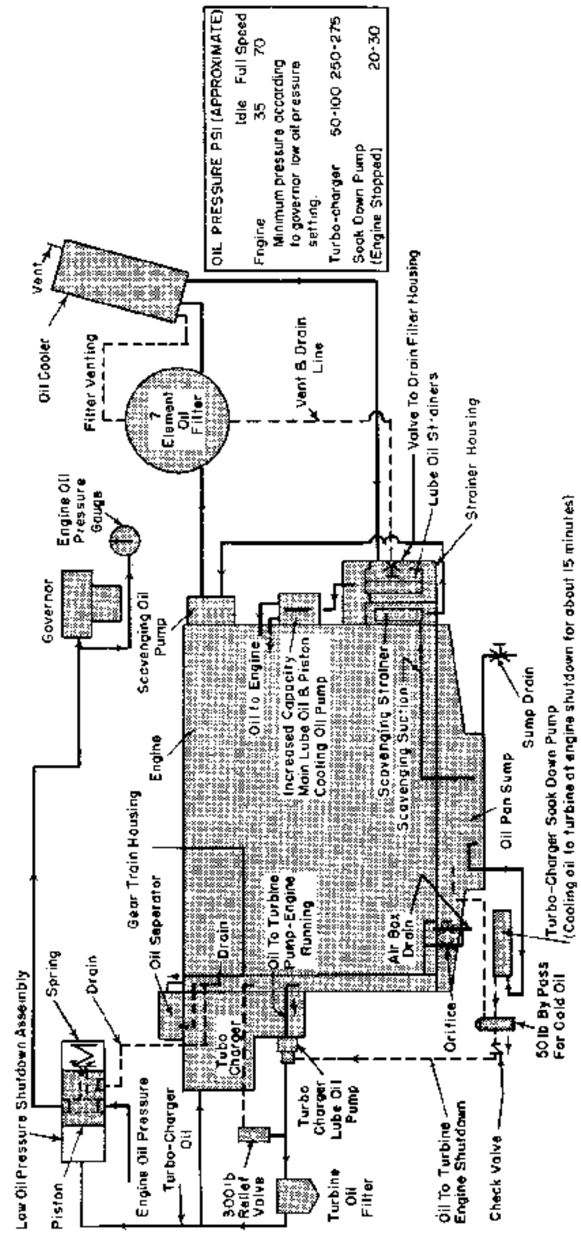
The winterization duct consists of a housing and a damper arrangement and No. 1 engine water cooling fan to divert, if desired, warm air into the engineroom. A handle on the outside of the duct controls operation of this winterization feature. The handle is manually placed in the summer or winter position as desired.

LUBRICATING OIL SYSTEM

ENGINE OIL SYSTEM

A schematic diagram of the lubricating oil system is shown in Fig. 4-3. Oil under pressure is forced through the engine for lubrication and piston cooling by the positive displacement combination piston cooling and lubricating oil pump. After circulating through the engine, the lubricating oil drains into the oil pan sump. The positive displacement scavenging oil pump draws oil from the sump and strainer housing, then forces it through the oil filter and cooler. From the cooler, the oil is delivered to another compartment in the oil strainer assembly where it is ready for recirculation by the combination piston cooling and lubricating oil pump.

The lubricating oil pumps are mounted on the front end of the engine and are gear driven by the engine through the accessory drive gear train. The oil strainer housing is also mounted on the front of the engine. The oil cooler and filter assemblies are located in the equipment rack adjacent to the front of the engine at the long hood end of the locomotive.



Lubricating Oil System Schematic Diagram
Fig. 4-3

TURBOCHARGER

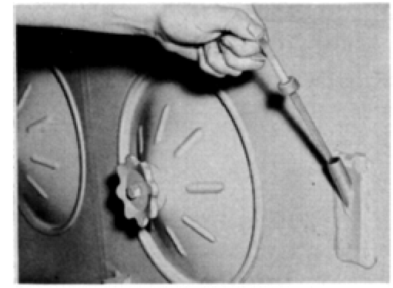
The turbocharger has a separate oil system and its pressure is much higher than the engine lubricating oil pressure. As shown in Fig. 4-3, a separate engine driven pump supplies oil for the turbocharger. Oil suction is taken from the engine oil supply at a connection to the No. 2 idler gear stubshaft. This oil is then forced under pressure varying from 100 to 300 psi, depending on engine speed, to the turbine and compressor bearings and other lubrication areas of the turbocharger. Oil leaving the turbocharger empties into the engine rear gear train housing and drains back into the oil pan sump. A relief valve is provided on the discharge side of the turbocharger oil pump to relieve pressure above 300 psi.

A separate automatically started motor driven turbocharger "soak down" oil pump is used to supply oil to the turbine whenever the engine is shut down. It is timed by time delay relay TLTD to run for about 15 minutes after the engine is shut down. Continued oil circulation is necessary for this period after engine shutdown to protect the turbine bearings from the retained heat in the turbine. The "soak down" oil pump carries this residual heat away and the heated oil is returned to the oil pan sump. For this motor driven pump to function as intended, the main battery switch and turbocharger lube oil pump circuit breaker must remain closed after engine shutdown.

The "soak down" oil pump takes its suction from the oil pan sump as shown in Fig. 4-3. Discharge from the pump enters the turbocharger oil system at its connection to the engine driven turbocharger oil pump discharge. A built-in check valve in the engine driven pump prevents soak down oil from passing through the pump. A fifty pound relief valve is connected between the discharge and oil pan to protect against overpressure when engine lubricating oil is cold. A check valve in the soak down pump discharge line prevents high pressure oil from the engine driven pump from damaging the soak down pump when the engine is running.

OIL LEVEL

The engine oil level should be checked with the engine hot and running at idle speed. A dipstick, Fig. 4-4, is located on the right side of the engine and should show a level between "Low" and "Full." When the engine is stopped, the oil in the filter and cooler will drain back into the oil pan. If the oil level is checked with the engine stopped, the reading on the dipstick will be above the FULL mark.



Checking Oil Level
Fig. 4-4

ADDING OIL TO SYSTEM

Oil maybe added with the engine running or I stopped. When oil is added to the system, it MUST be poured into the strainer housing through the opening having the square cap, as shown in Fig. 4-5. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury.

Adding Oil To Engine
Fig. 4-5

NOTE: The lubricating oil used in the 16-567D3 engine must have prior Electro-Motive approval. Total capacity of oil in the system is 220 gallons.

OIL PRESSURE

An engine oil pressure gauge is located below the water tank on the equipment rack, at the right bank side of the engine. Engine lubricating oil pressure should be approximately 70 psi at full engine speed and about 35 psi at idle speed. These pressures may however be somewhat lower due to changes in oil temperature and viscosity.

LOW OIL PRESSURE PROTECTION

In the event of low oil pressure, either in the engine lubricating oil system or the turbocharger oil system it will be evident at the governor low oil pressure protective device, which will act to shut down the engine. This device is built into the governor and when tripped, causes a small button, Fig. 4-6, to protrude from the front of the governor. Oil under the governor power piston then drains allowing spring pressure to move the layshaft and injector racks to the no fuel position, stopping the engine. The alarm bells will ring in all units and the low oil light will be illuminated in the unit affected. The alarms will cease when the governor button is manually reset.

Governor Low Oil Pressure Device Fig. 4-6

The governor low oil pressure device receives its oil supply and is therefore actuated from the low oil pressure shutdown assembly shown schematically in Fig. 4-3. This device is located on the turbocharger adjacent the turbocharger oil filter. As shown, it consists of a cylinder and spring loaded piston. Turbocharger oil under pressure enters the top of the cylinder and opposes any upward movement of the piston. Engine oil pressure enters at the side of the cylinder, passing around the cylinder through a channel to an oil line to the governor low oil pressure protective device. Engine oil also is conducted to the underside of the piston through a drilled passage in the piston. Thus, the engine oil

oil pressure assists the spring in opposing downward movement of the piston against turbocharger oil pressure. These pressures are normally balanced to maintain the piston in such a position as to permit passage of engine oil to the governor.

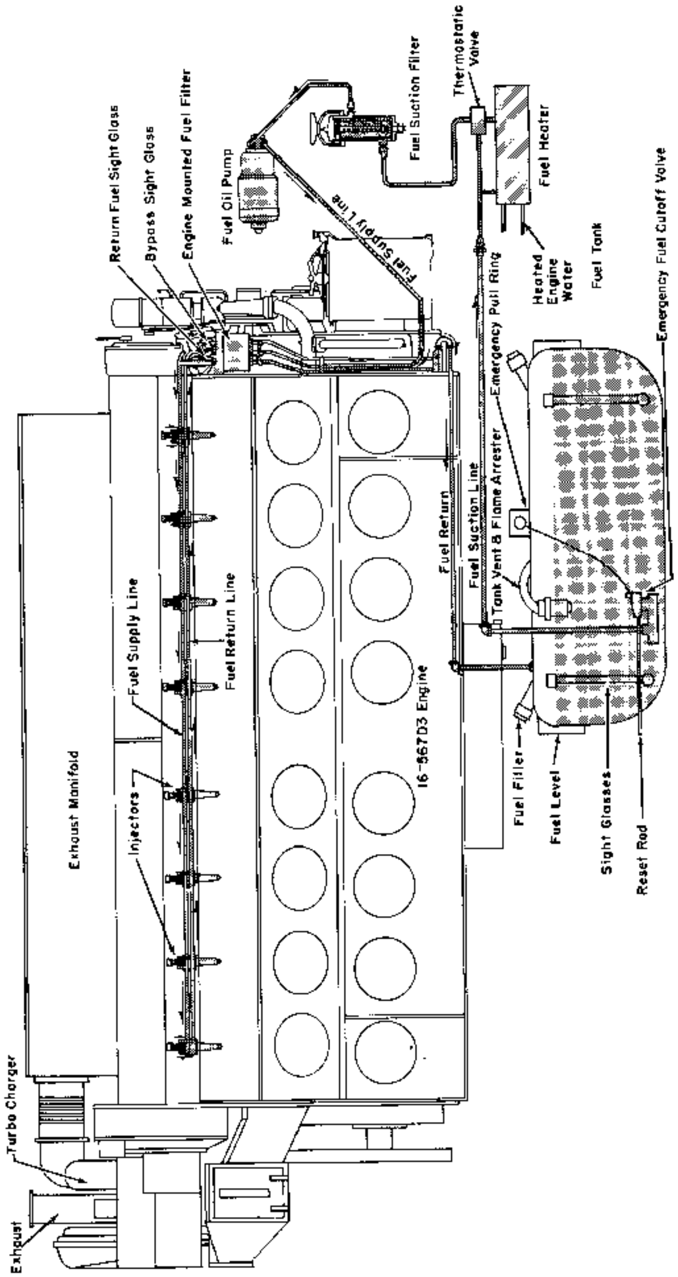
If engine oil pressure decreases, oil pressure at the governor will be lowered and the governor protective device will act to shut down the engine at a predetermined pressure. If turbocharger oil pressure is reduced beyond a safe limit, engine oil pressure, plus spring pressure will overcome the turbocharger oil pressure above the piston and force the piston upward. As the piston continues upward it will shut off the engine oil pressure and connect the oil in the governor line to a drain connection, simulating loss of engine oil pressure. Consequently, in either event of low oil pressure at the engine or turbocharger, the governor will act to shut down the engine.

FUEL OIL SYSTEM

GENERAL DESCRIPTION

A schematic diagram of the fuel oil system is shown in Fig. 4-7. Fuel is drawn from the storage tank through a suction fuel strainer by the motor driven gear type fuel pump. From the pump the fuel is forced to the filter mounted on the engine. After passing through the double element engine mounted filter, the fuel flows through manifolds that extend along both banks of the engine.

These manifolds supply fuel to the injectors. The excess fuel not used by the injectors returns to the fuel tank through the return fuel sight glass, mounted on the filter housing. A restriction inside the return glass causes a back pressure thus maintaining a positive supply of fuel for the injectors.



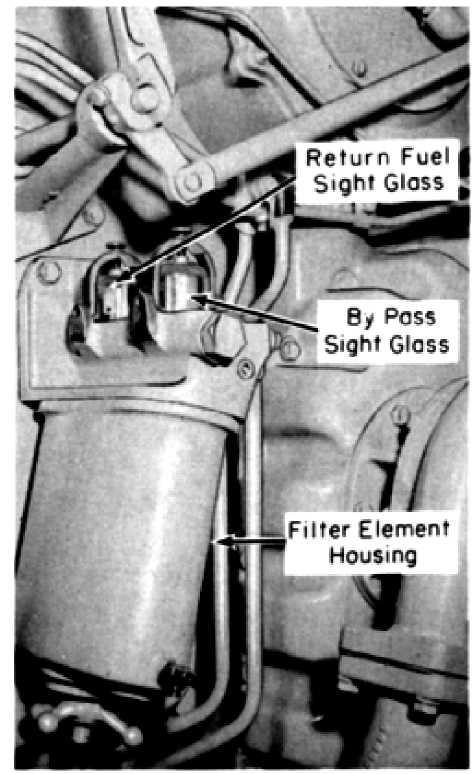
Fuel Oil System Schematic Diagram
Fig. 4-7

The fuel pump delivers more fuel to the engine than is burned in the cylinders. The excess fuel circulated is used for cooling and lubricating the fine working parts of the injectors.

FUEL SIGHT GLASSES

Two sight glasses, Fig. 4-8, are located on the engine mounted filter housing to give visual indication of fuel system condition.

For proper engine operation, a good flow of fuel (clear and free of bubbles) should be indicated in the sight glass nearest the engine called the "fuel return sight glass." The fuel flowing through this glass is the excess not required by the engine. Upon leaving the glass it returns to the fuel tank for recirculation.



Fuel Oil Sight Glasses
Fig. 4-8

The engine mounted filter is also equipped with a by-pass relief valve and sight glass. This sight glass, located furthest from the engine, is normally empty. When more than a trickle of fuel is seen in the by-pass sight glass, it indicates that the relief valve is open. Fuel will pass through the by-pass sight glass and relief valve to by-pass the engine and return to the fuel tank in case the filter elements become clogged. This condition may become serious to the extent that it may cause the engine to starve for fuel and thus shut down in operation.

FILLING FUEL TANK

The fuel tank can be filled from either side of the locomotive. A short sight level gauge is located next to each fuel filler. This fuel gauge indicates the fuel level from the top to about 4-1/2" below the top of the tank and should be observed while filling the tank to prevent overfilling. DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

EMERGENCY FUEL CUTOFF VALVE

An emergency fuel cutoff valve is provided to cut off the fuel supply to the fuel pump in the event of fire, or any emergency. It is located in a closed compartment at the lower left rear corner of the fuel tank. On each side of the locomotive, at the top rear corner of the fuel tank, is a small box with a lift cover. Enclosed in this box is a pull ring on the end of the cable running to the fuel cutoff valve. A similar ring is located in the cab of the locomotive. The fuel cutoff valve can be tripped by pulling any one of these three rings. If tripped, the valve must be reset manually.

To reset the valve, pull the "U" control rod extending from the valve compartment OUT as far as possible. See Fig. 4-9.

AIR SYSTEM

DESCRIPTION

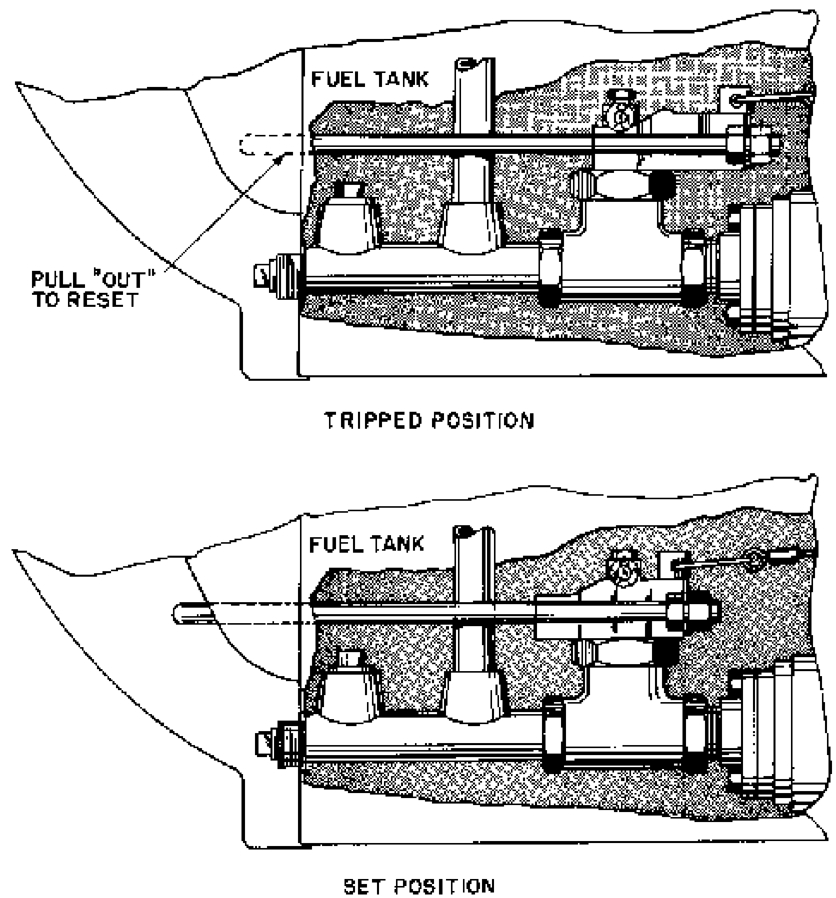
Compressed air is not only used on a diesel locomotive for operating the air brakes and sanders, but is also essential for the proper operation of many other items. The shutter operating cylinder, horn, bell and windshield wipers are also air operated. Air is also required for atomizing the fuel oil on units equipped with a steam generator.

AIR COMPRESSOR

Compressed air is received from a water cooled, 6 cylinder, two stage air compressor. The compressor is driven through a flexible coupling from the front end of the engine crankshaft.

The compressor has its own oil pump and pressure lubricating system. With the engine running, the level in the compressor crankcase can be checked on the float type indicator. At idle speed (275 RPM) and the compressor crankcase oil hot, the lubricating oil pressure should be approximately 15 to 20 pounds (no gauge provided).

The compressor has four low pressure and two high pressure cylinders. The pistons of all six cylinders are driven by a common c



Emergency Fuel Cutoff Valve
Fig. 4-9

crankshaft. The four low pressure cylinders are set at an angle to the two vertical high pressure cylinders. Air from the low pressure cylinders goes to a water cooled intercooler to be cooled before entering the high pressure cylinders. The intercooler is provided with a pressure gauge and relief valve. The gauge normally reads approximately 50 to 55 pounds when the compressor is loaded. The intercooler relief valve is set for 65 pounds. Any marked deviation of intercooler pressure from 50 to 55 pounds should be reported at the maintenance terminal.

It is important to drain the compressor intercooler (two drain valves are provided in the bottom header) and the main reservoirs to prevent moisture and dirt from being carried into the air brake and other air systems.

COMPRESSOR CONTROL

Since the air compressor is directly connected to the engine, the compressor is in continuous operation (although not always pumping air) whenever the engine is running. An unloader piston is provided in the head of each high and low pressure cylinder which cuts out the compressing action when actuated by air pressure from the compressor governor control. The unloader accomplishes this by blocking open the intake valve of the high and low pressure cylinders. When the air operating the unloader is cut off, the unloader releases the intake valves and the compressor resumes pumping. Main reservoir air pressure is used to actuate the unloader valves.

Two methods of compressor governor control are used: (1) Pneumatic governor control (basic for single units), and (2) Electro-pneumatic governor control (usually used on units equipped for multiple unit operation).

1. Pneumatic Control

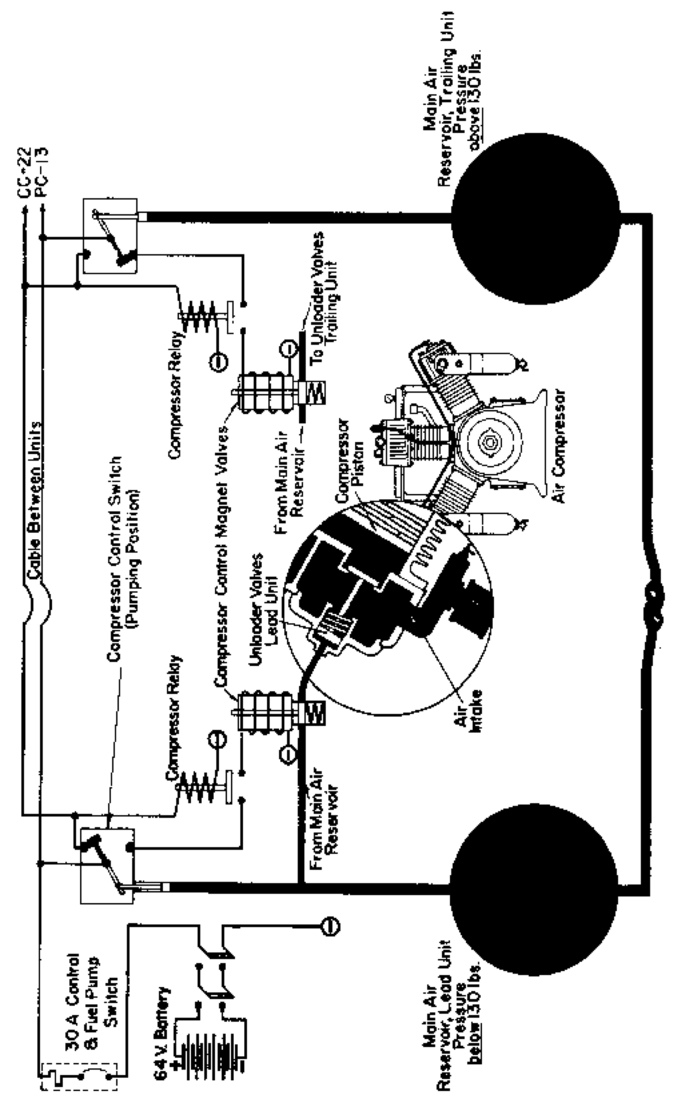
On locomotives with the pneumatic governor control system, each air compressor operates

as an individual component without regard to the main reservoir demands of other units in the consist. When the main reservoir air pressure reaches 140 pounds, the governor "cuts out" the air compressor by admitting air to the unloader valves. Admitting air to the unloader valves will hold the intake valves open stopping the compressing action. The compressor remains unloaded until the main reservoir pressure falls to 130 pounds. The governor then "cuts in" the air compressor by stopping the air supply to the unloader valves, releasing the intake valves and the compressor resumes pumping.

2. Electro-Pneumatic Control

If all the units of a locomotive consist are equipped with the electro-pneumatic system of compressor governor control, Fig. 4-10, the electrical arrangement is such that all compressors in the locomotive are synchronized to pump air into their respective main reservoirs when the main reservoir pressure in any one unit drops to 130 pounds. When the air pressure in all reservoirs reaches 140 pounds, the compressors will unload.

Each unit is equipped with a compressor control switch (CCS) actuated by main reservoir pressure, a compressor control magnet valve and a compressor relay (CR). A compressor control wire (CC) runs throughout the locomotive and connects the compressor relays in each unit in parallel. This electro-pneumatic governor control is located on the equipment rack. The compressor control switch may be considered to be a single-pole double-throw switch that is thrown to the "loaded" position when the main reservoir pressure drops to 130 pounds, or to the "unloaded" position when the main reservoir pressure reaches 140 pounds. In the unloaded position the CCS causes the compressor control magnet valve to be energized, allowing air to pass through the valve to the compressor unloader pistons stopping the compressing action. In the unloaded position the CCS breaks the circuit to compressor control magnet valve in that unit and



Electro-Pneumatic Compressor Control
Fig. 4-10

causes current to flow through the CC wire energizing the CR relays in each unit. When the CR relay is energized its interlock breaks the circuit to the compressor control magnet valve regardless of the position of the CCS in that unit. Breaking the circuit to the compressor control magnet valve shuts off the supply of air to the compressor unloader pistons, and the compressor resumes pumping.

Manual Unloader Valve

On pneumatic governor installations, a three-way valve is provided in case it is desired to keep an air compressor unloaded. A raised "T" pattern on the face of the valve indicates the flow of air through the valve. The valve is normally positioned so as to direct the air supply to the unloader valves through the compressor governor control. To manually unload the air compressor, turn valve to by-pass main reservoir air supply to the unloader valves around the compressor governor control.

On electro-pneumatic governor control systems, a means is also provided for keeping an air compressor unloaded. In this case, the method used is to mechanically hold the button depressed and air valve open on the compressor control magnet valve. The mechanical arrangement is mounted above the magnet valve and can be readily positioned by turning the knob provided.

Draining Of Air System

The air system should be drained periodically to prevent moisture from being carried into the air brake and other air systems. The frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at the time of each crew change, until a definite schedule can be determined by the individual railroad.

SECTION 5

ELECTRICAL EQUIPMENT

INTRODUCTION

The diesel engine drives three electrical generators each of which then supplies electrical energy required for locomotive operation. Basically, the main generator furnishes power to the motors for locomotive traction; the alternator supplies power to drive auxiliaries such as fans and blowers; the auxiliary generator supplies low voltage electricity for the control circuits.

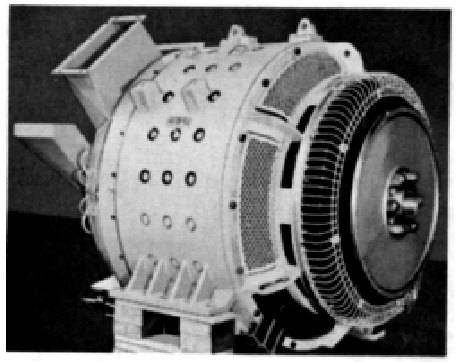
In order to control these generators as well as the circuits and equipment to which they supply power, it is necessary to use electrical devices called relays, contactors, switches, circuit breakers and regulators. As a group, such equipment is referred to as electrical switchgear. This switchgear is housed in two electrical cabinets. The first forms the rear portion of the cab and the second is located at the long hood end of the unit.

This section of the manual describes the function of the generators and switchgear components. The information is presented only for a better understanding of locomotive operation. This equipment all functions automatically, without any attention required on the part of the engineman. Electrical cabinet doors should always remain closed during operation.

MAIN GENERATOR

The main generator, Fig. 5-1, is a specially designed constant kilowatt (power) generator. A given amount of electrical power will be produced from the input of a given amount of mechanical power. Since power in watts is the product of volts times amperes, it can be seen that with a constant kilowatt generator, if the volts increase the amperage decreases, and vice versa.

The output voltage of the main generator is controlled by the extent to which the main generator is automatically excited, and by the speed of the engine. The high voltage direct current electricity from the main generator is rated at a nominal 600 volts.



Main Generator And Alternator Fig. 5-1

Built into the generator are the following field windings.

1. Starting - This field is used only for starting the diesel engine. When energized with low voltage battery current it temporarily makes a motor out of the generator to crank and start the diesel engine.

2. Battery - The battery field is separately excited by low voltage current from the auxiliary generator. It is energized by closing of the battery field (BF) contactor to provide initial generator excitation. This field has the load regulator and a protective fuse in its external circuit. Variations in this field excitation controls the electrical output of the generator.

3. Shunt - The shunt field is self-excited by the main generator through an external circuit controlled by the shunt field (SF) contactor. This field assists the battery field in building up generator output.

4. Differential - The differential field is used to obtain the constant kilowatt characteristics desired in the main generator. It does so by opposing the battery and shunt fields and functions to reduce generator excitation at high generator amperages.

5. Commutating - This field is wound on the generator interpoles to provide proper commutation.

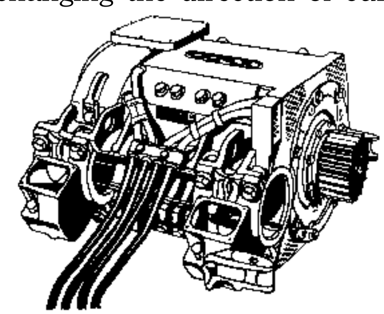
6. Compensating - The compensating field is composed of a group of windings embedded in the face of the main poles. The purpose of this field is to minimize distortion of the field flux set up by the armature current and to provide better commutation.

The differential, compensating and commutating fields are permanently connected and are a matter of engineering design providing desired generator characteristics and proper commutation.

TRACTION MOTORS

Electrical power from the main generator is distributed to the six traction motors, Fig. 5-2, which are mounted in the trucks. Each motor is geared to a pair of wheels, thus all wheels are drivers. Electro-magnetic power contactors connect the main generator to the motors in circuits for proper operation. These circuits will change automatically to permit full power utilization over the complete range of locomotive operation. These power circuit changes are called transition.

The locomotive is reversed by changing the direction of current flow through the traction motor field windings, while current flow direction through the armature remains the same. This is accomplished by the electro-magnetic reversing contactors establishing the circuits necessary for operation in either direction.



Traction Motor Fig. 5-2

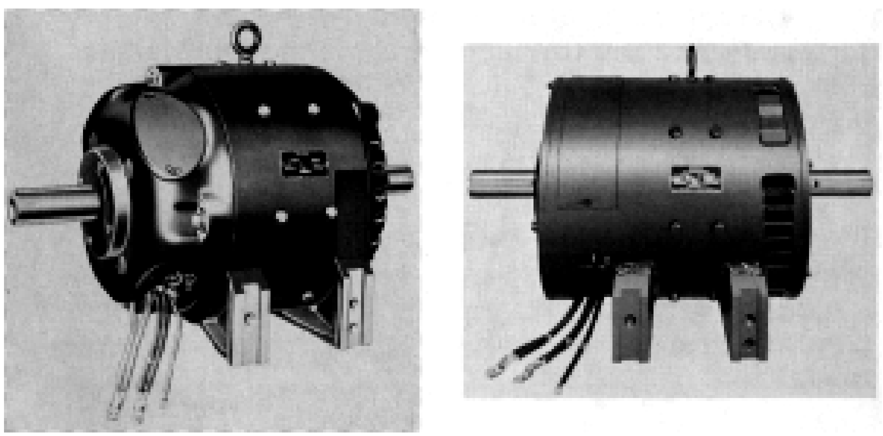
The traction motors are series wound to provide the high starting torque characteristics desired for locomotives. They are designed for heavy duty operation and are force air ventilated by means of external blowers located in the locomotive unit.

ALTERNATOR

The alternator, Fig. 5-1, is a part of the main generator assembly, having its stator bolted to the generator frame and 'rotor connected to the armature. Alternator output voltage and frequency vary with the speed of rotation. At full engine speed of 835 RPM, alternator output is 170 volts AC at 111-1/3 cycles per second.

The rotor field of the alternator is excited by low voltage current which it receives from the auxiliary generator through a pair of slip rings and brushes. The alternator itself provides additional excitation under certain circumstances which are explained in the section covering electrical circuits.

With the exception of a 40 ampere protective fuse and an external field adjusting resistor, there are no contacts or other controls in the circuit, thus the alternator will be excited and developing power whenever the diesel engine is running.



Auxiliary Generator 10 KW And 18 KW
Fig. 5-3

AUXILIARY GENERATOR

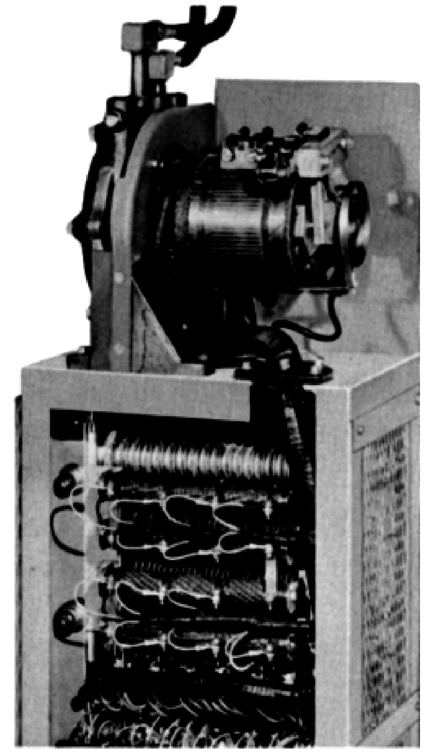
All low voltage direct current electricity required during locomotive operation comes from the auxiliary generator, Fig. 5-3. Such power is used for excitation of the main generator and alternator as well as for energizing control circuits and actuating electrical switchgear components.

The auxiliary generator is a self-excited machine using residual magnetism for initial excitation. To hold voltage output at a constant 74 volts, a voltage regulator is used in the field excitation circuit. This device varies excitation current as necessary to compensate for changes in generator rotating speeds.

LOAD REGULATOR

Essentially the load regulator, Fig. 5-4, is an automatically operated rheostat connected in series with the battery field of the main generator.

The load regulator is a self-contained unit which consists of a hydraulic vane type motor connected to a commutator type rheostat. Engine oil pressure is used to force the vane motor (and rheostat brush arm) to vary its position. Oil pressure is impressed on either side of the vane, as directed by the load regulator pilot valve, which is located in the engine governor.



Load Regulator
Fig. 5-4

For the purpose of load regulation, engine horsepower is determined by the rate of fuel consumption; this merely means that more horsepower is developed when more fuel is used, and vice versa. There is a definite rate of fuel consumption for each throttle position when the engine is loaded. The rate of fuel consumption is related to the position of the governor power piston, which controls the movement of the injector racks. If the load on the engine should be such that more fuel is demanded (to rotate the engine at the RPM "ordered" by the throttle) than the predetermined balance point (between load and fuel consumption), the load regulator pilot valve will cause the load regulator to reduce the engine load the required amount by reducing the battery field strength.

If the engine requires less fuel than the predetermined setting, the load regulator increases the load on the engine by increasing the battery field excitation of the main generator. In this manner, battery voltage, temperature changes in the generator windings, or locomotive speeds do not cause overloading or underloading of the engine and a constant power output is maintained for each throttle setting.

Located in the governor is an overriding solenoid, ORB, which can override the normal action of the load regulator pilot valve. When the ORS is energized it forces the load regulator pilot valve to cause engine oil pressure to move the load regulator toward the minimum field position, unloading the engine. The ORS is energized during transition and wheel slip action.

ELECTRICAL CABINET NO. 1

Forming the rear wall of the locomotive cab is the No. 1 electrical cabinet which houses the majority of the locomotive electrical switchgear. This equipment is located on both the cab and engineroom sides of the cabinet. Although access doors are provided, they should be kept closed at all times during operation.

A. CAB SIDE EQUIPMENT - Fig. 5-5

The cab side of this cabinet is shown in Fig. 5-5. The functions of the various pieces of equipment are as follows:

1. DISTRIBUTION PANEL

   The fuses, switches and other equipment mounted on the distribution panel are fully described in Section 2 of this manual covering cab controls.

2. SERIES-PARALLEL RELAY, SPR

   Energized during transition, this relay changes the traction motor connections from series to series-parallel. If it is de-energized, the reverse takes place.

3. PARALLEL RELAY, PR

   Performs the same type of function as SPR except it does the work of changing traction motor circuits from series-parallel to parallel. When de-energized, it returns the circuits from parallel to series-parallel.

4. FIELD SHUNTING AUXILIARY, FSA

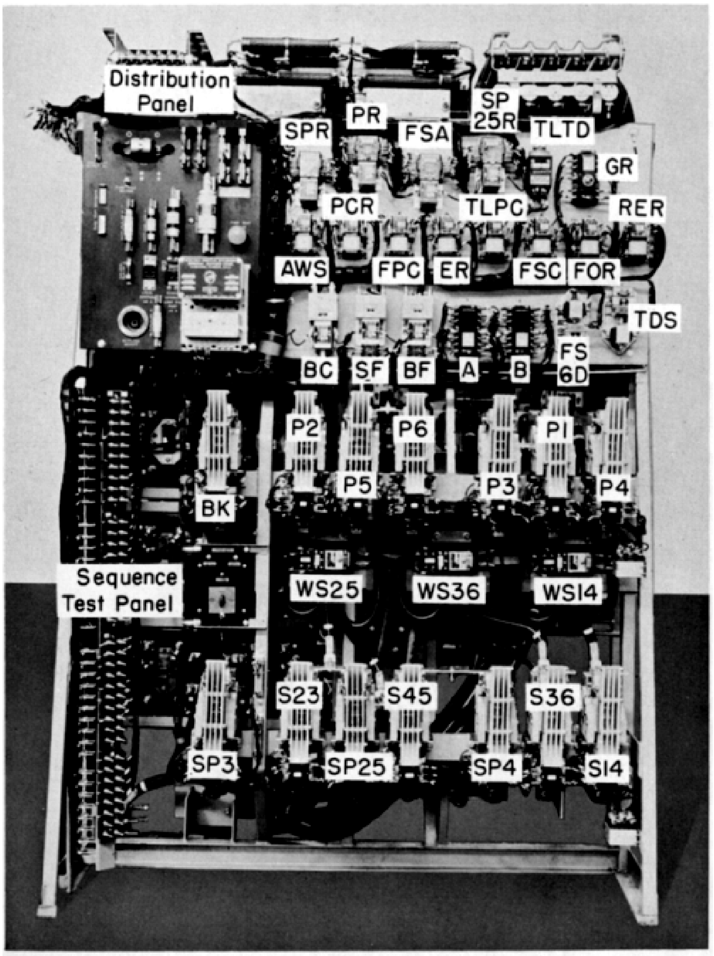
   This is an auxiliary relay used in the sequence circuits of the traction motor field shunting contactors. It will be energized during all steps of motor field shunting. Its interlocks are in the circuits to SPR and PR relay coils.

5. SERIES-PARALLEL AUXILIARY RELAY, SP25R

   Whenever SP25 power contactor is energized, one of its interlocks brings in the SP25R relay, which serves as an auxiliary to the power contactor. The SP25R relay interlocks increase the effective number of SP25 interlocks.

6. TURBINE LUBE TIME DELAY, TLTD

The TLTD relay is energized through the NVR whenever the diesel engine is stopped. Its contacts control operation of the turbine lube pump contactor, TLPC, which in turn controls the



No. 1 Electrical Cabinet - Cab Side
Fig. 5-5

turbocharger soak down lube oil pump. The motor driven pump is timed by the TLTD to run for about 15 minutes after engine shutdown.

7. GROUND RELAY, GR

The ground relay is a protective device and functions to detect high voltage grounds during operation or low voltage grounds when the diesel engine is started. When tripped, alarms will function and the engine in the unit concerned will go to idle speed (ER relay opens) and will not develop power (SF and BF contactors open). It is reset by a push button on the engine control panel.

8. AUXILIARY WHEEL SLIP, AWS

The auxiliary wheel slip is a relay used in conjunction with wheel slip relays to increase the number and size of contacts available for generator unloading in power as well as during dynamic braking.

9. PNEUMATIC CONTROL RELAY, PCR

If the pneumatic control switch, PCS, trips due to a penalty application of the air brakes, it drops out the PCR which in turn opens the ER circuit which is trainlined throughout the locomotive. All ER relays are then de-energized and all engines are reduced to IDLE speed and power. The PCR resets when the air brakes are recovered and throttle is placed in IDLE.

10. FUEL PUMP CONTACTOR, FPC

The FPC in each unit is energized by closing of the control and fuel pump switch on the controller of the lead unit. This partially establishes a circuit to the individual fuel pump motors. These circuits are completed and the individual pumps will run when the fuel pump circuit breaker in each unit is closed.

11. ENGINE RUN RELAY, ER

The ER relay has contacts in the circuits between the throttle and the engine speed control solenoids in the governor. In normal operation, the ER relay is energized, its contacts are closed permitting engine speed to respond to throttle position. During certain electrical difficulties however, such as ground relay action, the ER relay is de-energized, opening the circuit causing engine speed to be reduced to idle.

12. TURBINE LUBE PUMP CONTACTOR, TLPC

When ever the diesel engine stops, this contactor is energized to supply power for operation of the turbocharger soak down lube oil pump. After 15 minutes, the pump will stop due to TLPC contactor being de-energized through action of time delay relay TLTD.

13. FIELD SHUNT CONTACTOR, FSC

This is an auxiliary contactor used in the sequencing backward transition circuits from series-parallel to series, shunt 3.

14. FORWARD RELAY, FOR

The forward relay, FOR, is energized when the reverse lever is placed in the Forward position. Its contacts complete circuits so that the electro-magnetic forward reversing contactors, RVF1, RVF2, and RVF3 are energized. These contactors in each unit receive local control power from their respective auxiliary generators, yet their operation is trainlined through their control relay.

15. REVERSE RELAY, RER

As above, but energized for reverse locomotive operation.

16. BATTERY CHARGING CONTACTOR, BC

The battery charging contactor connects the auxiliary generator to the storage battery and locomotive low voltage system. It opens to prevent reversal of current flow from motorizing the generator in instances where the engine (and generator) are stopped. The BC contactor is controlled by the reverse current relay (RCR) which functions in response to generator voltage.

17. SHUNT FIELD CONTACTOR, SF

This contactor closes during operation whenever the throttle is opened with the generator field switch ON. It completes a circuit allowing for the self-excitation of the main generator.

18. BATTERY FIELD CONTACTOR, BF

Controlled by interlocks of the preceding SF contactor, the BF contactor provides primary excitation of the main generator from the locomotive low voltage system. This contactor is closed during operation but opens during transition or wheel slip action to reduce main generator output.

19. CLOSING RELAYS, A AND B

These relays are used in conjunction with FTR and BTR to sequence forward and backward transitions. For example, when FTR is energized it will pick up either the A or B relay to initiate a forward transition step. Similarly, when the BTR is de-energized it will pick up either the A or B relay to initiate a backward transition step.

20. FIELD SHUNT TIME DELAY, FS6D

The field time delay relay energizes the ORS in the governor 2 to 3 seconds prior to closing FS6A and FS6B for the sixth step of traction motor field shunting. This action provides for a smoother transition shunting step.

21. TIME DELAY SANDING RELAY, TDS

With the automatic sanding switch ON, during wheel creep or slip action, the TDS is energized causing a timed amount of sand to be applied.

22. BRAKE MOTOR FIELD CONTACTOR, BK

This relay is used during dynamic braking to complete the circuit of all traction motor fields in series to the main generator armature. When going from dynamic braking to power, the BK contactor opens first since it is equipped for arc discharge.

23. PARALLEL POWER CONTACTORS, P2, P5, P6, P3, Pl AND P4

These electro-magnetic contactors are energized and closed during transition to connect all of the traction motors in a full parallel circuit with the main generator. Further information may be found in Section 6 covering electrical circuits.

24. WHEEL SLIP RELAYS, WS25, WS36 AND WS14

The wheel slip relays are connected in the electrical circuits to detect differences in current flow between pairs of traction motors. Such differences indicate wheel slippage. When energized, the relays establish circuits to initiate automatic sanding, partial unloading, or if necessary, full unloading of the power plant.

25. SEQUENCE TEST PANEL

The sequence test panel is to be used only by shop personnel in making transition sequence checks. For normal automatic operation it

ELECTRICAL EQUIPMENT

should be turned to and left in the NORMAL position.

26. SERIES-PARALLEL CONTACTORS, SP3, SP25 AND SP4

These electro-magnetic contactors close during transition to connect the traction motors to the main generator in a series-parallel circuit. Further information may be found in Section 6 covering electrical circuits.

27. SERIES POWER CONTACTORS, S23, S45, S36 AND S14

These electro-magnetic power contactors close to establish a series type circuit between the traction motors and main generator. They will open automatically during transition. Further information may be found in Section 6 covering electrical circuits.

B. ENGINEROOM SIDE EQUIPMENT - Fig. 5-6

On the opposite or engineroom side of the No. 1 electrical cabinet are additional electrical devices that are identified and described below.

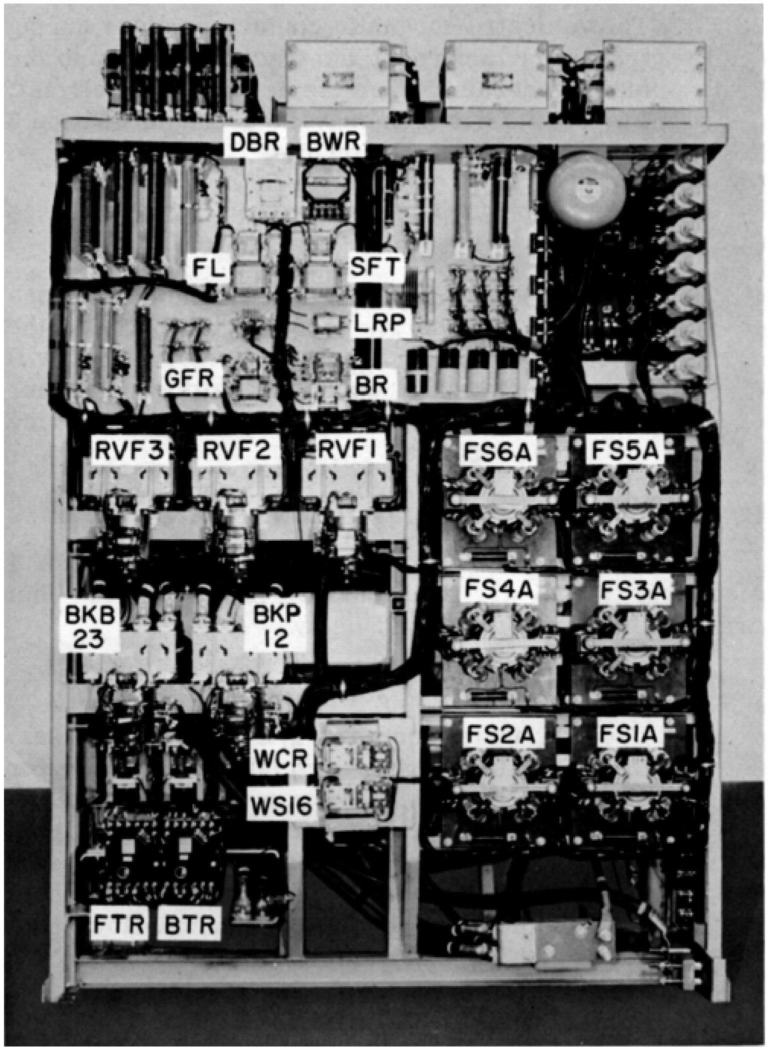
1. DYNAMIC BRAKE REGULATOR, DBR

Used on units equipped with dynamic brakes, the DBR functions to regulate main generator excitation so that the maximum braking effort of 700 amperes is not exceeded. Automatic in operation, it prevents overloads by causing current to flow through the generator shunt field windings in reverse to normal flow, thus bucking the battery field excitation.

2. BRAKE WARNING RELAY, BWR

Used on units equipped for dynamic braking, the BWR is energized in the event that the maximum braking effort of 700 amperes is exceeded.

It functions only to light the warning light on the cab controller and thus alert the engineman to the overloaded condition. The light goes out when braking current is reduced to a safe level.



No. 1 Electrical Cabinet - Engineroom Side
Fig. 5-6

ELECTRICAL EQUIPMENT

3. FIELD LOOP CONTACTOR, FL

Used on units equipped with dynamic brakes, the field loop contactor establishes a circuit placing the battery fields of all main generators in series. Generator excitation and dynamic braking strength is then controlled by regulating the strength of current flowing in the circuit. The FL contactor is energized only in the lead or controlling locomotive unit.

4. SHUNT FIELD TRANSFER RELAY, SFT Used only on units equipped with dynamic brakes, the SFT functions during such operation to connect the dynamic brake regulator into the main generator shunt field circuit. It also provides for a reverse direction of current flow through this field during regulation on the part of the DBR.

5. LOAD REGULATOR POSITIONER, LRP

The LRP is a micropositioner device used during dynamic braking. It functions to set up a balance between the load regulator and the dynamic brake rheostat in the controller. The purpose is to control the load regulator and thus control dynamic brake field loop strength.

6. GENERATOR FIELD RELAY, GFR

An auxiliary relay energized when the throttle is opened for power. One function of the relay is to prevent traction motor field shunting contactors from closing unless locomotive is in power, while a second function is to hold the "C" solenoid energized in the governor when a safety function de-energized the ER relay in power.

7. BRAKE RELAY, BR

When changing from power to dynamic braking, interlocks of BR relay are utilized in energizing and de-energizing various relays to give the proper dynamic braking circuits.

8. REVERSER SWITCHGEAR - FORWARD, RVF1, RVF2, RVF3

Electro-magnetic contactors are used to control the direction of current flow through the traction motors and thus control their direction of rotation. The forward reversing contactors are energized when the reverse lever is placed in the forward position. They are energized by local control power by action of the forward relay, FOR.

9. MOTOR FIELD SHUNTING CONTACTORS, FS1A, FS2A, FS3A, FS4A, FS5A AND FS6A

These contactors provide for the transition shunting steps on the traction motors (1, 2 and 3) in the front or No. 1 truck of the locomotive. They come in during all three major steps of transition, as follows:

During major transition of series, FS1A through FS5A are used.

During major transition of series-parallel, FSlA through FS6A are used.

During major transition of parallel, FS1A and FS2A are used.

10. POWER BRAKE SWITCHGEAR, BKB23 AND BKP12

These are large contactors used to make high voltage connections in circuits of main generator, traction motors, and dynamic brake grids as required during power operation and dynamic braking. BKP12 is energized in power, while BKB23 is-energized in dynamic braking.

11. WHEEL CREEP AND SLIP RELAYS, WCR, WS16

The wheel creep relay WCR is almost the same as the wheel slip relay WS except for sensitivity of setting. It detects minute electrical unbalance between motors, and initiates automatic sanding before an actual wheel slip occurs. The wheel slip relay functions to provide for gradual unloading of the power plant in the event of a true wheel slip.

12. FORWARD TRANSITION RELAY, FTR

The connections of the FTR are such that it is sensitive to main generator amperage and voltage. When the volts and amperes are at the proper relationship, FTR relay is energized causing the control circuit to make a forward transition change. After a forward transition change takes place, the FTR relay is de-energized and made ready for another forward change.

13. BACKWARD TRANSITION RELAY, BTR

This relay is very similar to the forward transition relay. When the BTR relay is de-energized the control circuits will make one step of backward transition.

ELECTRICAL CABINET NO. 2

The No. 2 electrical cabinet is located in the engineroom at the long hood end of the locomotive. It houses additional electrical equipment, primarily concerned with power circuits to the motors in the No. 2 truck of the locomotive.

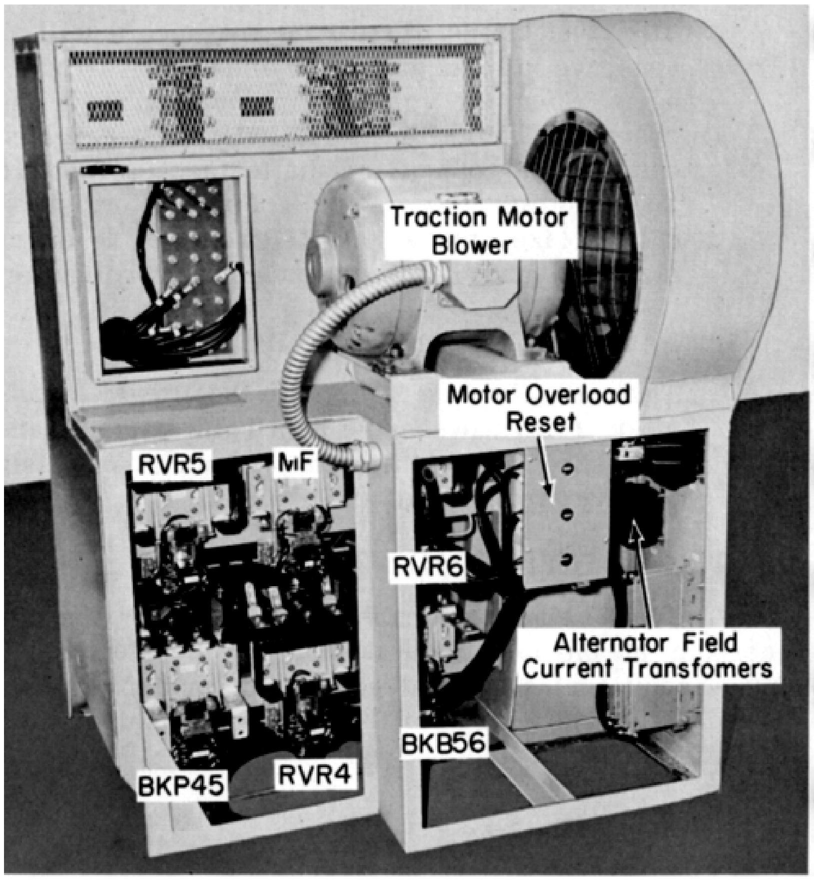
A. RIGHT SIDE - Fig. 5-7

1. TRACTION MOTOR BLOWER

A 25 HP alternating current motor drives the blower to supply cooling air to the three traction motors in the No. 2 truck of the locomotive. The motor operates automatically whenever the diesel engine (and alternator) are running.

2. REVERSER SWITCHGEAR - REVERSE, RVR4, RVR5, RVR6

The electro-magnetic reversing contactors are actuated by the reverse relay, RER in response to reverse lever position in the cab. The contactors are energized by local control power



No. 2 Electrical Cabinet - Right Side
Fig. 5-7

from the low voltage system in each unit. They control the direction of current flow through the motors for reverse rotation.

3. MOTOR OVERLOAD RESET

Where provided, reset buttons are used to reestablish operating circuits for the individual cooling fans in the event that they tripped due to overloads.

4. BRAKE MOTOR FIELD CONTACTOR, MF

The motor field contactor is used during dynamic braking. It is in the series circuit of the traction motor fields and main generator armature.

5. POWER BRAKE SWITCHGEAR, BKP45, BKB56

These are large contactors used to make high voltage connections in the circuits of main generator, traction motor and dynamic brake grids as required during power operation and dynamic braking. BKP45 is energized in power while BKB56 is energized during dynamic braking.

6. ALTERNATOR FIELD CURRENT TRANSFORMERS

Three transformers are connected in the AC output circuit of the alternator and provide additional alternator excitation during instances of overload.

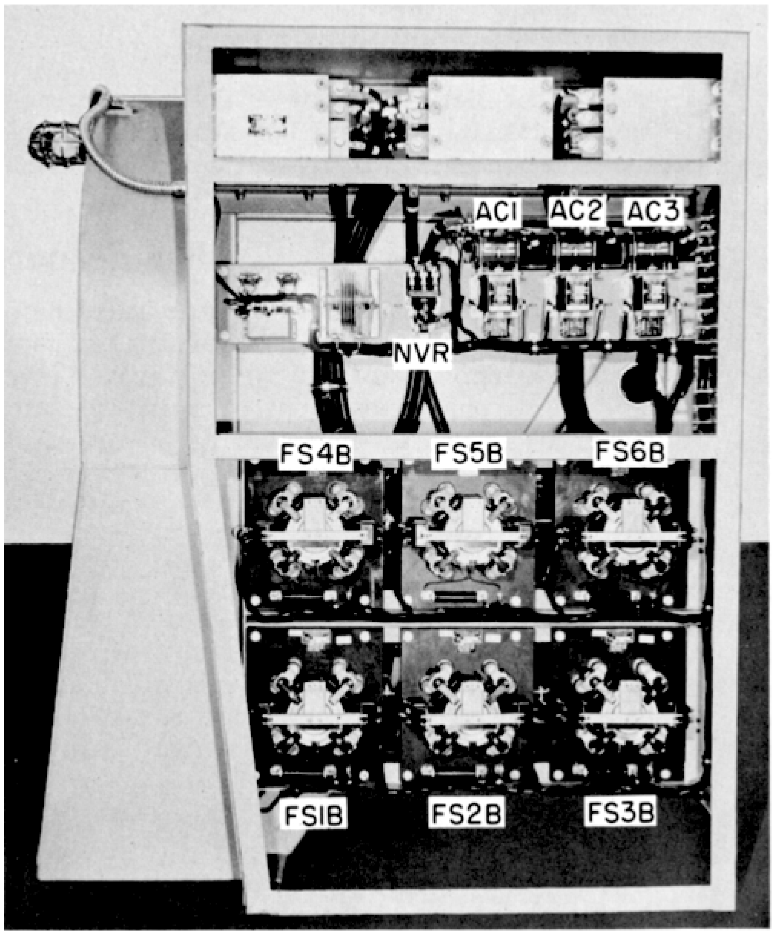
B. LEFT SIDE - Fig. 5-8

1. NO VOLTAGE RELAY, NVR

The NVR is energized by AC current during operation. In the event that the alternator fails or AC power is otherwise lost, the NVR drops out to set off the alarms and initiate protective action. It causes the engine speed and power of the unit affected to go to IDLE conditions thus preventing power from being applied without the benefit of the traction motor blower or engine cooling fans operating.

2. COOLING FAN CONTACTORS, AC1, AC2, AC3

Actuated by low voltage control circuits from their respective temperature control switches, the AC contactors function to



No. 2 Electrical Cabinet - Left Side
Fig. 5-8

bring in the cooling fans by connecting them to the alternator during operation.

3. MOTOR FIELD SHUNTING CONTACTORS, FS4B, FS5B, FS6B, FSlB, FS2B AND FS3B

During transition, these contactors connect the field shunting resistors in parallel with fields of the traction motors (4, 5 and 6) in the No. 2 or rear truck of the locomotive. They come in during all three major steps of transition, as follows:

During major transition of series, FSlB through FS5B are used.

During major transition of series-parallel, FS1B through FS6B are used.

During major transition of parallel, FS1B and FS2B are used.

SECTION 6

ELECTRICAL SYSTEMS

INTRODUCTION

Electrically, the locomotive can be thought of as being divided into the following three separate systems:

1. High voltage direct current system (includes dynamic braking system - if used). Nominally 600 volts.

2. Low voltage direct current system. Regulated to 74 volts.

3. Alternating current system. Maximum 170 volts.

The high voltage system is directly concerned with moving the locomotive; or in retarding the locomotive with dynamic brakes. The main components of the high voltage system are the main generator, traction motors, transition relays, shunt field contactor, motor shunting contactors, reverser contactors, wheel slip relays, ground relay, power contactors, braking contactors, braking resistor grids and grid blower motors.

The low voltage system contains the circuits which control the flow of power in the high voltage system, and those auxiliary circuits conducting power to the locomotive lights, heater fans, fuel pump, and the main generator battery field. A 64-volt battery, in the low voltage system, is the source from which power is taken to start the diesel engine. Once the engine is started, the auxiliary generator takes over to supply 74 volts for operation of all low voltage circuits and equipment.

The alternator supplies AC power for operation of the three motor driven cooling fans and the electrically operated traction motor blower. Use of AC induction motors for direct drive of these important auxiliaries provides for efficient, trouble free operation.

Functions of the individual electrical devices that operate in these electrical systems are discussed elsewhere in this manual. This particular section is devoted to electrical circuits and their functions during locomotive operation.

TRACING SCHEMATIC WIRING DIAGRAMS

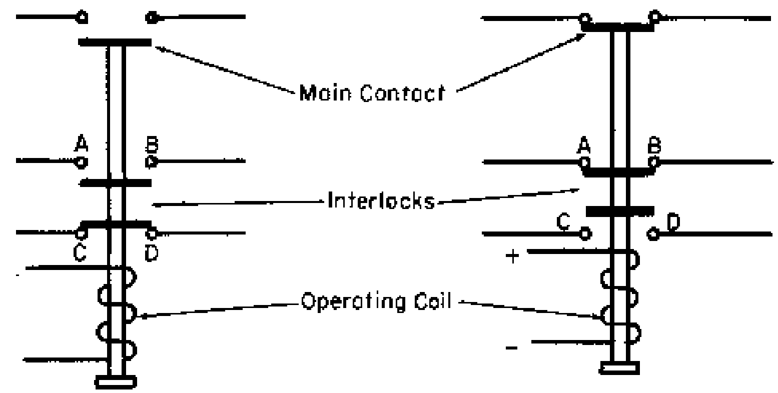
An understanding of how to trace a schematic wiring diagram would be helpful to anyone desiring a greater knowledge of the electrical operation of the locomotive. It would also be valuable for purposes of trouble shooting when electrical difficulties arise. The circuits that will be traced are those that are basic to the operation of the locomotive. They include the turbine lube oil pump, fuel pump, engine starting, reversing, control and excitation circuits. Before tracing these circuits, certain electrical fundamentals should be understood which are as follows:

1. A complete circuit or path must exist before electricity will flow and perform a desired function. Thus, starting from a source of electricity such as a battery or generator, current will flow through wires, switches and contacts providing that the path is uninterrupted back to the original source. The flow of electricity will be traced starting at the positive (+) side of a source and ending at the negative (-) side.

2. A contactor or relay will function when its associated operating coil is energized. Current flowing through such coils creates the magnetic force necessary to actuate the contacts. The contacts, which are a part of the contactor or relay, will then open or close as the case may be, to make or break other electrical circuits.

3. Almost all contactors and relays are equipped with interlocks. These interlocks, Fig. 6-1, are actuated similar to the main contacts by means of energizing or de-energizing the operating coil and they function to make or break low voltage control circuits to achieve desired results.

These interlocks will be in their normal position, either open or closed, when the operating coil is not energized. When the coil is energized, they change position; thus the normally closed



No Power To Coil
Main contact normally open
Interlock AB normally open
Interlock CD normally closed

Power Applied To Coil
Main contact now closed
Normally open AB interlock now closed
Normally closed CD interlock now open

Shown schematically on a wiring diagram, the normally open (N.O.) interlock is either below a horizontal line or to the right of a vertical line. The normally closed (N.C.) interlock is shown above or to the left side of a line.

Contact And Interlock Operation Fig. 6-1 interlocks will open. When the coil is de-energized, the interlocks return to their previous normal position.

4. Most schematic wiring diagrams are drawn illustrating a "dead" locomotive with all switches open, controls off and electrical contactors and relays de-energized. Thus all contacts and interlocks are shown in their normal position. Such normal positions will change as the various contactors and relays are energized during the course of circuit tracing.

   Before attempting to trace circuits, it is recommended that the legend of electrical equipment located at the end of this section be studied in detail. This will prove valuable in identifying the various electrical components on the diagrams.

TURBINE LOBE PUMP CIRCUIT, Fig. 6-2

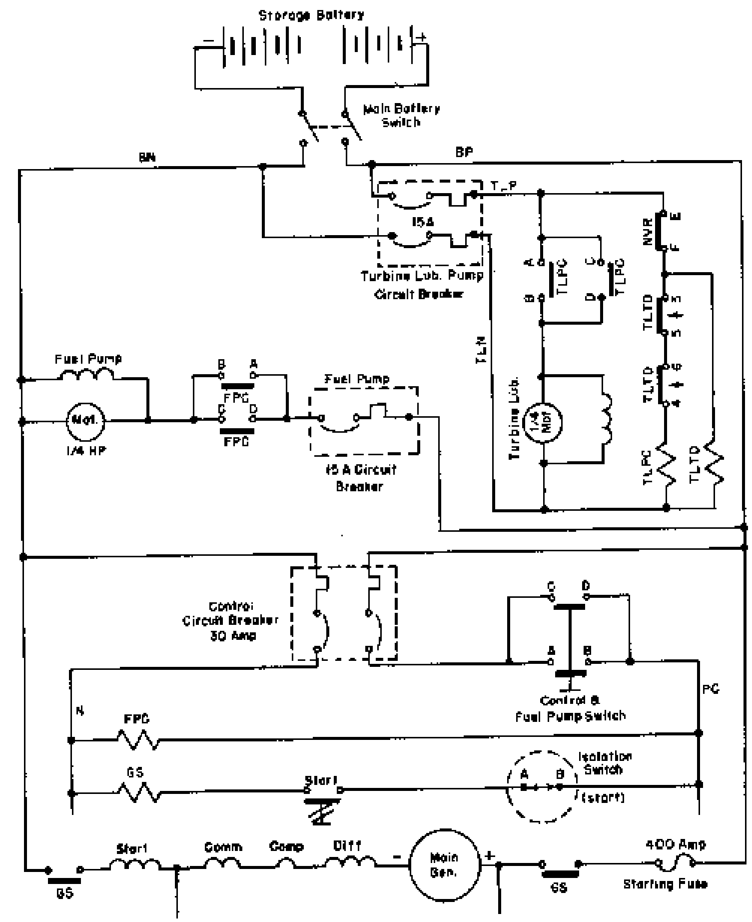
With the engine stopped, by closing the main battery switch, a motor driven pump will begin running to circulate oil to the turbocharger. It starts automatically, runs for a timed period then stops. The purpose of this arrangement is to function after an engine and turbocharger has been in operation and then stops. In such instances, the circulation of oil would then provide for a gradual cooling of the turbocharger. The circuit used to accomplish this is shown in Fig. 6-2.

With the engine stopped, the no AC voltage relay, NVR will be dropped out. In so doing, its E-F contacts close to establish simultaneous circuits to the turbine lube time delay relay, TLTD and the turbine lube pump contactor, TLPC.

As the TLPC coil is energized, its contacts A-B and C-D close in the circuit leading to the pump motor. This allows current to flow from the storage battery, through the main battery switch and 15 ampere turbine lube pump circuit breaker to operate the pump motor.

During this action, the normally closed contacts 4-6 and 5-3 of the TLTD are being timed by this relay. Approximately 15 minutes after being energized, these contacts open, breaking the circuit to TLPC which in turn opens the circuit to the motor thus stopping the pump.

NOTE: If the engine were started during the 15 minute pump operating period, the NVR, would be energized thus its E-F contact



Turbine Lube Pump, Fuel Pump And Starting Circuits
Fig. 6-2

would open the circuit to both TLTD and TLPC. This action would stop the motor driven pump. Lubrication would then be supplied the turbocharger by the engine driven pump.

CAUTION: For the above described circuit to function, the main battery switch and turbine lube oil pump circuit breaker must remain closed the prescribed period after engine shutdown.

FUEL PUMP CIRCUIT, Fig. 6-2

The fuel pump circuit must be established before starting the engine and it must remain functioning during all phases of locomotive operation. This circuit is shown in Fig. 6-2.

The first portion of this circuit is that which is trainlined from the lead or controlling unit to all units in the locomotive consist. It is established by closing the main battery switch to energize the BP wire, then by placing the 30 ampere control circuit breaker ON, and the control and fuel pump switch ON, the circuit is completed to the PC wire. The PC wire is trainlined and serves to energize the fuel pump contactor FPC in each unit. The circuit is completed back to the lead unit storage battery by means of the N wire.

In each unit, the A-B and C-D contacts of the FPC will be closed to partially establish a circuit to the fuel pump motor. The circuit is completed and the motor will run when the main battery switch is closed and the 15 ampere fuel pump circuit breaker is placed ON.

From the foregoing, it can be seen that individual fuel pumps can be started or stopped by means of the 15 ampere circuit breaker. Similarly, with the individual circuits established, the operation of all fuel pumps in a multiple unit locomotive could then be controlled from the control and fuel pump switch in the cab of the lead unit.

ENGINE STARTINGCIRCUIT, Fig. 6-2

Referring to Fig. 6-2, the engine is started as follows:

With current flowing through the PC wire (previously energized) a circuit leads to the isolation switch. When in the START position as shown, pressing the START push button completes the circuit to the starting contactor coil (GS).

The GS contacts will now close in the main generator circuit. This allows battery current to flow from the BP wire through the 400-ampere starting fuse; GS contact, main generator armature, generator field windings including the starting field, and through another GS contact to complete the circuit to the BN wire. The main generator now operates as a motor to crank and start the diesel engine.

LOCAL CONTROL CIRCUITS

The heavy duty reversing, power and braking contactors are electro-magnetically actuated which involve the use of trainlined as well as local control circuits.

From the controls in the cab, trainlined control circuits are established which provide the signal to actuate the switchgear in each unit. The switchgear however is actually operated by local low voltage power received from the auxiliary generator in each unit.

This arrangement is necessary since if all the electro-magnetic switchgear was both controlled and operated by trainlined circuits, the current drawn from the lead unit auxiliary generator would be excessive. Thus the lead unit simply sets up controlling circuits while the auxiliary generators in the individual units provide the power to actuate the switchgear components.

The actual functioning of the local control circuit may be found in the explanation of the reversing and control circuits which follow.

REVERSING CIRCUIT, Fig. 6-3

To control the direction of locomotive movement, electromagnetic reversing contactors are used to establish the proper circuits through the traction motors. The operation of this circuit is shown in Fig. 6-3 and is described below.

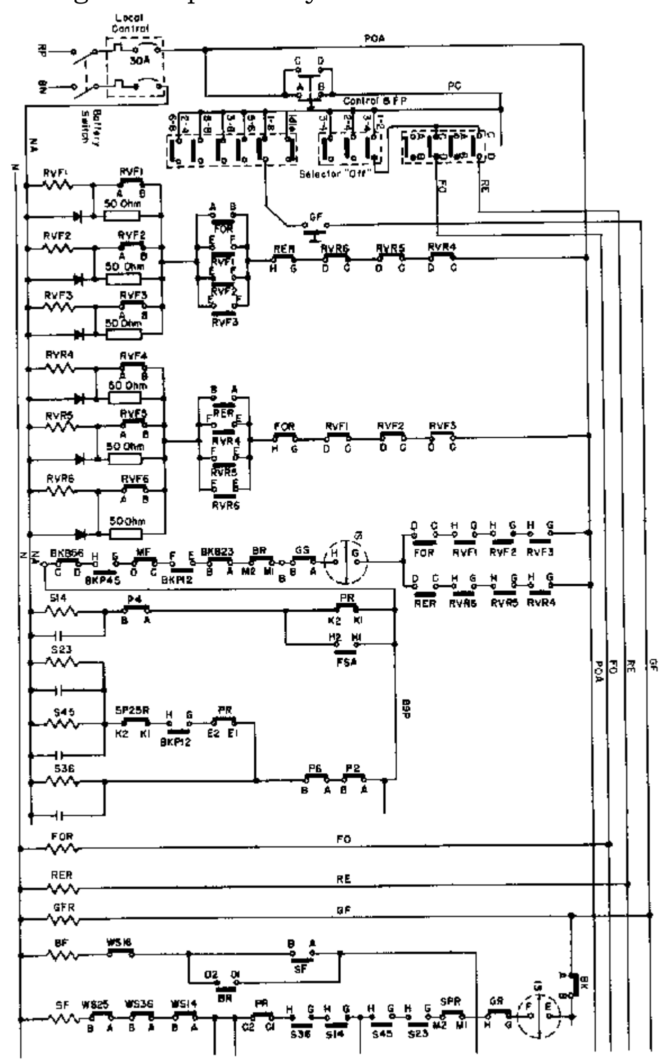
From the previously energized PC wire, a circuit leads to the selector portion of the controller. With the lever placed in No. 1 position and the reverse lever in FORWARD, the current then flows in the FO trainline wire which runs throughout the locomotive consist. From this wire, a circuit energizes the forward relay (FOR) which results in its contacts FOR A-B closing in circuit leading to the forward reversing contactors, RVF1, RVF2 and RVF3.

The local control circuit is now established coming from the auxiliary generator and RP wire, then through the 30-ampere local control circuit breaker to energize the POA wire. Coming from the local control wire, POA, is a circuit which leads through normally closed interlocks RVR4 C-D, RVR5 C-D, RVR6 C-D and RER G-H and the now closed FOR A-B, through RVF1, RVF2 and RVF3 A-B interlocks to energize the coils of the forward reversing contactors RVF1, RVF2 and RVF3. As the magnetic coils are energized, the E-F interlocks for RVF1, RVF2 and RVF3 close to establish their own holding circuits. At the same time, the A-B interlocks for RVF1, RVF2 and RVF3 open, inserting 50 ohm resistors in series with the reversing contactor coils. This reduces the current drawn from the local control circuit. The main contacts of these contactors (not shown) are now closed in the high voltage circuit to connect the traction motors for forward rotation.

Operation in reverse is similarly accomplished but in that case the RE trainline wire is energized bringing in the reverse relay RER which in turn energizes the reverse reversing contactors RVR4, RVR5 and RVR6.

CONTROL CIRCUIT, Fig. 6-3

After the reversing contactors have picked up, their interlocks together with those of other contactors complete the circuit to the series power contactors S23, S45, S14 and S36. This circuit is shown in Fig. 6-3. coming off the previously established local control circuit



Reversing, Control And Excitation Circuits
Fig. 6-3

POA.

Some of the many interlocks in the circuit are normally closed; for example, GS, BR, BKB23, MF, BKB56, PR, P4, P2, P6 and SP25R. Others shown open will also be closed due to their contactors having been energized by other circuits, some of which are not shown. This includes for example, RVF3, RVF2, RVF1, FOR, BKP12 and BKP45. Of course the isolation switch (IS) will also have to be placed in RUN position for the circuit to be complete.

When the coils are energized, the main contacts of S23, S45, S14 and S36 close in the high voltage system to establish proper circuits between the main generator and traction motors for operation.

EXCITATION CIRCUIT, Fig. 6-3

With all the previous circuits established, all that remains is to excite the main generator for power output. Referring again to Fig. 6-3, the circuit is as follows:

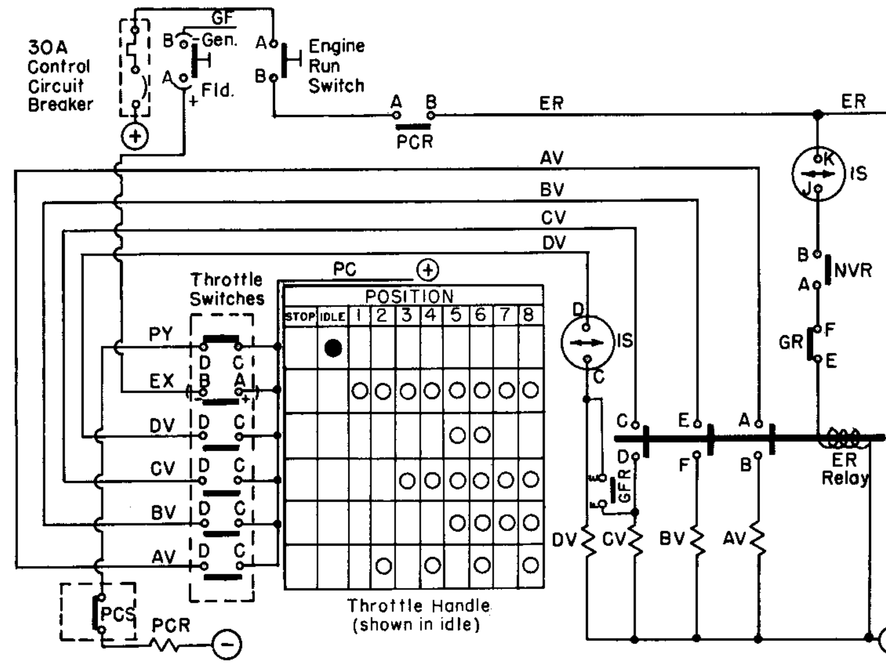
When the throttle is opened to Run 1 or higher and the generator field switch is placed ON, current will flow from the PC wire to energize the GF trainline wire which runs through the locomotive consist. Main generator excitation is established by a circuit coming from the GF wire and leading to the shunt field contactor SF. With the isolation switch in RUN position, this circuit goes through the following normally closed interlocks as well as those shown open that will now be closed: BK, IS, GR, SPR, S23, S45, S14, S36, PR, WS14, WS36, and WS25 to the SF coil. Beneath the GR interlock in the preceding circuit is a circuit leading to the battery field contactor BF. It goes through SF A-B (now closed) and WS16 A-B to the BF coil.

The main contacts of SF and BF are now closed completing circuits for main generator excitation. With the closing of the BF contactor, the overriding solenoid, ORS, located in the engine governor is de-energized. This permits the load regulator to advance from minimum field position under control of the load control system. The locomotive will now begin developing power

NOTE: The generator field relay GFR is energized directly from the GF wire. The purpose of this relay is to connect local control wire POA into the transition shunting control circuits (not shown) and prevent picking up BKB23, BKB56 and MF if B trainline wire was accidentally energized.

ENGINE SPEEDCONTROL CIRCUIT, Fig. 6-4

To increase locomotive power output, the speed of the diesel engine is increased. This is accomplished by means of the throttle switches, ER relay, and the engine governor solenoids. Basically, movement of the throttle lever establishes circuits to the governor solenoids which in turn cause the governor to increase or decease fuel



Engine Speed Control Circuit
Fig. 6-4

to the engine. In the circuits between the throttle and governor are contacts of the ER relay. When energized, the ER relay permits throttle control of the engine. When de-energized due to certain electrical difficulties, it breaks the circuit causing the engine to go to idle speed regardless of throttle position.

The functioning of the circuits involved are shown in Fig. 6-4. To start with, the ER relay in each unit must be energized in order to permit throttle operation of the individual governors. This circuit is established when the 30 ampere control circuit breaker and the engine run switches are placed ON then with the PCR energized (PC switch set) the ER trainline wire will be energized.

In each unit, when the IS is in RUN position, NVR closed (engine running) and the GR set, a circuit will be completed from the ER wire to the ER relay coil. When energized, the ER relay closes its contacts in the circuits leading to governor solenoids AV, BV and CV, but not DV which is normally used for stopping the engine.

The throttle lever controls switches which receive power from the PC wire and distribute it in trainlined circuits to the AV, BV, CV and DV governor control solenoids in each unit. These solenoids provide for engine speed response as follows:

AV increases speed 80 RPM.
BV increases speed 320 RPM.
CV increases speed 160 RPM.
DV reduces speed 160 RPM.

The solenoids are energized in various combinations which result in an 80 RPM change in engine speed for each throttle position. Referring to Fig. 6-4, the solenoids energized and resulting speed for each throttle position are as shown on the following chart:

ENGINE SPEED CHART

Throttle Position	Governor Solenoids Energized				Engine Speed RPM
	A	B	C	D	
STOP				*	0
IDLE					275
1					275
2	*				355
3			*		435
4	*		*		515
5		*	*	*	595
6	*	*	*	*	675
7		*	*		755
8	*	*	*		835

To stop the diesel engine, the isolation switch is placed in the START or ISOLATE position which sets up a circuit to the stop push button and opens the ER relay and the solenoid circuit it controls. By pressing the stop button, the DV solenoid is energized to stop the engine.

NOTE: The engine on the SD24 does not stop in throttle 5 or 6 when the ER relay is de-energized due to some electrical difficulty. In such cases, the speed is reduced only to idle. The reason for this is that the GFR is energized by the GF wire during operation. The GFR interlock is closed in a circuit between the DV and CV solenoids. Thus when DV is energized as in Run 5 or 6, this circuit also energizes CV to prevent the engine from stopping even though the normal CV circuit was opened by the ER relay. A blocking rectifier prevents current flow from CV to DV in normal operation.

TRANSITION CONTROL SYSTEM

As the locomotive speed increases, the transition control system functions to automatically maintain the proper traction motor field strength and connections to the main generator. The changes in field strength from full field (FF) to stages of field shunting and changes in connecting circuits is called transition. These changes are necessary to maintain the constant kilowatt output throughout the locomotive operating speed range, and, at the same time, operate within the voltage and current limitations of the main generator and the current limitations of the traction motors.

During locomotive acceleration, the circuit changes occurring are called forward transition. After going through the forward transition steps and upon deceleration of the locomotive, circuit changes again occur which are referred to as backward transition.

A brief explanation of the transition steps and circuit changes follows.

1. Starting out from standstill, the traction motors are connected to the main generator in what is termed a series circuit. This is accomplished by power contactors S14, S45, S23 and S36 being closed. Contactors S14 and S45 connect motors 1, 4 and 5 in a series circuit. Contactors S23 and S36 connect motors 2, 3 and 6 in another series circuit. Both series circuits are paralleled across the main generator as shown in Fig. 6-5.

   From this basic circuit, five steps of forward transition can occur through closing of the traction motor field shunting contactors FS1, FS2, FS3, FS4 and FS5. Starting with full field, these steps occur one at a time.

2. After completing the preceding transition steps, the next involves a change of basic circuit from series to series-parallel. In this instance, power contactors S14, SP4, SP25, SP3 and S36 will be closed. Contactors S14 and SP4 connect motors 1 and 4 in series. Contactor SP25 connects motors 2 and 5 in series.

   Contactors SP3 and S36 connect the remaining motors 3 and 6 in series. The three groups of two motors are then paralleled across the main generator as shown in Fig. 6-6.

   From this basic circuit, six stages of traction motor field shunting can occur. These start from full field, then FS1 through FS6, advancing one step at a time.

3. The next and last change in basic circuit occurs after completing the preceding transition steps. The circuit changes from series-parallel to full parallel. In this instance, power contactors P1, P4, SP4, P2, P5, SP3, P3 and P6 will be closed connecting the six motors in parallel with the generator, as shown in Fig. 6-7.

   This circuit change is then followed by two steps of shunting, namely FS1 and FS2.

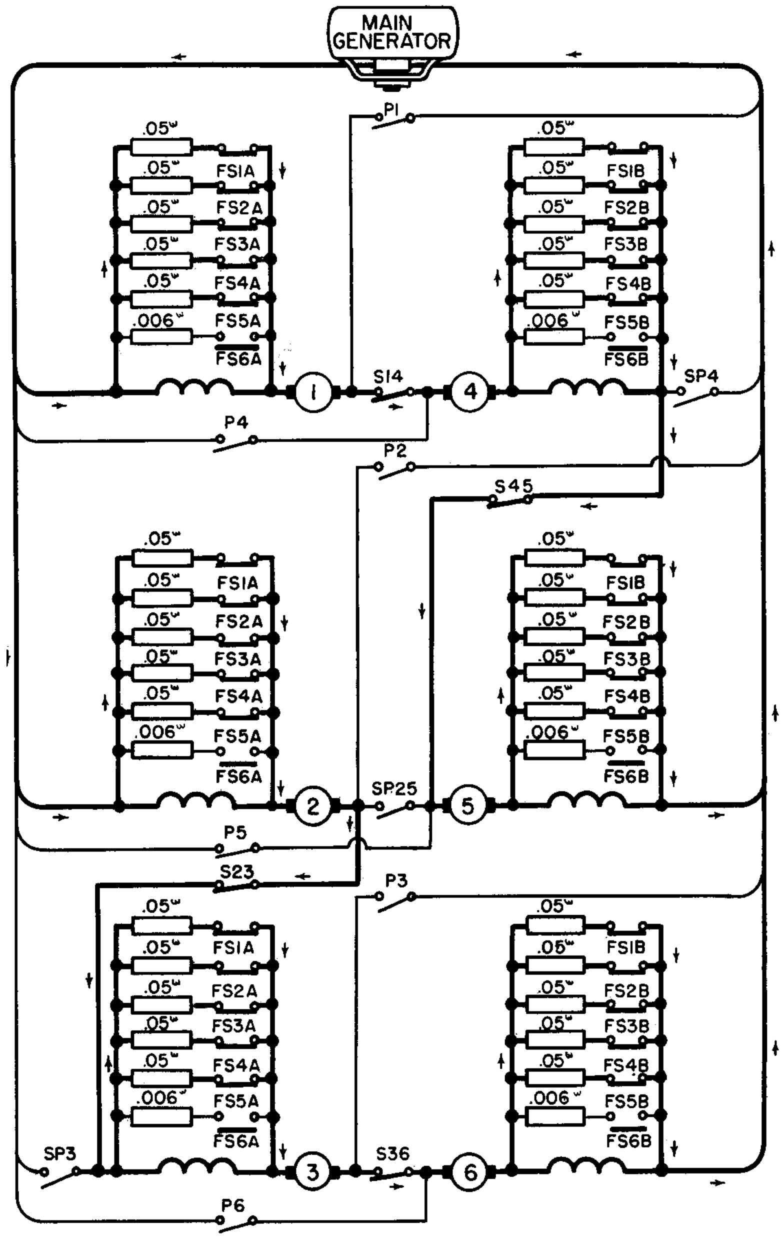
4. Backward transition with decelerating locomotive speed results in circuit changes that are essentially in reverse to the order in which forward transition occurred.

All transition steps, both forward and backward, are initiated by two relays, FTR and BTR. These relays are connected to the high voltage circuit to sense main generator output voltage and current.

A forward transition step is initiated by BTR and FTR pickup while backward transition is initiated by BTR and FTR dropout. Normal locomotive operation is with BTR picked up except for low voltage series full field condition.

FORWARD TRANSITION - SERIES FIELD SHUNTING INCREASE, Fig. 6-5

As the locomotive begins accelerating from standstill, the main generator voltage increases and the current decreases to the proper value for BTR relay to pick up. As speed increases, generator voltage



Series Field Shunting Circuit
Fig. 6-5

increases (and current decreases) to proper values for FTR relay to pick up. The following steps then occur:

1. FTR relay picks up A relay.

2. A relay closes FS1A and FS1B contactors and knocks down FTR relay.

3. FS1A drops out A relay and picks up FSA relay. Shunting of the traction motor fields results in increased main generator current and decreased voltage below the proper values for FTR relay pickup until a further increase in locomotive speed.

Further locomotive speed increase results in further main generator voltage increase and current decrease to proper values for FTR relay pickup.

1. FTR relay then picks up B relay.

2. B relay closes FS2A and FS2B contactors and knocks down FTR relay.

3. FS2A closing drops out B relay.

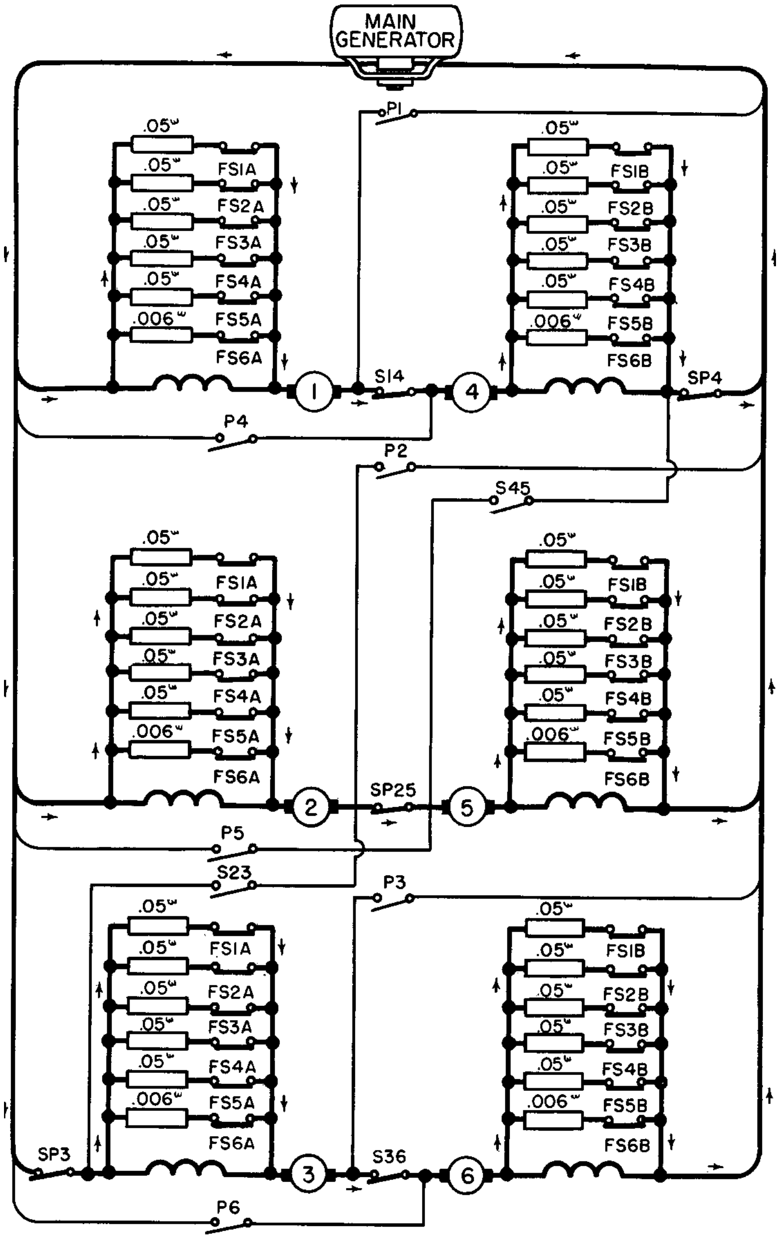
Further increasing locomotive speed results in steps FS3, FS4 and FS5 as in preceding paragraphs.

FORWARD TRANSITION SERIES FS5 TO SERIES-PARALLEL FF, Fig. 6-6

Further locomotive speed increase results in further main generator voltage increase and current decrease to proper values for FTR relay pickup.

1. FTR picks up B relay.

2. B relay picks up series-parallel relay, SPR. 3. SPR picking up opens SF and BF contactors and successively opens FS5, FS4, FS3, FS2 and FS1 contactors.



Series-Parallel Field Shunting Circuit
Fig. 6-6

ELECTRICAL

4. When main generator voltage and current decrease to proper values (due to excitation being reduced), FTR drops out.

5. FTR then drops out FSA relay.

6. FSA closes SP25 contactor.

7. SP25 opens S23 and S45 contactors.

8. S23 and S45 closes SP3 and SP4 contactors.

9. SP3 and SP4 closes SF and BF contactors.

FORWARD TRANSITION SERIES- PARALLEL FIELD SHUNTING INCREASE

Further increase of locomotive speed results in successive steps of traction motor field shunting through step FS5 as explained previously.

FORWARD TRANSITION SERIES-PARALLEL FS5 TO FS6

FTR relay pickup in series-parallel step FS5, picks up B relay.

1. B relay picks up FS6D relay and knocks down FTR.

2. FS6D energizes ORS, moving load regulator towards minimum field position. Reducing main generator excitation minimizes engine overloading when closing FS6 contactors.

3. At the end of the FS6D time delay duration, the ORS is de-energized, FS6A and FS6B contactors close.

4. FS6A drops out B relay.

FORWARD TRANSITION SERIES- PARALLEL FS6 TO PARALLEL FF, Fig. 6-7

Further increasing locomotive speed in series-parallel FS6 picks up FTR relay.

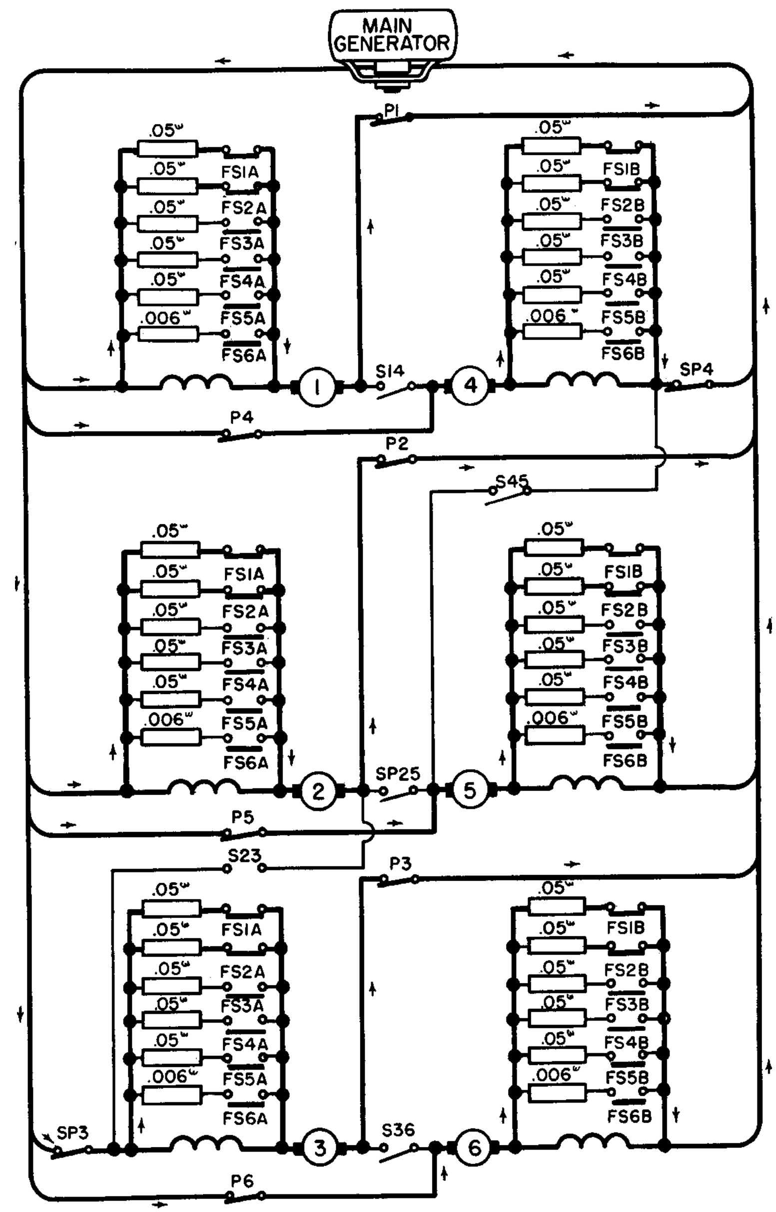
1. FTR relay picks up A relay.
2. A relay picks up PR relay.
3. PR opens SF and BF contactors and successively opens FS6, FS5, FS4, FS3, FS2 and FS1 contactors.
4. When main generator voltage and current decreases to proper values (due to excitation being reduced, FTR drops out.
5. FTR drops FSA relay.
6. FSA opens S14 contactor.
7. S14 closes P1 and P4 contactors.
8. Pl opens SP25 contactor.
9. SP25 closes P2 and P5 contactors.
10. P2 opens S36 contactor.
11. S36 closes P3 and P6 contactors.
12. P3 and P6 close SF and BF contactors.

FORWARD TRANSITION PARALLEL FIELD SHUNTING INCREASE

Further increasing locomotive speed results in parallel FS1 and FS2 steps as previously described under "Forward Transition Series Field Shunting Increase."

BACKWARD TRANSITION PARALLEL FIELD SHUNTING DECREASE

While running in parallel FS2, decreasing locomotive speed results in increasing main generator current and decreasing voltage until proper values for BTR relay drop out.



Parallel Field Shunting Circuit
Fig. 6-7

1. BTR dropping picks up A relay.
2. A relay then picks up BTR relay and opens FS2A and FS2B contactors.
3. FS2 drops out A relay.

Reduction of traction motor field shunting results in increased main generator voltage and decreased current above the proper values for BTR relay dropout until a further decrease in locomotive speed.

Further locomotive speed decrease results in main generator current increase and voltage decrease to proper values for BTR relay dropout.

1. BTR dropping out picks up B relay.
2. B relay then picks up BTR relay and opens FSlA and FSlB contactors.
3. FS1 drops out B relay.

BACKWARD TRANSITION PARALLEL FF TO SERIES - PARALLEL FF

Further locomotive speed decrease results in main generator current increase and voltage decrease to proper values for BTR dropout.

1. BTR dropping drops out PR relay.
2. PR opens SF, P1 and P4 contactors.
3. SF opens BF contactor; P4 opening closes S14 contactor.
4. S14 opens P2 and P5 contactors.
5. P5 closes SP25 contactor.
6. SP25 opens P3 and P6 contactors.
7. P6 closes S36 contactor.
8. S36 closes SF and/or BF contactors.

9. Making backward transition from parallel full field to series-parallel full field will result in progressive stepping up to FS6 as previously described under "Forward Transition Series Field Shunting Increase."

BACKWARD TRANSITION SERIES - PARALLEL FIELD SHUNT DECREASE

Further reduction in locomotive speed will cause the transition control system to progressively step backward as required and previously described under "Backward Transition Parallel Field Shunting Decrease."

BACKWARD TRANSITION SERIES - PARALLEL FF TO SERIES FS3

Still further reduction in locomotive speed in series-parallel full field will result in BTR dropout.

1. BTR relay dropping drops SPR relay.
2. SPR opens SF and SP25 contactors.
3. SF opens BF; SP25 closes S23 and S45 contactors.
4. S23 and S45 opens SP3 and SP4 contactors and closes SF contactor.
5. SF closes BF contactor; SP3 closes FS3A and FS3B contactors.
6. BF drops FSC relay; FS3A closes FS2A and FS2B contactors.
7. With locomotive running at this speed, it is possible that the transition control would step up to FS4, or down to FS2 to result in the proper degree of motor field shunting. The degree of field shunting varies with the temperature (resistance) of the traction motor fields.

BACKWARD TRANSITION SERIES FIELD SHUNTING DECREASE

Further reduction in locomotive speed will cause the transition control system to progressively step backward as required and previously described under "Backward Transition Parallel Field Shunting Decrease."

DYNAMIC BRAKE OPERATION

Dynamic braking is an electrical arrangement used to change some of the power developed by the momentum of a moving locomotive into an effective holding brake. The traction motor armatures, being geared to the axles, are rotating whenever the train is moving. When using dynamic brake, electrical circuits are set up which change the traction motors into generators. Since it takes power to rotate a generator, this action retards the speed of the train. The dynamic brake is, in effect, very similar to an independent brake, and the load indicating meter serves the purpose of a 'brake cylinder pressure gauge."

In descending a grade, with throttle in IDLE position, drawbar "push" of the trailing train tonnage moves the locomotive forward. If no resistance other than the locomotive and the wheel friction is exerted against this "push," the momentum of the train on the descending grade would soon reach a speed where the train brakes would have to be applied. In dynamic braking, a resistance to this drawbar push is set up which in effect "holds back" the speed of the train as would the application of the locomotive independent brake. The effect of the resistance is to slow down the traction motor armatures being driven by the "push" of the train.

The resistance set up in each traction motor is a magnetic field through which the traction motor armature must rotate. Increasing

the strength of the magnetic field will effect a "slow down" of the traction motor armature, thus holding back the train. The magnetic field is produced by connecting the traction motor fields of each unit in series with the main generator, and passing a current through these fields. The strength of the magnetic field is controlled by varying the main generator excitation and thus its current to the traction motor fields in each unit.

The main generator battery field of each unit in the locomotive consist is connected in series to the low voltage supply of the lead unit. This is called the "field loop" circuit. Movement of the selector lever in the lead unit into the "B" braking position, sets up the controller for the throttle lever to control the position of the load regulator which in turn regulates the main generator battery field current for dynamic braking. The throttle moves a 499 ohm rheostat which acts through a micropositioner relay (LRP) to position the load regulator. Moving the throttle lever toward the 8th notch and away from IDLE increases the effectiveness of the "holding brake." Thus, in effect, the strength of the traction motor field in which the traction motor armature must rotate is controlled by the throttle lever.

In dynamic braking, the traction motor armatures are connected to grids located in the top of the carbody. Rotation of the armature through the magnetic field generates power (braking current) and this current flows through the grids to be dissipated as heat. The current generated increases as the armature rotation increases (momentum of train increases the drawbar push) or as the strength of the magnetic field is increased. The maximum braking current that can flow through the grids is automatically limited to 700 amperes regardless of locomotive speed or throttle lever position.

WHEEL SLIPCONTROL

The wheel slip control system goes into operation the moment that the slipping of a pair of wheels is detected while under power. Located in the electrical cabinet are the following wheel slip control relays: WCR, WS14, WS16, WS25 and WS36.

The relays are through cable type operated by a current differential between two cables that pass through the relay frame. These cables are so arranged that the normal current flow through them is of equal magnitude and in opposite directions. Thus, the magnetic field established by the current flow in one cable is nullified by the magnetic field established by the current flow in the second cable. When an unbalance in the current flow occurs as a result of a "slipping" motor, the resultant magnetic field established actuates the relays.

The wheel creep relay WCR has a lower pickup value, thus is more sensitive than the wheel slip relays. Its function is to detect a wheel "creep" before an actual slip occurs. When the WCR picks up it energizes the time delay sanding relay TDS. This then energizes either the forward or reverse sanding valves (FSV or RSV) providing the auto-sand switch on the controller panel is placed ON. Sand is then automatically applied to the wheels to correct the tendency to slip.

In the event one of the wheel slip relays picks up upon detecting an actual slip, circuits are established to automatically reduce main generator excitation and resulting power. The wheel slip light will also be lit in the cab regardless of which unit has the slipping wheels, since this circuit is trainlined. With an automatic reduction in power, the wheel slip is corrected after which the wheel slip relay drops out, the light is extinguished and power gradually returns to normal. Thus locomotive tractive effort is kept at the highest possible level during slip correction.

By means of the wheel creep and slip relays and the automatic sanding feature, it is seldom, if ever, necessary for the engineman to reduce throttle or manually apply sand to correct a slip.

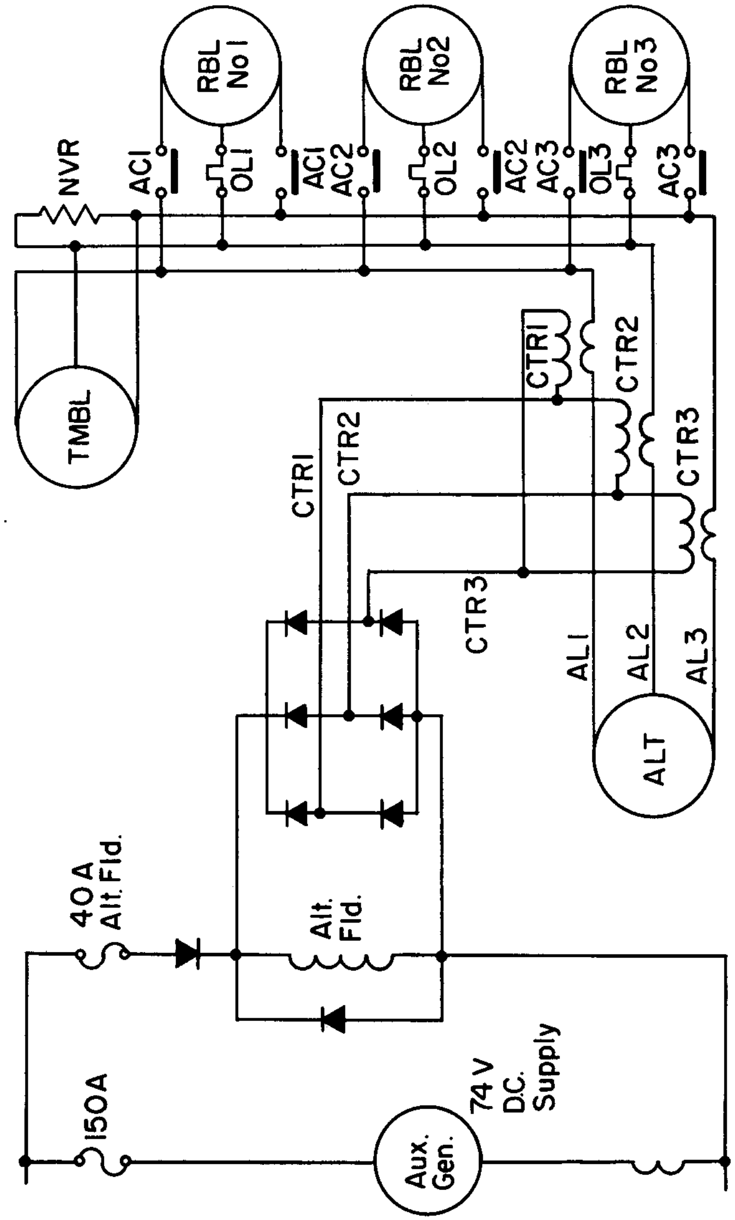
When encountering unusually poor rail conditions while in dynamic braking, there may occur a tendency for a pair of wheels to run slower than the rest due to the retarding effort. When this happens, the wheel slip relays will again function and will result in operation of the automatic sanding feature. This will then correct the problem and return operation to normal.

ALTERNATOR FIELD EXCITATION, Fig. 6-8

During normal operation, the alternator is excited from the auxiliary generator output of 74 volts direct current to the locomotive low voltage system. When starting a heavy load such as one of the 35 HP cooling fans, to prevent excessive voltage drop, the alternator provides its own excitation. This self-excitation circuit functions as follows:

When an AC cooling fan contactor closes to start a fan, the current draw from the alternator is high with a correspondingly high voltage drop. This high current flows through the primaries of current transformers CTRL, CTR2 and CTR3 on its way to the fan motor. The voltage induced in the transformer secondaries is connected to give 3 phase AC which is then rectified to DC. When the output voltage of the rectifiers exceeds the 74 volts being supplied by the auxiliary generator, it will cause an additional current flow through the alternator field, increasing excitation to maintain alternator voltage.

With the foregoing arrangement, the cooling fan starts and reaches operating speed rapidly. The alternator current and voltage thus are quickly restored to normal values.



Alternator Field Excitation Circuits
Fig. 6-8

LEGEND OF ELECTRICAL EQUIPMENT

A	A Closing Relay
AC	Cooling Fan Contactor
AWS	Auxiliary Wheel Slip
B	B Closing Relay
BC	Battery Charging Contactor
BF	Battery Field Contactor
BK	Brake - Motor Field
BKB	Power Brake Switchgear
BKP	Power Brake Switchgear
BR	Brake Relay
BWR	Brake Warning Relay
BTR	Backward Transition Relay
C 1	Capacitor
CC	Compressor Control Magnet Valve
CCS	Compressor Control Switch
CR	Compressor Relay
CR1	Control Rectifier
CTS	Cooling Temperature Switch
DPC	Dynamic Pressure Switch
DBI	Dynamic Brake Interlock
DBR	Dynamic Brake Regulator
ER	Engine Run Relay
ETS	Engine Temperature Switch
FOR	Forward Relay
FL	Field Loop Contactor
FPC	Fuel Pump Contactor
FSA	Field Shunting Auxiliary
FS1A	Motor Field Shunting Contactor
FS1B	Motor Field Shunting Contactor
FSV	Forward Sanding Valve
FTR	Forward Transition Relay
GFR	Generator Field Relay
GR	Ground Relay
GS	Generator Start Contactor

IS	Isolation Switch
LOS	Lube Oil Switch (Gov.)
LRP	Load Regulator Positioner
MF	Brake - Motor Field
OL	Motor Overload
ORS	Overriding Solenoid (Gov.)
OLS	Overload Switch (Gov.)
PCR	Pneumatic Control Relay
PCs	Pneumatic Control Switch
P2	Parallel Contactor
PR	Parallel Relay R18 Resistor
RBL	Radiator Blower Motor
RER	Reverse Relay
RCR	Reverse Current Relay
RVF	Reverser Switchgear - Forward
RVR	Reverser Switchgear - Reverse
RSV	Reverse Sanding Valve
S14	Series Contactor
SP	Series-Parallel Contactor
SF	Shunt Field Contactor
SMV	Shutter Magnet Valve
SFT	Shunt Field Transfer Relay
SPR	Series-Parallel Relay
SSC	Switching Service Control Relay
TLPC	Turbine Lube Pump Contactor
TLTD	Turbine Lube Time Delay Relay
TDS	Time Delay Sanding
TM	Traction Motor
TMBL	Traction Motor Blower Motor
USS	Unit Selector Switch
VR	Voltage Regulator
WS	Wheel Slip Relay
WCR	Wheel Creep Relay

AV, BV, Governor Control Solenoids CV, DV

SECTION 7

TROUBLE SHOOTING

INTRODUCTION

This section is devoted to operational problems that may be encountered on the road and the steps that can be taken to determine their cause and to make necessary corrections. No attempt is made to provide detailed explanations of the equipment functions concerned as such information is provided in other sections of this manual.

Troubles occurring on the road and the resulting delays can be minimized through proper locomotive inspection, maintenance and operation. When operating problems do occur, however, it is important that they be quickly eliminated. Towards that end, a good, thorough understanding of locomotive equipment function will be most helpful. This basic knowledge, together with the suggestions given in this section should provide the necessary means for achieving the "on time" performance desired.

GENERAL PROCEDURE

Safety devices automatically protect the equipment in case of faulty operation of most any component. In general this protection is obtained by unloading or preventing the loading of the diesel engine with a resulting loss of locomotive pulling power. In most instances, the diesel engine speed will be reduced to idle.

Operating difficulties are usually indicated by the ringing of an alarm bell and the lighting of one or more signal lights. The alarm circuit is arranged so that the bells would ring in all units of a multiple unit consist, but the signal light would be illuminated only on the unit experiencing the trouble. The unit experiencing the trouble could thus be quickly determined.

Operating difficulties sometimes occur without being indicated by alarms. In such instances it should be remembered that if only one unit of a multiple unit consist is affected, the cause of trouble is generally in that particular unit. On the other hand, if all units experience the same difficulty, the cause probably exists in the cab of the controlling unit.

ALARM SIGNAL LIGHTS

Colored alarm signal lights are located on the engine control panel on the rear cab wall above the electrical cabinet. Additional white signal lights are located on the locomotive controller.

RED - HOT ENGINE

Cause- Excessive engine cooling water temperature.

Effect- Alarm bells ring in all units. Engine speed and power remain normal.

Correction - To silence the alarms and extinguish the light, it will be necessary to reduce engine cooling water temperature.

1. Isolate unit and allow engine to run at idle.
2. Check water tank to see if there is sufficient water in the system. If no water is visible in sight glass, stop engine.
3. Check to see if cooling fans are running (AC contactors in No. 2 electrical cabinet must be closed). Depress reset buttons (where used), if tripped.
4. Shutters should be open. If closed, check position of shutoff valve in air supply line.
5. Local control circuit breaker must be ON.

BLUE - NO POWER

Cause - Alternator failure; thus, no AC power is being generated and NVR drops out. May be due to loss of alternator excitation or electrical difficulty in the AC system (true failure). May also be caused by the diesel engine stopping for any reason while on the line (false failure).

Effect - Alarm bells ring in all units. Speed of engine in unit affected will be reduced to idle. Engine will be stopped if the engine itself caused the alarm.

Correction - To silence alarms, isolate unit. Method of correction depends upon whether engine was stopped or running at IDLE speed.

A. Engine Stopped (false AC failure)

1. Engine overspeed device tripped. Check lever position, reset if necessary.
2. Engine starving for fuel. Observe for proper fuel flow through return sight glass. If fuel is not evident, check reasons given under "Lack Of Fuel."
3. Throttle lever in STOP position.
4. Low oil pressure. Yellow low oil light would also be on in such cases.

B. Engine Running At Idle (true AC failure)

1. Blown 40-ampere alternator field fuse.
2. Blown 150-ampere auxiliary generator fuse.
3. Blown 30-ampere auxiliary generator field fuse.

YELLOW - LOW OIL

Cause - Low oil pressure or high oil suction in the diesel engine lubricating system or low oil pressure to the turbocharger. May be due to insufficient oil, excessively hot oil, diluted oil, or clogged strainers.

Effect - The diesel engine in the unit concerned will be stopped. The push button on the governor will be out with the red indicating band exposed. The blue no power light will also be illuminated due to engine being stopped with isolation switch in RUN position.

Correction - The following steps should be taken to correct or determine cause of difficulty.

1. Isolate unit to stop alarm bells. Blue light also goes out.
2. Reset governor trip button. Yellow light goes out.
3. Check engine lubricating oil level using dipstick. Oil should be near FULL mark.
4. Observe for external oil leakage from broken pipes.
5. Restart engine. Observe oil pressure on gauge. Should be a minimum of 6 psi at IDLE. Note oil suction on color coded gauge. Should be in green area.
6. Lubricating oil viscosity reduced due to dilution with fuel oil.
7. Lubricating oil viscosity reduced due to excessive oil temperature. In such instance, the hot engine alarm would also be indicated.

CAUTION: In the event of continued low pressure or high suction, the governor trip button will again move out to stop the engine. The engine should not be repeatedly started or forced to run when the governor keeps shutting the engine down.
The engine should NEVER be manually operated by using the layshaft lever to take control away from the governor when the governor persists in stopping the engine.

WHITE - GROUND RELAY

Cause - Tripped ground relay due to high voltage ground. May also trip due to low voltage ground but only when starting diesel engine.

TROUBLE SHOOTING

Effect - If ground relay trips during operation, engine speed will be reduced to IDLE, and the alarm bell will ring. No power will be developed due to generator excitation contactors SF and BF being opened.

If ground relay trips when starting the engine, the engine will remain idling and will not respond to throttle changes. Also no power will be developed.

Correction -

1. Isolate unit. If under power or in dynamic braking, first place throttle in IDLE.
2. Press ground relay remote reset button. Light should go out.
3. Start engine if necessary and place engine "on the line."

CAUTION: In instances where ground relay trips repeatedly during operation, the unit concerned should be isolated and the trouble reported. As is true with repeated wheel slip action, the unit concerned should not be allowed to remain in the locomotive consist unless it is absolutely certain that all wheels are rotating freely.

WHITE - PC OPEN

Cause - Tripping of the PC switch due to safety control "penalty" or emergency air brake application.

Effect - The speed and power of ALL engines in the locomotive consist is reduced to IDLE conditions regardless of throttle position. No alarm bells will ring.

Correction - The PC switch is automatically reset provided that:

1. Throttle is placed in IDLE.

2. Cause of difficulty (safety control pedal, locomotive overspeed, train control) is eliminated.

3. Air brake is recovered. This is done by moving the automatic brake valve handle to the suppression position (26L) and allowing it to remain there until the application valve resets. This ordinarily takes 6 to 10 seconds. The PC light will then go out indicating a reset switch.

4. Return brake valve handle to running position.

NOTE: In the event of the PC switch tripping due to an emergency air brake application initiated from the locomotive, the brake valve should be returned to release position after the locomotive stops. The PC switch will reset automatically and the light will go out if the throttle is placed in IDLE.

If emergency brake is applied due to train action (conductor's valve or break-in-two), it is suggested that after the train stops, the automatic brake valve be placed in emergency position and left there until cause of application has been corrected. After this, place brake valve in running position and the throttle in IDLE to reset PC switch.

WHITE - WHEEL SLIP

Cause - Flashing light indicates a pair of wheels are running slower (sliding) or faster (slipping) than other wheels on the unit. A light burning more or less steady and not going out until throttle is in IDLE or locomotive is stopped may indicate a pair of locked wheels.

Effect - Sanding will commence provided auto-sand switch is ON. Power will be automatically reduced (and restored) on the unit affected by the wheel slip control system.

Correction -

1. Auto-sand switch should be ON to obtain desired automatic sanding.

2. Throttle should be reduced only in the event of continued slipping.

CAUTION: Unit experiencing continuous wheel slip and/or ground relay action should not be isolated and allowed to remain in the locomotive consist unless inspection reveals all wheels to be capable of rotating freely.

WHITE - BRAKE WARNING (If Used)

Cause - Excessive dynamic braking strength.

Effect - No noticeable effect. Equipment damage is possible (excessive braking current) if light is allowed to remain on for more than a few seconds.

Correction - Excess braking current is usually quickly and automatically corrected by the dynamic brake regulator. In the event the warning light remains on, the throttle should be moved to reduce braking strength. Light should never be allowed to remain on for more than a few seconds at most.

CORRECTION OF OPERATI NG DI FFICULTIES

INSUFFICIENT FUEL

Insufficient fuel will cause erratic engine operation. Lack of fuel will cause engine to shut down. It would also prevent an engine from being started.

Condition of the fuel system may be determined by observing the two sight glasses mounted on top of the filter assembly located at the right front of the engine. The glass closest to the engine should be full whenever the fuel pump and engine are running. The adjacent glass should always be empty. Refer to the Fuel System portion of Section 4 for details.

TO START FUEL PUMP

1. Main battery switch must be closed.
2. Control 30-ampere circuit breaker must be ON.
3. Control and fuel pump switch must be ON.
4. Fuel pump 15-ampere circuit breaker must be ON.
5. Cable should be firmly connected to motor.

NO FUEL WITH PUMP RUNNING

1. Lack of fuel in tank.
2. Emergency fuel cutoff valve tripped.
3. Slipping or broken coupling between motor and pump.
4. Suction leak in piping.
5. Clogged suction or discharge filters.

ENGINE CANNOT BE STARTED

Engine starting difficulties fall into two categories, namely, engine does not rotate when START button is pressed, or engine rotates but does not start. The following items should be checked in either event:

Engine Does Not Rotate

1. Main battery switch must be closed.
2. Control 30-ampere circuit breaker must be ON.
3. Control and fuel pump switch must be ON.
4. Isolation switch must be in START position,
5. Starting fuse 400-ampere must be good and in place.

Engine Rotates But Does Not Start

1. Engine overspeed trip lever must be set.
2. Low oil pressure button in governor must be in.

3. Insufficient fuel or lack of fuel. See preceding fuel system difficulties.

ENGINE DOES NOT RESPOND TO THROTTLE

In instances where an engine is running normally at IDLE speed but does not speed up when throttle is advanced indicates that the governor speed control solenoids AV, BV and CV are not receiving power. Generally, this condition would be due to the ER relay being de-energized. The following items should be checked:

1. Cable must be firmly connected to governor.
2. Ground relay must be set.
3. NVR must not be open.
4. Isolation switch should be in RUN.
5. PC switch should be set.
6. Engine run switch must be ON.
7. Control and fuel pump switch must be ON.

LOCOMOTIVE DOES NOT LOAD UP

In instances where the diesel engine is running and responds properly to throttle yet the locomotive does not move or load up, the following points should be checked:

1. Air brakes and hand brakes should be released.
2. Reverse lever must be in either FORWARD or REVERSE.
3. Selector lever must be in POWER-NO. 1 position.
4. Generator field switch must be ON.
5. Battery field 80-ampere fuse must be good and in place.
6. Local control 30-ampere circuit breaker must be ON.

ENGINE GOES TO IDLE DURING OPERATION

See possible causes in preceding article "Engine Does Not Respond To Throttle."

ENGINE STOPS DURING OPERATION

In instances where a diesel engine stops during normal operation, the following items may be responsible.

1. Engine overspeed trip may have occurred.
2. Low oil button on governor may be out.
3. Insufficient or lack of fuel. See preceding fuel system difficulties.
4. Throttle is in STOP position.

BATTERY CHARGING METER SHOWS DISCHARGE

With the diesel engine running, the auxiliary generator should provide all low voltage current needs. The battery charging ammeter should read either zero or charge. If it continually reads discharge, the following should be checked.

1. Auxiliary generator knife switch must be closed.
2. Auxiliary generator fuse 150-ampere must be good and in place.
3. Auxiliary generator field fuse 30-ampere must be good and in place.

UNUSUAL OPERATING PROBLEMS

In the majority of instances, the various safety devices will function in the event of trouble to safeguard the equipment by unloading the engine, or causing it to go to idle or stop. There are possible instances however, that such action is not automatically taken and it might be advisable to do so. Since these occasions are unusual, each should be handled individually using good judgment. The following suggestions may be helpful.

A. Mechanical Problems

1. Smoke Coming Out Of Exhaust - Operation may continue.
2. Oil Coming Out Of Exhaust - Stop engine.
3. Smoke In Engine Room Coming From Engine - Stop engine, DO NOT REMOVE ANY INSPECTION COVERS.
4. Governor Low Oil Button Trips Continually Leave engine stopped.
5. Engine Cooling System Losing Water Rapidly Stop engine.
6. Unusual Noises - Investigate source. Stop engine or discontinue operation if noise is pronounced, to prevent damage.
7. Engine Cylinder Test Valve Leaking - Stop engine and tighten valve. Do not allow engine to operate with leaking or blowing valve.
8. Safety Valves Popping On Air Compressor Intercooler Or Main Reservoir - Continue operation.
9. Engine Overspeed Trip Stops Engine Repeatedly - Leave engine stopped.

B. Electrical Problems

1. Ground Relay Trips Continually - Isolate unit. (See "Wheel Slip" below.)
2. Continuous Wheel Slip Indication - Isolate unit, stop locomotive and check to see that all wheels can rotate freely.
3. Generator Flashover - Isolate unit.
4. Fuses Blowing Or Circuit Breakers Constantly Tripping Open - Operation may continue. This however depends upon which circuit is involved. In some instances operation may not be possible and unit should be isolated and engine stopped.
5. Traction Motor Blower Inoperative -Isolate unit.