SD35 - SDP35 OPERATING MANUAL

GENERAL MOTORS LOCOMOTIVES

GENERAL MOTORS LOCOMOTIVES

DIESEL LOCOMOTIVE

OPERATING MANUAL

for

MODEL SD35

AND

MODEL SDP35

October, 1964

SERVICE DEPARTMENT

ELECTRO-MOTIVE DIVISION

GENERAL MOTORS CORPORATION

LA GRANGE, ILLINOIS, U.S.A.

NOTICE

The data appearing in this manual is intended as a guide and as an aid in explaining the locomotive equipment and systems. It is generally applicable to a basic locomotive, that is, a locomotive without optional equipment. Some data is included for optional equipment, but it is also of a basic nature. Therefore, always consult specific drawings and wiring diagrams for a particular locomotive when working with the equipment or systems. Such diagrams take precedence over information presented herein.

INTRODUCTION

This manual has been prepared to serve as a guide to railroad personnel engaged in the operation of the 2,500 horsepower General Motors Models SD35 and SDP35 turbocharged diesel-electric locomotives.

The contents are divided into seven sections as follows:

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 Equipment And Systems - Describes the diesel engine, 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.

A block of page numbers is allocated to each section, Section 1 starting with page 101, Section 2 with 201 and the others following in this manner. Figures are identified by section and sequence. For example: Fig. 2-3 is the third figure used in Section 2.

To obtain the most benefit from this manual, it is recommended that the sections be read in the sequence in which they appear.

GENERAL DATA

Model Designation	SD35 - SDP35
Locomotive Type	0660
Locomotive Horsepower	2,500
Diesel Engine	
Model	567D3A
Type	Turbocharged
Number of Cylinders	16
Cylinder Arrangement	45° "V"
Cylinder Bore and Stroke	8-1/2" x 10"
Operating Principle	2 Stroke Cycle Turbocharged, Unit Injection, Water Cooled
Full Speed	900 RPM
Idle Speed	315 RPM
Starting Speed	75-100 RPM
Main Generator	
Model	D32
Nominal Voltage (DC)	600
Number of Poles	12
Alternator	
Model	D14
Type	3 Phase
Nominal Voltage (AC)	180
Number of Poles	16
Frequency (At 900 RPM)	120 cps
Auxiliary Generator	
Rating (SD35)	10KW
Rating (SDP35)	18KW
Voltage (DC)	74
Traction Motors	
Model	D67
Number	6
Type	Series Wound

GENERAL DATA (Cont'd)

Driving Wheels	
Number	6 Pair
Diameter	40”
Tread	
SD35	Tapered
SDP35	Cylindrical Optional
Gear Ratio - Maximum	
Speed Options	62:15 - 71 MPH
	61:16 - 77 MPH
	60:17 - 83 MPH
	59:18 - 89 MPH
Air Compressor	
Model	WBO
Type	2 Stage
Number of Cylinders	3
Capacity (At 900 RPM)	253 cu. ft. per min.
Cooling	Water
Air Reservoir Capacity	49,000 cu. in.
Lube Oil Capacity	10-1/2 gal.
6 Cylinder Compressor	
Capacity (at 900 RPM)	405 cu. ft. per min.
Lube Oil Capacity	18 gal. Storage
Battery	
Number of Cells	32
Voltage	64
Rating (8 hour)	420 ampere hour
Supplies	
Lubricating Oil Capacity	243 gal.
With deep sump oil pan	395 gal.
Cooling Water Capacity	275 gal.
Fuel Capacity (Basic)	3000 gal.
Fuel Capacity (With steam generator)	1500 gal.
Water Capacity (Steam generator)	1500 gal.
Sand	40 cu. ft.

GENERAL DATA (Concl'd)

Approximate Weight on Rails	
SD35	360,000
SDP35	360,000
Weight on Drivers	100%
Major Dimensions	
Length Between Coupler Faces	60' 8"
Distance Between Truck Bolster Centers	35' 0"
Width Over Basic Arm Rests	10' 4"
Overall Height From Top of Rail to Top of Exhaust Stack	15' 7-1/4"
Minimum Curve Radius	
Single Unit or Units Coupled	250 ft.
Truck Rigid Wheel Base	13' 7"
Steam Generator Rating	4500 lbs./hr.
Air Brakes	26L

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SECTION 1

GENERAL DESCRIPTION

INTRODUCTION

The General Motors Model SD35 locomotive, Fig. 1-1 or the Model SDP35, Fig. 1-3, is equipped with a turbocharged diesel engine that delivers 2500 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.

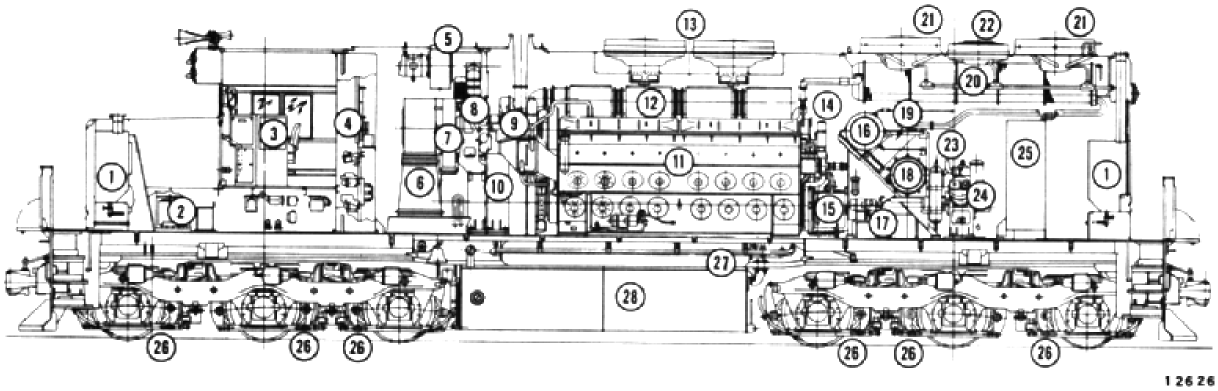
The basic locomotive is arranged and equipped so that the short hood or cab end is considered the front or forward part of the unit. However, the locomotive operates equally well in either direction, and on special order controls may be arranged so that the long hood end is forward, or dual controls may be provided.

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 through jumper cables connected between the units.

The general arrangement of equipment used on the SD35 locomotive is shown in Fig. 1-2. Fig. 1-4 shows equipment used onthe SDP35 locomotive. Each of the more important equipment components is numbered and identified in these illustrations. Some of the items are covered in detail in other sections of the manual. The Table of Contents should be consulted for such additional information.

The SDP35 locomotive is essentially an SD locomotive with the long hood and rear walkway extended to accommodate a steam generator. The fuel tank is divided into a combination fuel tank

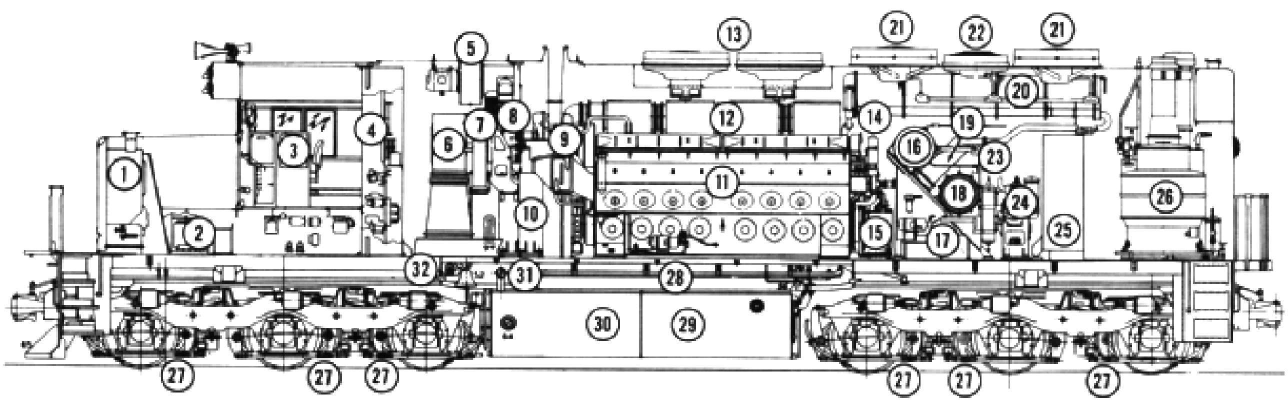
Fig. 1-1 — SD35 Locomotive



1. Sand Box
2. Battery
3. Loco. Controls
4. No. 1 Electrical Cabinet
5. Inertial Separator
6. Traction Motor Blower
7. Generator Blower
8. Auxiliary Generator
9. Turbocharger
10. Main Generator
11. Engine 16-567D3A
12. Exhaust Manifold
13. Dyn. Brake Fans
14. Engine Governor
15. Lube Oil Strainer
16. Engine Water Tank
17. Fuel Pump
18. Lube Oil Filters
19. Lube Oil Cooler
20. Radiators
21. 48" Fan And Motor
22. 36" Fan And Motor
23. Fuel Filter
24. Air Compressor
25. No. 2 Electrical Cabinet
26. Traction Motors
27. Main Air Reservoir
28. Fuel Tank

Fig. 1-2 — General Arrangement — SD35 Locomotive

Fig. 1-3 — SDP35 Locomotive



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18. Lube Oil Filters
19. Lube Oil Cooler
20. Radiators
21. 48" Fan And Motor
22. 36" Fan And Motor
23. Fuel Filter
24. Air Compressor
25. No. 2 Electrical Cabinet
26. Steam Generator
27. Traction Motors
28. Main Air Reservoir
29. Water Tank
30. Fuel Tank
31. Fuel Filler Opening
32. Emergency Fuel Cutoff Button

Fig. 1-4 — General Arrangement - SDP35 Locomotive

and water tank and the gear ratio at the traction motor pinion is suitable for high speed operation. This equipment enables the locomotive to perform as a passenger locomotive and as a freight locomotive at low minimum continuous speeds comparable to GP locomotives equipped with the usual freight gearing.

HOW THE LOCOMOTIVE OPERATES

1. The fuel pump is driven by an electric motor which, for fuel priming, uses current from the storage battery. Once the engine is started and running, the fuel pump motor uses current directly from the auxiliary generator. The fuel pump transfers fuel from the fuel 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. A 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 motor and generator blowers.

4. The auxiliary generator charges the storage battery and supplies low voltage direct current for the control and lighting circuits. The alternating current generator furnishes power to the static exciter, various transductors, the three radiator cooling fans, and the inertial separator blower motor. The main generator supplies high voltage direct current 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 relays in the electrical cabinet. These electrical devices function to complete other circuits or cause action desired for locomotive operation.

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

7. The throttle electrically controls speed and power by actuating a governor mounted on the engine. 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 prevents the engine from being over or underloaded by regulating the electrical load on the engine in all throttle positions.

9. The air compressor supplies, to the reservoirs, air under pressure used primarily for the air brakes. The air brakes are controlled by the operator through suitable equipment in the cab.

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

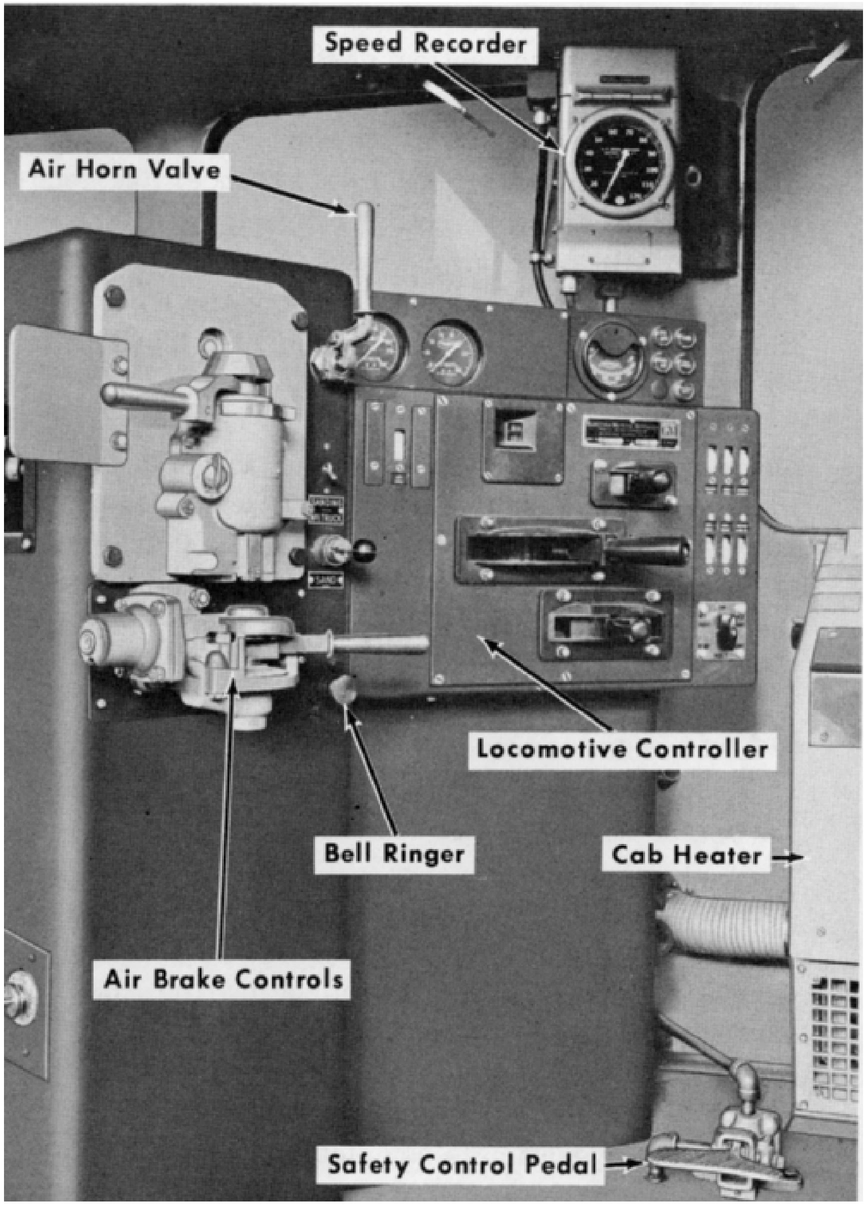


Fig. 2-1 – Locomotive Control Station

SECTION 2

CAB CONTROLS

INTRODUCTION

All of the control equipment used during locomotive operation is at four locations within the cab.

1. The Switch and Fuse Panel
2. The Engine Control Panel
3. The Locomotive Control Stand
4. 4. The Air Brake Pedestal

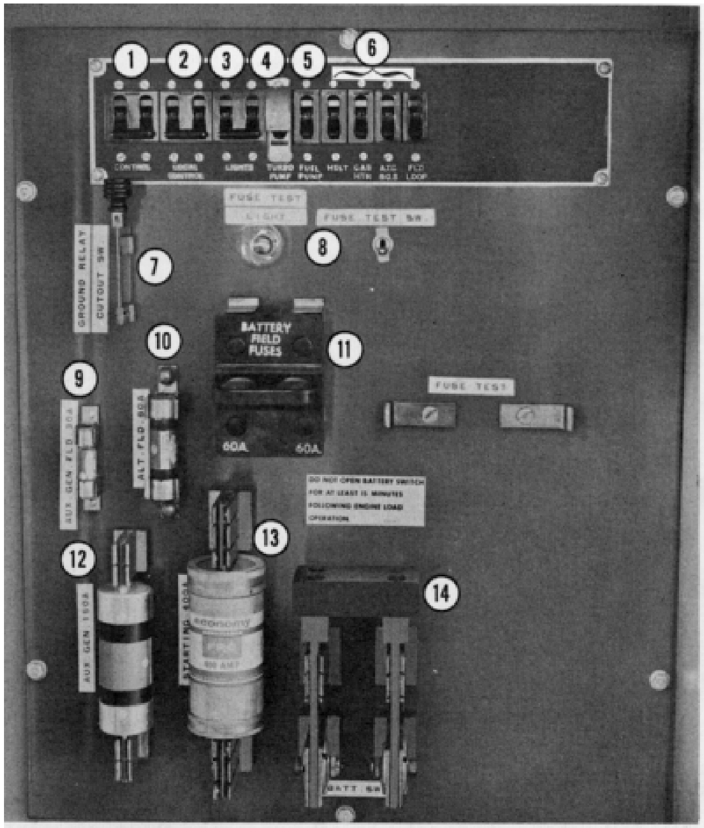
Each of these locations contains various devices with which the operator should be familiar, as most of them will be used at one time or another during operation.

The first locations 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 locomotive operation is controlled f rom the station shown in Fig. 2-1. This station contains the locomotive controller and air brake pedestal.

The following paragraphs briefly describe the equipment at the control locations. Paragraph headings identify the equipment, while the text in parentheses indicates the exact nomenclature appearing adjacent to the equipment.

SWITCH AND FUSE PANEL

The panel shown in Fig. 2-2 is located within the electrical cabinet that forms the rear wall of the locomotive cab. Its position is directly below the engine control panel which is located in the upper left hand corner of the electrical cabinet.



1. Control 40-Ampere Circuit Breaker
2. Local Control 30-Ampere Circuit Breaker
3. Lights 30-Ampere Circuit Breaker
4. Turbine Lube Pump Motor 30-Ampere Circuit Breaker
5. Fuel Pump Motor 15-Ampere Circuit Breaker
6. Miscellaneous Circuit Breakers
7. Ground Relay Cutout Switch
8. Fuse Test Equipment
9. Auxiliary Generator Field 30-Ampere Fuse
10. Alternator Field 60-Ampere Fuse
11. Battery Field 60-Ampere Fuses
12. Auxiliary Generator 150-Ampere Fuse
13. Starting 400-Ampere Fuse
14. Main Battery Knife Switch

Fig. 2-2 - Switch And Fuse Panel

Control 40-ampere Circuit Breaker
(CONTROL)

This circuit breaker must in the ON position before locomotive operation is possible. It establishes power from the battery to energize the fuel pump relay FPR, and it sets up the fuel pump and control circuits for engine starting. Once the engine is running, power is supplied through this breaker from the auxiliary generator to maintain operating control.

Local Control 30-ampere Circuit Breaker
(LOCAL CONTROL)

This circuit breaker must be in the ON position before operation of the locomotive is possible. It completes the circuit to the fuel pump contactor through interlocks of the generator (engine) start switch; and during operation it establishes "local" power from the auxiliary generator to operate heavy duty switchgear, and various control devices.

Lights 30-ampere Circuit Breaker
(LIGHTS)

This circuit breaker must be ON to supply power for the individual switches provided for platform, engine room and identification lights.

Turbine Lube Pump Motor 30-ampere Circuit Breaker
(TURBO PUMP)

This circuit breaker must be in the ON position to start the engine and operate the turbocharger auxiliary lube oil pump. It must remain in the ON position to provide auxiliary lubrication to the turbocharger at engine start and after the engine is shut down. A guard is provided over this breaker switch to prevent accidental movement to the OFF position.

Fuel Pump Circuit Breaker
(FUEL PUMP)

The fuel pump circuit breaker must be ON for normal operation.

Miscellaneous Circuit Breakers

These breakers can include one each for the headlight, automatic train control, overspeed switch, cab heater, and field loop if applicable. The circuit breakers should be placed in the ON position to obtain the desired operation.

Ground Relay Knife Switch
(GROUND RELAY CUTOUT SW.)

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 will be nullified and 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.

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 fuse panel. Fuse may be readily

tested as follows. First, move the toggle switch to the ON position to make sure the fuse test light is not burned out. Extinguish the light by moving the toggle switch to the OFF position. 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 always advisable to test fuses before installing them in their circuits. Always isolate the circuits in question by opening their switches before changing or replacing fuses.

Auxiliary Generator Field 30-ampere Fuse
(AUX. GEN. FLD. 30A.)

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 stops auxiliary generator output to the low voltage system and also stops fuel pump operation. 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 to the alternator. With the loss of alternator current, contacts of NVR will open to de-energize the ER relay and reduce engine speed to idle.

Battery Field 60-ampere Fuses
(BATTERY FIELD FUSES)

The battery field winding of the main generator is excited with rectified current received from the alternator.

This circuit is established by means of the battery field auxiliary (BFA) contactor. The 60-ampere battery field fuses are used in this circuit for protection against possible overload or short circuit damage to the rectifiers or reactors.

The fuses must be in good condition, since if one is blown, the locomotive unit concerned will not develop normal power due to a reduction in main generator excitation. In such instance no alarms would occur; trouble in the excitation circuit can result in abnormal locomotive power.

<u>Auxiliary Generator 150-ampere Fuse</u>
(AUX. GEN. 150A.)

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 the 400-ampere starting fuse is never installed in place of the 250-ampere fuse.

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. The fuel pump will stop and the no AC voltage relay (NVR) will drop out to de-energize the ER relay, and the alarm will sound.

<u>Alternator Field 60-ampere Fuse</u>
(ALT. FLD. 60A.)

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 60-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 alarm, and reduces the engine speed to idle.

<u>Starting 400-ampere Fuse</u>
(STARTING 400A.)

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 motor the main generator and crank the engine.

Although this fuse should be in good condition and always left in place, it has no effect on locomotive operation other than for engine starting. A defective fuse can be detected 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.

<u>Main Battery Knife Switch</u>
(BATT. SW.)

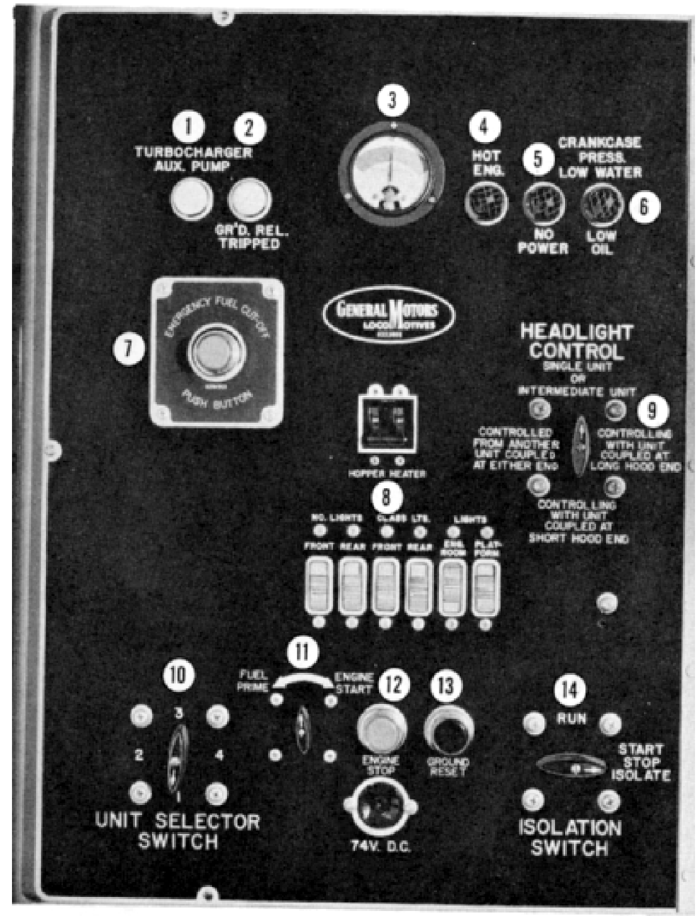
The large double-pole single-throw knife switch at the lower right hand corner of the fuse panel is the main battery switch and is used to connect the battery to the locomotive low voltage system. It should be kept closed at all times during operation.

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 is opened after the engine has been started, the auxiliary generator will continue to supply the low voltage needs, but the batteries will not receive charge.

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 when a notation at the switch cautions against opening the switch immediately after engine shutdown. At least 15 minutes should be allowed after engine shutdown before this switch is opened after operation under load or the turbo lube oil pump will fail to function properly. This motor driven pump operates automatically upon NVR dropout (provided the main battery switch and the turbo lube pump 30A circuit breaker are closed) to circulate oil to the turbocharger, thus permitting a gradual cooling of the turbocharger.

ENGINE CONTROL PANEL

The engine control panel, Fig. 2-3, is located at the upper left hand corner of the electrical cabinet that forms the rear wall of the cab. This panel contains several switches and alarm lights, along with the engine start switch, stop button, ground relay reset button, and a battery charging meter. Since all of these items will be used at one time or another during operation, a brief description of their individual functions follows:



1. Turbocharger Auxiliary Lube Pump Light
2. Ground Relay Light
3. Battery Charging Meter
4. Hot Engine Light
5. No Power Light
6. Crankcase (Oilpan) Pressure/ Low Water / Low Oil Light
7. Emergency Fuel Cutoff Switch
8. Miscellaneous Switches And Circuit Breakers
9. Headlight Control Switch
10. Unit Selector Switch
11. Fuel Prime And Engine Start Switch
12. Engine Stop Pushbutton
13. Ground Relay Reset Button
14. Isolation Switch

Fig. 2-3 - Engine Control Panel

Turbocharger Auxiliary Pump Motor Light
(TURBOCHARGER AUX. PUMP)

This light will come on as soon as the main battery switch and turbo lube pump circuit breaker are closed. It indicates that the turbocharger auxiliary lube oil pump is supplying lube oil to the turbocharger. It will remain on for approximately 15 minutes after the main battery switch is closed. When the fuel prime engine start switch is operated after the 15 minute period, the time cycle is again re-established and the light remains on for another 15 minutes.

The light will also come on and remain on for approximately 15 minutes after the engine is stopped to provide an indication that the auxiliary lube oil pump is supplying oil to cool the turbocharger bearings.

Ground Relay Light
(GRID. REL. TRIPPED)

The ground relay light will come on whenever the ground relay trips. In such instances the unit concerned will not develop power and the engine will remain at idle. 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.

Battery Charging Meter

With the main battery knife switch closed, the battery charging ammeter is connected into the low voltage circuits to indicate the extent of current flowing to and from the storage battery. This meter does not indicate the output of the

auxiliary generator. Since the storage battery is usually well charged, the meter in normal operation should read zero or slightly in the green area. The meter pointer should never be in the red area with the diesel engine running, even at idle speed. Such a reading indicates that the battery is discharging, which if allowed to continue could lead to failure of the locomotive unit.

A very strong discharge at time of engine shutdown, followed by blown fuses, indicates a shorted battery charging rectifier. When a very strong discharge is indicated, exercise care before opening the main battery switch.

Hot Engine Alarm Light
(HOT ENG.)

The hot engine alarm light (red) operates in conjunction with the alarm bell to warn the operator that the engine cooling water has reached an excessive temperature. This alarm light will come on only in the unit affected, although the alarm bell will ring in all units of the locomotive consist.

No Power Alarm Light
(NO POWER)

The no power light (blue) will come on, and the alarm bell will ring any time the no AC voltage relay (NVR) opens with the isolation switch in RUN position. This will occur if the engine stops for any reason or if an alternator failure occurs during operation.

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

Crankcase (Oilpan) Pressure/ Low Water/ Low Oil Alarm Light

A mechanism to detect low engine lubricating oil pressure or high suction is built into the engine governor. This mechanism is actuated by true oil pressure failure or by dumping oil from the engine oil line leading to the governor. In either event a small button will pop out of the governor body, indicating that the mechanism has tripped the low oil alarm switch. The amber light on the engine control panel will come on to indicate that the low oil mechanism has tripped.

An alarm bell will sound as the engine shuts down. This alarm can be silenced by placing the isolation switch in the start position.

When a Crankcase (Oilpan) Pressure / Low Water/ Low Oil alarm occurs it is necessary to determine whether the crankcase pressure - low water detector has tripped to dump engine oil from the line leading to the governor, or whether a true oil failure has occurred. This can be determined by checking the crankcase pressure - low water detecting device, Fig. 3-2, for protruding reset buttons. A protruding upper button indicates excessive oilpan pressure; a protruding lower button indicates low water.

The low water detector balances airbox pressure against water pressure. It is more sensitive when the engine is operating in 8th throttle position than when it is in idle. The low water detector will shut down an idling engine when the level of water falls below the cylinder head-toliner seals. It will shut down an engine operating at full throttle when water level is slightly below the low water mark on the water level gauge. If water level is less than 24 inches above the detector, the reset button will not remain set when pressed.

Emergency Fuel Cutoff Switch

The switch on the engine control panel is wired in series with emergency fuel cutoff switches located at the fuel filler openings. Pressing any one of the switches will cause the engine to stop. The switches are spring loaded and do not need to be reset.

Miscellaneous Switches

Switches are included in circuits for various lights on ,the locomotive. The switches are closed as desired to operate the class lights, the number lights, the engine room lights, and the platform lights.

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 switch and fuse 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 provides for operation of the rear unit headlight from the lead unit. The switch is shown in Fig. 2-4, and its positions are set on each unit as follows:

1. On Lead Unit

If only a single locomotive unit is being used, place the switch in SINGLE UNIT position.

In multiple unit service, if trailing units are coupled to the No. 2 or long hood end of the lead unit, place the switch in the CONTROLLING - COUPLED

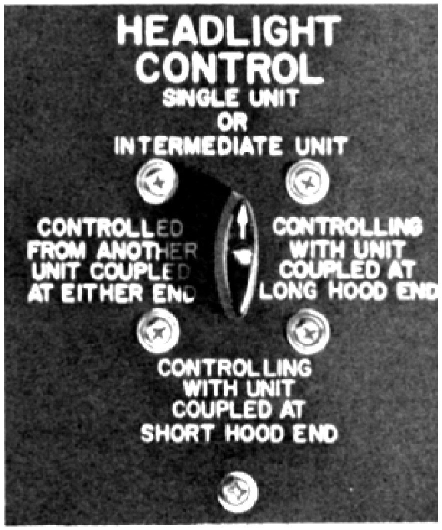


Fig. 2-4 - Remote Headlight Switch

- COUPLED AT LONG HOOD 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 SHORT HOOD END position.

2. On Intermediate Units

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

3. On Trailing Units

The last unit in a multiple unit consist should have the headlight control switch placed in the CONTROLLED - COUPLED AT EITHER END position.

Unit Selector Switch (If provided)

The unit selector switch is used only on locomotives equipped with dynamic brakes and a field loop circuit.

Its purpose is to adjust circuit resistance for uniform dynamic brake operation.

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 while it 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 in 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.

Fuel Prime And Engine Start Switch

This switch is a two position rotary switch used for fuel priming and engine starting. Before starting the diesel engine, the isolation switch must be in the START position, and the rotary switch must be placed in the FUEL PRIME position and held there 10 to 15 seconds to operate the fuel pump. Then the rotary switch must be placed in the ENGINE START position and held in approximately 15 seconds until the engine starts. Placing the rotary switch in the ENGINE START position establishes circuits to close the starting contactor GS which allows battery current to flow through the starting windings of the main generator to crank the engine.

Engine Stop Pushbutton

The diesel engine will stop whenever the engine stop pushbutton is pressed; however, the isolation switch should first be placed in the STOP position. This will de-energize the E R relay to reduce the engine to idle. Then by pushing the engine stop button the FPC contactor is de-energized to stop the fuel pump and the shutdown solenoid DV in the governor is energized to shut the engine down.

When stopping the engine the button need be depressed only momentarily, since the FPC drops out when the circuit is interrupted.

NOTE: Main battery switch and turbocharger circuit breaker must remain closed for 15 minutes when the engine stops after operation under load.

Ground Relay Reset Pushbutton

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, when it trips it will set off the alarm and turn on the relay light on the engine control panel. In addition, the diesel engine speed can 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

CAB CONTROLS

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.

Isolation Switch

The isolation switch has two positions, one labeled START / STOP / ISOLATE, the other labeled RUN. The functions of these two positions, shown in Fig. 2-5, are as follows:

1. START / STOP / ISOLATE Position

The isolation switch is placed in this position whenever the diesel engine is to be started. The start switch is effective only when the isolation switch is in this position.

The START position is also used to isolate the unit, and when isolated the unit will not develop power or respond to the controls. In this event the engine will run at idle speed regardless of throttle position. This

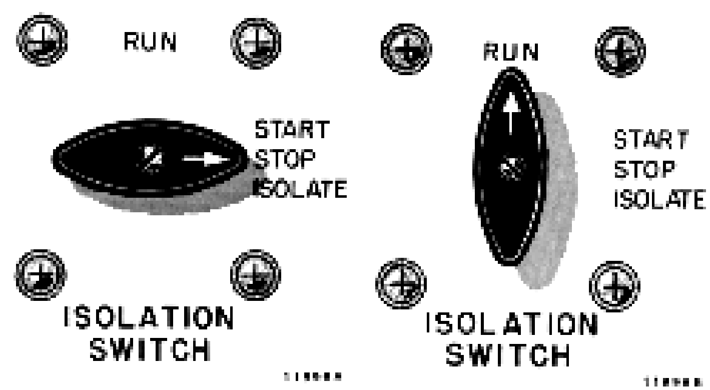


Fig. 2-5 Isolation Switch Positions

position will also silence the alarm bell in the event of a no power or low lube oil alarm. It will not, however, stop the alarm in the event of a hot engine. 2. RUN Position

After the engine has been started, the unit can be 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.

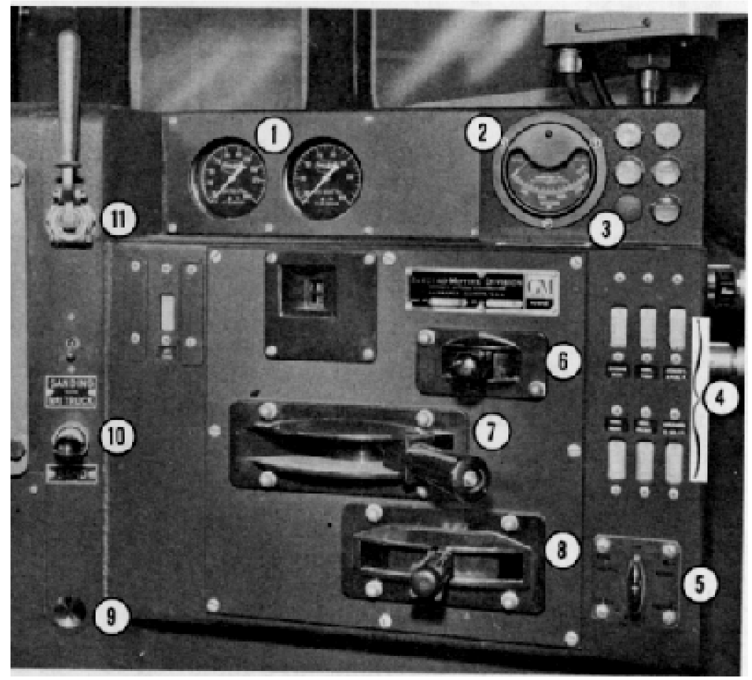
NOTE: The isolation switch should never be moved from one position to another while operating in dynamic braking. Dynamic braking should be temporarily terminated (by placing throttle in idle) whenever it is desired to place the unit on or off the line. It is also good practice while operating under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

LOCOMOTIVE CONTROLLER

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

<u>Air G</u>auges

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 better visibility at night.



1. Air Gauges
2. Load Indicating Meter
3. Indicating Lights
4. Operating Switches
5. Headlight Dimming Switch
6. Selector Lever (Optional)
7. Throttle Lever
8. Reverse Lever
9. Bell Pushbutton
10. Sanding Lever
11. Air Horn Lever

Fig. 2-6 - Locomotive Controller

<u>Load Indicating Meter</u>

The locomotive pulling force is indicated by the load indicating meter located at the upper portion 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 receive 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-parallel circuit, the multiplying factor is 3; in parallel it is 6.

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

Indicating Lights

Four or more indicating lights are installed to provide a visual warning of operating difficulties. The four basic lights are wheel slip, PCS open, brake warning, and sand. The functions of these lights are as follows:

1. Wheel Slip Light

Depending upon the makeup (units with or without TDL relays) of a locomotive consist, the wheel slip light may or may not flash on and off as the wheel slip control system functions to correct the slips. Normal intermittent flashing of the light indicates that the wheel slip system is doing its job and is correcting the slips. The throttle and locomotive power need not be reduced unless severe lurching threatens to break the train.

WARNING: A wheel slip light flashing slowly and persistently may indicate a pair of sliding wheels or circuit difficulty. Stop the locomotive and make a careful inspection to ascertain that there are no locked sliding wheels.

2. PCS OPEN Light

The PCS 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.

CAUTION: The engine run switch must be in the OFF position in all trailing units, or the PCS switch will not act to reduce engine speed to idle.

When the switch is tripped the PCS OPEN indicating light on the controller will come on. This light is extinguished and locomotive power restored by resetting the PCS switch. This occurs automatically, provided that:

a. Control of the air brake is recovered.

b. The throttle is returned to IDLE position.

3. 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 come 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 will be removed and the warning light will be quickly extinguished.

4. Sand

This light comes on to indicate that the SANDING No. 1 TRUCK switch is closed and that sand is being applied at the No. 1 axle. The light is not affected by the manual, emergency, or wheel slip sanding circuits.

Operating Switches

A group of switches is located along the front face of the controller, each identified by a name plate indicating switch function. The switches are in the ON position when moved upward.

Before the engine is to be started, the control and fuel pump switch must be placed ON. To obtain power from the locomotive, the generator field switch must be ON. To obtain control of engine speed, the engine run switch must be ON. These three important switches are grouped at the right side of the controller. They must be placed in the OFF position on controllers of trailing units.

Other switches control sanding, attendant call, and various lights. They are placed on as needed.

Headlight Dimming Switch

A three position switch is located on the controller to the right of the throttle. In one position it provides for DIM headlights on both ends of the locomotive. In the other two positions it provides for a bright headlight at either the front or the rear of the locomotive.

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

Selector Lever

The controller is equipped with a selector lever, Fig. 2-7, in instances where the locomotive unit is equipped with dynamic brakes or when it is necessary to manually control transition on trailing units not equipped for automatic transition. On units so equipped, this lever serves to establish proper circuits for either of these functions.

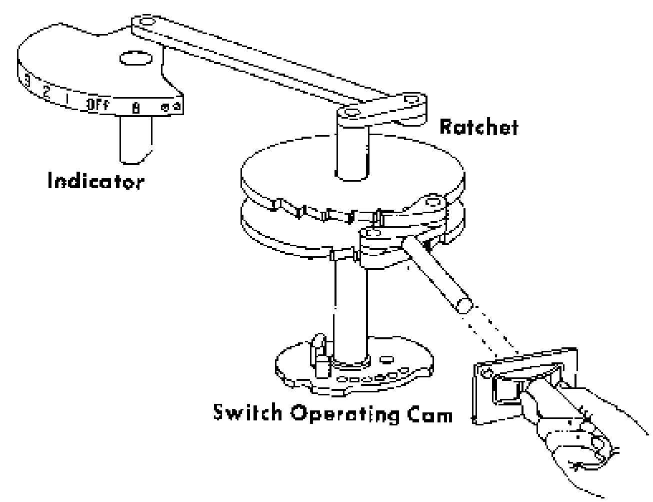


Fig. 2-7 - Selector Lever Operation

The position of the lever is indicated in the lower of the two illuminated windows located at the upper left corner of the controller front panel. The lever is spring loaded 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 center position before indexing again in either direction. When the selector lever is indexed to the B or braking position, the dynamic braking electro-magnetic contactors are energized. In this position the throttle lever moves freely (without notching) to control a 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 any non-automatic trailing units operating in the locomotive consist.

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. 2-8. Each of these positions is 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 an average of 84 RPM starting at 315 RPM at IDLE and Run 1 and going to 900 RPM at full throttle.

Reverse Lever

The reverse lever, Fig. 2-9, has three positions: FORWARD, 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 the controller. The reverse lever should be removed from the controllers in all but the lead unit of a multiple unit locomotive consist.

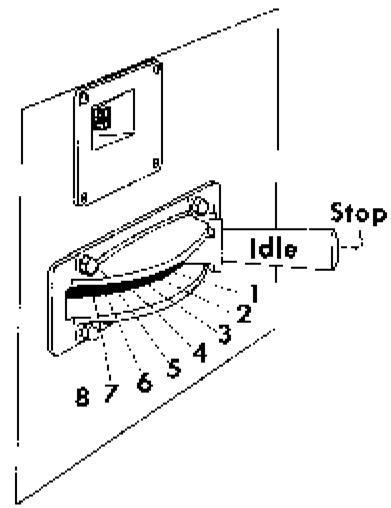


Fig. 2-8 - Throttle Positions

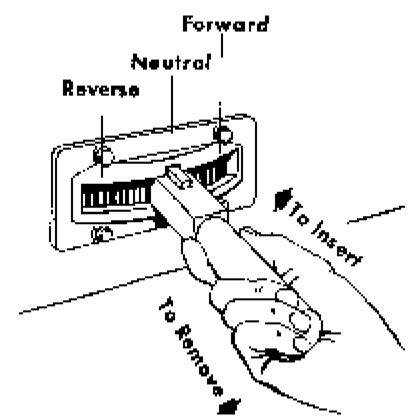


Fig. 2-9 - Reverse Lever Positions

Bell Ringer

When the bell ringer is operated, compressed air is directed to the locomotive warning bell operator.

Sanding Switches

1. SANDING NO. 1 TRUCK Toggle Switch

The signal from this switch is not trainlined. The switch provides sand to only the number 1 axle of the lead unit of a consist. This method of sanding dresses the rail and is adequate for most conditions.

2. SAND Lever Switch

When the sanding switch lever is operated, electrical energy is directed through interlocks of reverser switchgear to operate either the forward or reverse sanding magnet valves in all units of a consist. The basic switch may be operated in any direction for correct sanding and it is non-latching. A directional sanding switch may be provided as an optional extra, and the switch may be latching if requested by the railroad.

Electrically controlled sanding is the basic system used on the SD35 locomotive, but since the SD35 may be operated in multiple with older units that are equipped only for pneumatic control of sanding, trainlined pneumatic control of sanding may be provided as an optional extra in addition to electrical control. In such cases the sanding switch operates solenoid actuated control valves for sanding on units that are equipped with electrical sanding control. The sanding switch also operates solenoid operated relay valves that direct compressed air to trainlined actuating pipes

connected between units. In a mixed consist, pneumatic control is superimposed upon electrical control, and all units, whether equipped for electrical control or pneumatic control are provided with sanding. Refer to Section 6 of this manual for an explanation of the electrical sanding system.

MECHANICAL INTERLOCKS ON THE CONTROLLER

The levers on the controller are interlocked so that:

1. With reverse lever in neutral
   a. Throttle can be moved to any position.
   b. Selector lever can be moved to any position; OFF, or 1 through 4, except "B."
2. Reverse lever in forward or reverse –
   a. Throttle can be moved to any position.
   b. Selector lever can be moved to any position.

3. Throttle lever in IDLE position -
   a. Reverse lever can be moved to any position.
   b. Selector lever can be moved to any position.

4. Throttle lever in STOP position -
   a. Reverse lever can be moved to any position, but can not be removed from the controller.
   b. Selector lever can be moved to any position.

5. Throttle above IDLE position -
   a. Reverse lever position can not be changed.
   b. Selector lever can not be moved out of "B" into OFF or from 1 to OFF. It may however be moved as desired between 1 and 4.

6. Selector lever in OFF position -
   a. Reverse lever can be moved to any position and removed from controller if throttle lever is in IDLE position.
   b. Throttle can be moved between IDLE and STOP only.

7. Selector lever in "B" position -
   a. Reverse lever can not be moved.
   b. Throttle lever can be moved to any position.

8. Selector lever 1, 2, 3, or 4
   a. Reverse lever can be moved to any position.
   b. b. Throttle lever can be moved to any position. Where positions 2, 3 and 4 are incorporated in the selector for manual transition, the handle may be moved 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. 2-10

Basic locomotives are equipped with the type 26L air brakes. Type 24RL or 6BL air brakes are available as optional equipment and may have been 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. 2-10, this equipment consists of an automatic brake, independent brake, multiple unit valve when MU is installed),

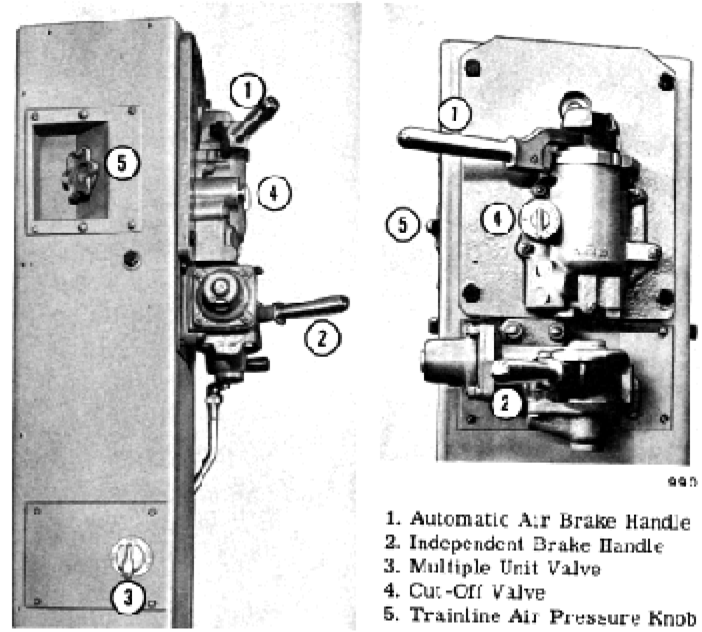


Fig. 2-10 - 26L Air Brake Equipment

cut-off valve and a tramline air pressure adjustment device. The dead engine feature, a part of the 26L equipment, is shown in Fig. 2-12.

<u>Automatic Brake Valve</u>

The automatic brake valve handle may be placed in any of six operating positions as shown in Fig. 2-11.

<u>Independent Air Brake</u>

The independent air brake handle is located directly below the automatic brake handle. It has two positions; namely, RELEASE and FULL APPLICATION.

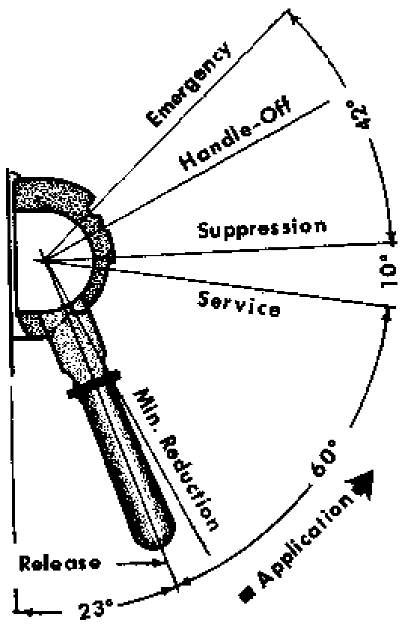


Fig. 2-11 - Automatic Brake Handle Positions

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.

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. 2-10. 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 basic MU-2 valve has three positions which are:

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.

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. FRT (Freight)
3. PASS (Passenger)

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 is shown in Fig. 2-10.

Dead Engine Cutout Cock

The SD35 locomotive is equipped with a dead engine cutout cock that is part of the 26L braking equipment.

The cock is accessible from the outside of the locomotive through side doors provided. See Fig. 2-12.

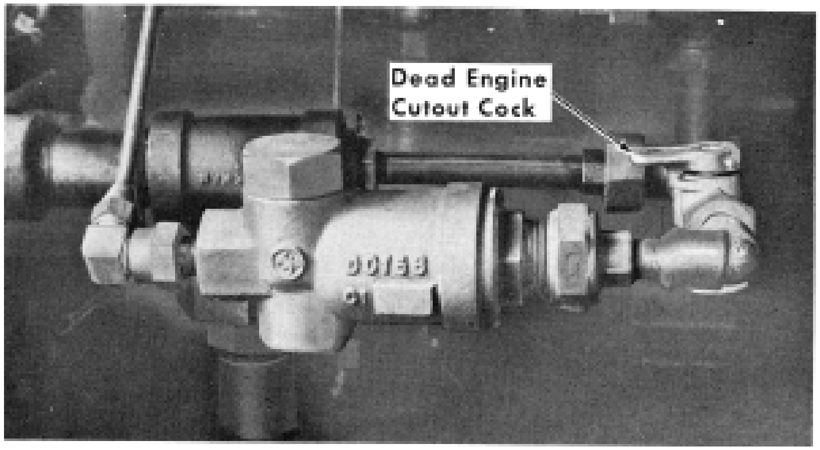


Fig. 2-12 - Dead Engine Cutout Cock

BRAKE EQUIPMENT POSITIONS

When operating SD35 locomotives equipped with 26L air brakes, the brake equipment should be positioned according to the information given in Fig. 2-13.

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				Open	Open
Double Heading	Release	Release	Cutout	Closed				Closed	Open
Shipping Dead In Train	Handle Off Position	Release	Cutout	Open	Relief Valve At Control Reservoir 73 : 2*			Closed	Closed
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	Relief Valve At Control Reservoir 73 : 2*	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		Graduated Direct	Lead	Open	Open
Non-Operative Station	Handle Off Position	Release	Cutout						

Fig. 2-13 — Brake Equipment Positions

SECTION 3

OPERATION

INTRODUCTION

This section of the manual covers recommended procedures for operation of the locomotive. The procedures are briefly outlined and do not contain detailed explanations of equipment location or function, as this is done in other sections of this manual.

The information in this section is arranged in sequence, commencing with inspections in preparation for service, and with instructions for starting the engine, handling a light locomotive, coupling to train, and routine operating phases. The various operating situations and special features such as dynamic braking are also covered.

PREPARATION FOR SERVICE

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 shut-off valves.
5. Air cut-in to truck brake cylinders.
6. Satisfactory condition of brake shoes.
7. Adequate supply of fuel.
8. Proper installation of control jumper cables between units.
9. Adequate supply of water (on units with steam generators operating in passenger service).
10. Observe that control jumper cables are installed between units operating in multiple.

ENGINEROOM INSPECTION

The engine can be readily inspected by opening the access doors along the sides of the long hood end of the locomotive.

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.

ENGINE INSPECTION

The engine should be inspected before as well as after starting. After inspection, all engine room doors should be closed and latched securely, as engine room is pressurized during operation.

1. Check to see that engine overspeed lever is set, Fig. 3-1.
2. Observe that governor low oil pressure trip button is set and that there is oil visible in the governor sight glass.
3. Observe that the crankcase (oilpan) pressure and low water detector reset buttons are set (pressed in). If the buttons protrude, press to reset. A hydrometer bulb may be used to test crankcase pressure trip. A test cock is provided for low water test. (Fig. 3-2)
4. Step down on air box drain valves, Fig. 3-3, to clear any possible obstruction in the drain openings.

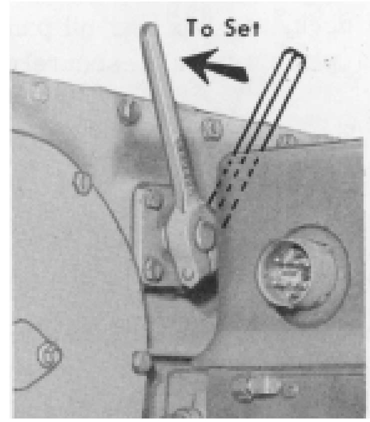


Fig. 3-1 - Engine Overspeed Trip

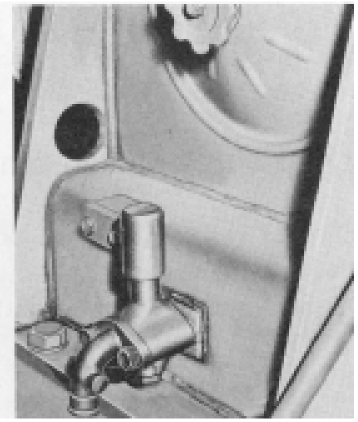


Fig. 3-3 - Airbox Drain

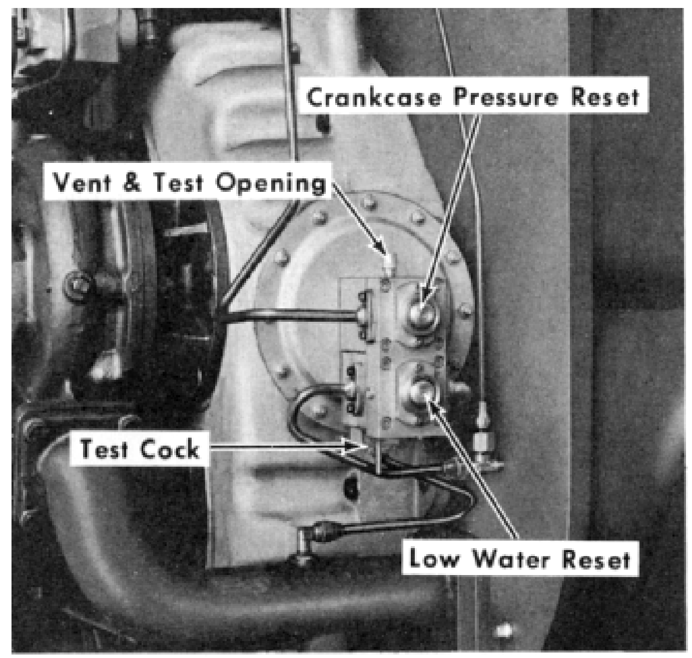


Fig. 3-2 - Low Water And Crankcase (Oilpan) Pressure Detector

5. Observe that engine top deck, air box and oil pan inspection covers are in place and are securely closed.

LEAD UNIT CAB INSPECTION

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

Fuse And Switch Panel

1. Main battery switch closed.
2. Control circuit breaker ON.
3. Local control circuit breaker ON.
4. Fuel pump circuit breaker ON.
5. Ground relay knife switch closed.
6. All fuses installed and in good condition.
7. Lights circuit breakers and miscellaneous circuit breakers ON as needed.
8. Turbocharger lube oil pump circuit breaker ON.

Engine Control Panel

1. Isolation switch in START position.
2. Unit selector switch (where used), Fig. 3-4, in position corresponding with total number of units in locomotive consist (See Fig. 3-6).
3. Headlight control switch in proper position for lead unit operation.
4. Miscellaneous switches and circuit breakers ON as required.

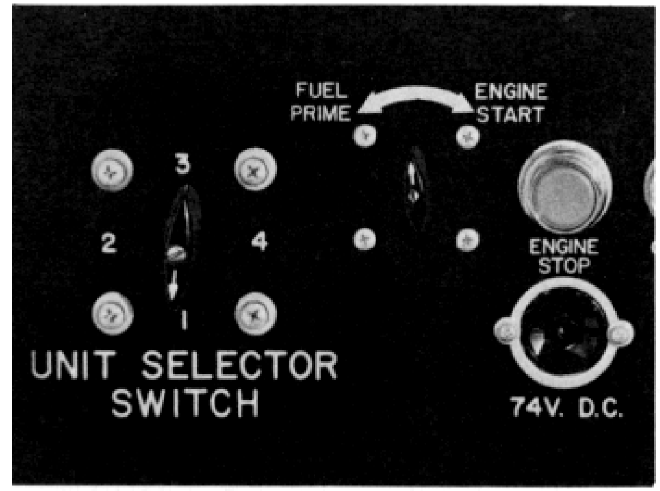


Fig. 3-4 - Unit Selector, Fuel Prime / Engine Start And Engine Stop Switches

Locomotive Controller

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

1. Place control and fuel pump switch in ON (up) position.

2. Install reverse lever.

3. Make sure throttle remains in IDLE position.

Air Brakes - Type 26L

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

STARTING DIESEL ENGINE

The diesel engine in the lead unit can be started after completing the preceding inspection. Perform the following:

NOTE: If a man is stationed at the engine layshaft lever during engine starting, he should be made aware that the compressor control strainer drain valve, Fig. 4-4, will blow during engine start until air pressure at the valve builds to 20 psi.

1. Place the fuel prime and engine start switch, Fig. 3-4, in FUEL PRIME position, and hold there for 10 to 15 seconds to prime the fuel system. Move switch to ENGINE START position and hold (not more than 15 seconds) until engine starts and runs. If the engine fails to start, consult "Trouble Shooting" section for possible cause.

2. If the alarm bell rings and the ground relay light comes on as the engine starts, press the ground relay reset pushbutton and report the presence of a low voltage ground. Use routine reporting procedure established by the railroad.

5. Check that engine and governor oil levels are satisfactory.

6. Check that engine cooling water level does not fall below the "LOW" mark on the "Engine Running" portion of the water level gauge plate. If the water level is slightly low, the engine will continue to run at idle speed, but may shut down when the throttle is advanced.

OPERATION

5. Place the unit "on-the-line" by moving the isolation switch to the RUN position.

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:

<u>Fuse And Switch Panel</u>

1. All knife switches closed.

2. Local control breaker ON; control breaker ON.

3. Fuel pump and turbo lube circuit breakers ON.

4. All fuses installed and good condition.

<u>Engine Control Panel</u>

1. Isolation switch in START position, and headlight control switch in position to correspond with unit position in consist.

2. Other switches may be placed ON as needed or left off, as they do not affect locomotive operation.

<u>Locomotive Controller</u>

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

1. Control and fuel pump switch, generator field switch, and engine run switch must be OFF.

2. Throttle in IDLE.

3. Selector lever in OFF.

4. Reverse lever placed in NEUTRAL and 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. 3. Place MU valve in desired position for trailing unit operation.

4. Place cutoff valve in CUTOUT position.

STARTING DIESEL ENGINE

Trailing units are started and placed on the line in the same manner as the lead unit.

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 will function in response to control and permit operation without air pressure for brakes.

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

3. Release hand brake and remove any blocking under 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 the engine run switch and generator field switch in ON (up) position.

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 (if so equipped).

5. Depress safety control foot pedal (if so equipped).

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 130^0 F.

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

9. Reverse lever should be moved to change direction of travel only when locomotive is completely stopped.

DRAINING OF AIR RESERVOIRS AND STRAINERS

The air reservoirs and air strainers or filters should be drained at least once each day whether or not equipment is provided with automatic drain valves. Draining should be done at the time of crew change until a definite schedule is established by the railroad. See Section 4 for information on system drains.

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 cable between units; also dynamic braking cables, if so equipped, and if operation with field loop control of dynamic brakes is desired.

NOTE: If the consist is made up with older units that are equipped for only pneumatic control of sanding, connect actuating pipes between all units in the consist. Refer to the following paragraph for notes on mixed consist dynamic braking.

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 shown in Fig. 3-5.

Unit equipped with 26L brake equipment to operate in multiple (lead or trail) with 24RL or 6BL units.

OPERATION

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	lndep. applic. & rel. pipe
Sanding pipe	to	Sanding pipe	to	Sanding pipe

Fig. 3-5 - Brake Pipe Connections Between Units

6. 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 undesired 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 they are released.

COUPLING LOCOMOTIVE UNITS TOGETHER FOR DYNAMIC BRAKING IN MIXED CONSISTS

The SD35 locomotive, when equipped with basic dynamic brakes, makes use of electrical potential from the brake control rheostat to control braking strength by controlling excitation of the main generator battery field. This electrical potential is impressed upon the 24T wire to control dynamic braking strength of all units in a consist equipped with potential line brake control.

If the SD35 is to be used with older locomotives that are not equipped with potential line brake control, SD35 equipment for field loop control of dynamic brakes may be provided in one of two forms.

1. To lead only with field loop control of dynamic brakes.

2. To lead or trail with field loop control of dynamic brakes.

If the unit is equipped to lead or trail in field loop, it is provided with an operation selector switch located in the electrical cabinet, Fig. 3-6. Units equipped to lead only in field loop are not provided with an operation selector switch. Such units must be in the lead if field loop control of dynamic braking is to be used.

Any instructions regarding mixed consist dynamic braking must consider the equipment provided on the units involved, the position of the various units in the consist, and individual railroad policy and rules. However, the following general suggestions may be helpful in cases where doubt regarding braking arrangements exists. These suggestions should not be followed if they conflict with railroad rules.

OPERATION

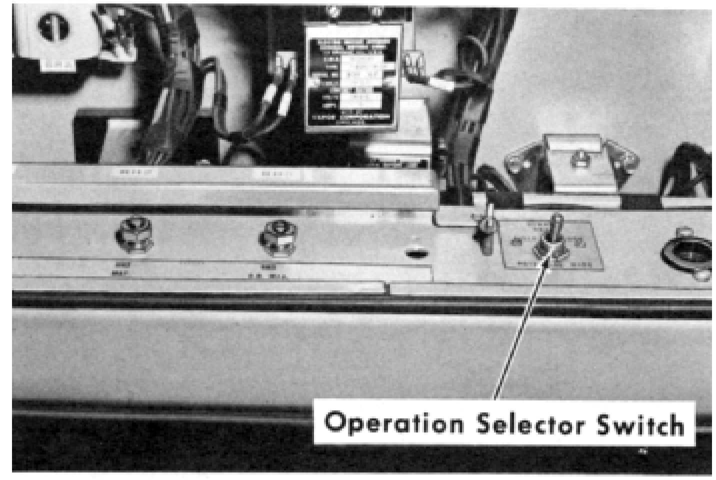


Fig. 3-6 - Operation Selector Switch

1. If all units in a mixed consist are equipped with potential line control of dynamic brakes, do not connect the field loop cables. If the units are equipped with an operation selector switch, place all such switches in the POTENTIAL position.

2. If one or more units in a mixed consist are equipped only for field loop control of dynamic braking, connect all units in the field loop, and place the operation selector switches on all units in the FIELD LOOP position. (SD35, GP35, or GP30 units not equipped with an operation selector switch can not trail in field loop.)

COUPLING LOCOMOTIVE TO TRAIN

Locomotive should be coupled to train using the same care taken when coupling units 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 in OFF (down) position.

2. Move reverse lever to NEUTRAL position.

3. Open throttle as needed to speed up engine and thus increase air compressor output.

NOTE: Throttle may be advanced to RUN 4 or 5 if necessary. Engine should not however be run unloaded (as in pumping up air) at speeds beyond throttle No. 5 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 until the equalizing reservoir gauge indicates that a 15 psi reduction has been made.

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 the rate established by railroad rules.

6. After checking trainline leakage for one minute and the results are observed to be 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 RE LEASE position.

STARTING A 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 and length of the train 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 operator to use good judgment in properly applying the power to suit requirements. There are, however, certain general considerations that should be observed. They are discussed in the following paragraphs.

A basic characteristic of the diesel locomotive is its VERY HIGH STARTING TRACTIVE EFFORT. It is there-fore imperative that the air brakes be 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 be allowed after stopping, or otherwise applying brakes, to allow them to be fully released before attempting to start the train.

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

Proper handling is important when starting trains, 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.

OPERATION

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 engine run and generator field switches in the ON (up) position.

4. Release both automatic and independent air brakes.

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

    a. To Run 1- Engine loading may be noted on the load indicating meter. At an easy starting, place, the locomotive may start the train in Run 1 or 2.

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

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

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

NOTE. When operating at full power to climb a hill, the wheel slip light (if the consists contains units not equipped with TDL) may indicate frequent slipping. In such case do not reduce throttle unless severe lurching occurs and there is danger of pulling the train apart.

ACCELERATING A TRAIN

After the train has been started, the throttle can 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 toward the right (increased amperage) as the throttle is advanced. As soon as the increased power is absorbed, the meter pointer begins moving toward 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 toward the left until full power is reached in throttle position 8.

Additional train acceleration is provided by forward transition which takes 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 operator.

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 Division of General Motors on request.

POWER CONTROL SYSTEM

As in earlier locomotive power systems, the load regulator on the SD35 is the primary power output controlling device. It allows the engine to maintain a constant power output for each throttle setting. The load regulator is, however, unable to compensate for fluctuations in power output due to variables in quality and condition of fuel, air temperature and pressure, and metering of fuel by the engine injectors. These variables are compensated for by devices (a fully static power control system, PLS) that sense main generator current and voltage and regulate generator excitation to maintain locomotive power at a stable maximum value during operation at full throttle.

The compensating devices also act to adjust tractive effort during drag duty at speeds below 9.4 MPH (62:15 gear ratio). They allow the locomotive to work at optimum speed and power within adhesion considerations for extended periods. At speeds below 9.4 MPH (62:15 gear ratio) it is necessary to observe short time ratings as indicated on a plate at the engineer's control stand.

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 indicated by load indicating meter pointer movement toward the right. Backward transition will take place automatically. (See note under Accelerating A Train.)

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 decreases. Since the pull of the locomotive is indicated by the amperage on the load meter, the operator 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.

OPERATING OVER RAIL CROSSING

When operating the locomotive at speeds exceeding 25 MPH, reduce the throttle to a RUN 4 position at least eight seconds before the locomotive reaches a rail crossing. If the locomotive is operating in RUN 4 position or lower, or running less than 25 MPH, allow the same interval and place the throttle in the next lower position. Advance the throttle after all units of the consist have passed over the crossing. This procedure is necessary to ensure decay of motor and generator voltage to a safe level before the mechanical shock that occurs at rail crossings is transmitted to the motor brushes.

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

Automatic sanding, together with reduction of locomotive power functions to correct wheel slip. After adhesion is regained, a timed application of sand continues while power is smoothly restored. The system functions entirely automatically, and no action is required by the locomotive operator.

NOTE: Throttle reduction is recommended only when slip conditions are such that repeated wheel slip causes severe lurching that may pull a train apart.

Depending upon the makeup (units with or without TDL) of the locomotive consist, the wheel slip light may or may not flash on and off as the wheel slip control system functions to correct slips. Normal intermittent flashing of the light indicates that the wheel slip system is doing its job and is correcting the slips. Correction of wheel slips without the light flashing on and off is a normal condition in late model locomotives. No action is required by the operator.

If the wheel slip light blinks on and off slowly and persistently during locomotive operation, a pair of wheels may be sliding or circuit difficulty may exist. Due to 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 indicate serious traction motor trouble that should be investigated at once.

Do not allow any unit that must be isolated due to repeated wheel slip or ground relay action to remain in a locomotive consist UNLESS IT HAS BEEN ABSOLUTELY DETERMINED THAT ALL OF ITS WHEELS ROTATE FREELY.

LOCOMOTIVE SPEED LIMIT

The maximum speed at which the locomotive can 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 a single 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. The equipment 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 initiates certain air brake functions which 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) for units having established 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. At train speeds higher than the optimum, braking effectiveness gradually declines as speed increases. For this reason, it is important that dynamic braking is started BEFORE train speed becomes excessive. While in dynamic braking, the speed of the train should not be allowed to "creep" up by careless handling of the brake.

If the locomotive is equipped with the basic dynamic brake, braking strength rapidly declines as speed falls below the optimum (nominally 23 MPH). However, on special order the extended range dynamic brake may be provided. The extended range system maintains near maximum braking strength down to train speed of about 6 MPH. At lower train speeds dynamic braking strength declines rapidly.

A description of the dynamic braking system may be found in Section 6 of this manual.

To operate dynamic brakes, proceed as follows:

1. On units equipped with a field loop circuitfor control of dynamic brakes, 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 must be positioned in the direction of the locomotive movement.

3. Throttle must be reduced to idle.

4. Move selector 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 13^0 away from IDLE it will be noted that the engine speed automatically increases.

7. Braking effort may be increased by slowly advancing the throttle to the full 8th 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.

9. 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 on for any longer than two or three seconds before steps are taken to reduce braking strength.

10. When necessary, the automatic brake may be used in conjunction with the dynamic brake. However, the independent brake must be KEPT FULLYRELEASED whenever the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 MPH the basic 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.

The locomotive can be operated in dynamic brakingwhen 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 operator 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 SD35 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 an SD35 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 due to an unusual rail condition while in dynamic braking.

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. 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 8 seconds after the wheel slide tendency is corrected.

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 CUTOUT 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 IN HELPER SERVICE

Basically, there is no difference in the instructions for operating the SD35 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 the grades should be in the full throttle position. The throttle can be reduced, however, in instances where excessive wheel slips are occurring. For proper traction motor cooling, the locomotive should never be operated on grades below the 5th throttle position.

ISOLATING A UNIT

When the occasion arises where 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 can then be moved from RUN to START, thus isolating the unit. The throttle can 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 the unit. This is done by reducing the braking lever (throttle) to IDLE. The isolation switch can then be moved to START position to eliminate the braking on that unit. If the braking is resumed, other units will function normally. If field loop control of dynamic brakes is being used, do not change position of the unit selector switch.

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

OPERATION

CHANGING OPERATING ENDS

When the locomotive consist 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.

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 may be removed if so equipped.)

6. Place selector lever in OFF position.

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

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

9. At the engine control panel, place headlight control switch in proper position for trailing unit operation. Place other switches ON as needed.

10. At the switch and fuse panel, the control circuit breaker and other circuit breakers must remain ON.

NOTE: If the local control circuit breaker is inadvertently placed OFF at this time, the engine will shut down when the trainlined control circuit is re-established. However, the engine may be restarted in the normal manner after placing the local control circuit breaker ON.

11. After completing the operations outlined in the preceding steps, move to the cab of the new lead unit.

ON END BEING CUT IN

1. At the controller, make certain throttle lever is in IDLE, selector lever is in OFF, and the generator field switch is OFF.

2. Insert reverse lever and leave in NEUTRAL position.

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

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

5. Position cutoff valve in either FRGT or PASS position depending on make up of the train.

6. Place MU valve in LEAD position.

7. At the switch and fuse panel, the control circuit breaker and other circuit breakers remain ON.

8. At the engine control panel, place the headlight control switch in proper position, and other switches on as needed. If the unit selector switch is used it must be properly positioned.

9. At the controller, place the engine run, control and fuel pump, and generator field switch in ON position. Other switches may be placed ON as needed.

STOPPING ENGINE

There are six ways to stop the engine. They are:

1. Press stop button on engine control panel.

   When the locomotive is standing still or under power, the isolation switch should be placed in STOP position. The stop button can then be pressed in to stop the engine. Since the reaction of the stop button is instantaneous, it need not be held in.

2. Press emergency fuel cutoff button.

   Emergency fuel cutoff pushbuttons are located near each fuel filler opening and on the engine control panel. These pushbuttons operate in the same manner as the STOP button and need not be held in nor reset.

3. Use layshaft lever.

   The layshaft lever at the accessory end of the engine can be operated to override the engine governor and move the injector racks to the no fuel position.

4. Close the low water detector test cock.

   When the low water detector trips, oil is dumped from the governor low oil shutdown device, stopping the engine.

5. Use throttle lever.

   To stop all engines "on the line" in a consist simultaneously from the cab of the lead unit, move the throttle to the IDLE position, pull the lever out and away from the controller, and move it beyond IDLE to the STOP position.

6. Pull out or depress low oil shutdown rod on the side of the governor.

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.
4. Place all switches on the controller panel inthe OFF position (down).
5. Place all circuit breakers and switches on the fuse and switch panel and the engine control panel in the OFF position and open all knife switches.

NOTE: Main battery switch and turbo lube oil pump circuit breaker must remain on for 15 minutes after shut down.

6. Apply hand brake and block wheels, if necessary.

7. Cover exhaust stack if there is danger of a severe rain.
8. Drain or otherwise protect engine if there is danger of freezing.

TOWING LOCOMOTIVE IN TRAIN

When a 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 unless engine is to remain idling.
2. Place the MU valve in DEAD position.
3. Place cutoff 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, Fig. 2-12, to OPEN position. Dead engine cock 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 60-ampere fuses should be removed. Other fuses should be left in place.

e. Control and fuel pump switch ON.

f. f. Control circuit breaker ON.

g. g. Fuel pump circuit breaker ON.

h. h. Throttle in IDLE, selector in OFF, reverse lever in NEUTRAL. REMOVE REVERSE LEVER FROM CONTROLLER to lock controls.

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

a. All knife switches OPEN.

b. 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.

FREEZING WEATHER PRECAUTIONS

As long as the diesel engine is running, the cooling system will be kept adequately warm regardless of ambient (outside) temperatures encountered. 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 danger of freezing is present, the cooling system should be completely drained or have steam admitted.

SECTION 4

MECHANICAL EQUIPMENT AND SYSTEMS

DIESEL ENGINE

The General Motors 16 cylinder Model 567D3A diesel engine, Fig. 4-1, is used as the source of power for the SD35 locomotive. At full operating speed of 900 RPM, this turbocharged engine delivers 2500 horsepower to the generator for tractive purposes.

Engine starting speed when being cranked by the motored main generator is 75 to 100 RPM. Idling speed is 315 RPM. Engine speed and power is advanced in 7 increments (by the throttle) of an average of 84 RPM each until the full speed of 900 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

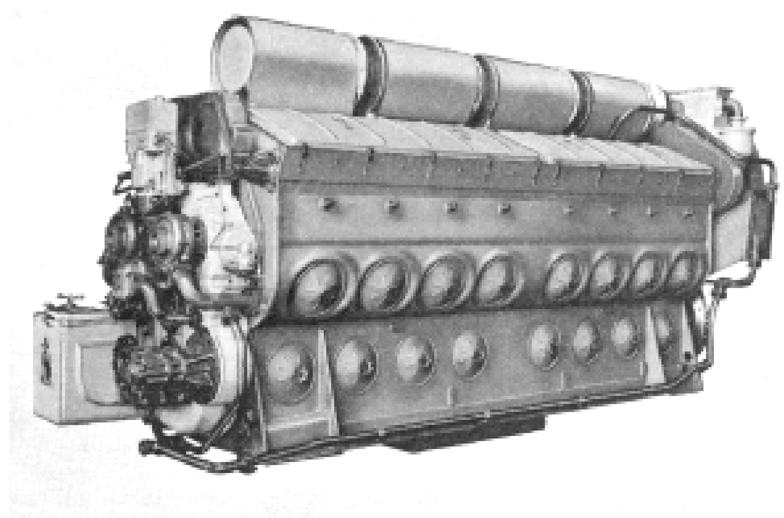


Fig. 4-1 - Model 16-567D3A Engine

overspeed trip mechanism, and a crankcase pressure / low water detector. 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 8-1/2" bore and a 10" stroke, providing a piston displacement of 567 cu. in from which the engine model designation is derived. Operation is on the highly efficient two stroke cycle principle.

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. After going through the turbine, the gases are expelled through the roof of the locomotive.

The centrifugal compressor, driven by the rotating turbine shaft, takes clean filtered air, compresses it, and delivers it to the airbox in each bank of the engine. When starting the engine and during operation at the lower throttle positions, or when lightly loaded, the turbocharger is driven mechanically 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. At high throttle position with the engine heavily loaded, exhaust gas energy becomes sufficient to power the turbine unit and drive the compressor without help from the engine gear train.

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 inclined toward the right side of the engine. At speeds between 990 and 1005 RPM, the overspeed trip device functions to stop the injection of fuel, which stops the diesel engine. When TRIPPED, the lever is inclined toward the left side of the engine and must be manually reset before the engine can be started.

A combination low water pressure and crankcase (oilpan) pressure detector is provided. The detector will trip when pressure in the oilpan exceeds a predetermined level or when loss of engine cooling water results in low pressure at the detector. When the detector is tripped, it dumps oil from the low oil shutdown in the engine governor, and the engine stops. Whenever a low oil shutdown occurs, the low water and crankcase pressure detector should be checked. The upper reset button protrudes if the shutdown was due to oilpan pressure. The lower reset button protrudes if the shutdown was due to low engine cooling water.

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 315 RPM at IDLE to 900 RPM in Run 8.

The throttle position is transmitted to the electro-hydraulic governor through electrical circuits. The governor is connected through 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 action in turn controls engine loading by adjusting main generator excitation and in this way maintains a predetermined speed/fuel relationship in the engine. This prevents undesired overloading of the diesel engine and insures stable operation at all throttle positions.

A device built into the engine governor stops the engine in the event of low oil pressure or in case a clogged system prevents oil from reaching the main lubricating oil pump on the suction side. This device is also actuated when the crankcase (oil pan) pressure/low water detector trips. If such 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 come on in the unit affected, the fuel pump will stop and the turbo lube pump will run.

COOLING SYSTEM

ENGINE COOLING

The engine cooling system in the locomotive is pressurized to provide more uniform cooling throughout the operating range of the engine. A schematic flow diagram of the closed engine cooling system is shown in Fig. 4-2.

SYSTEMS

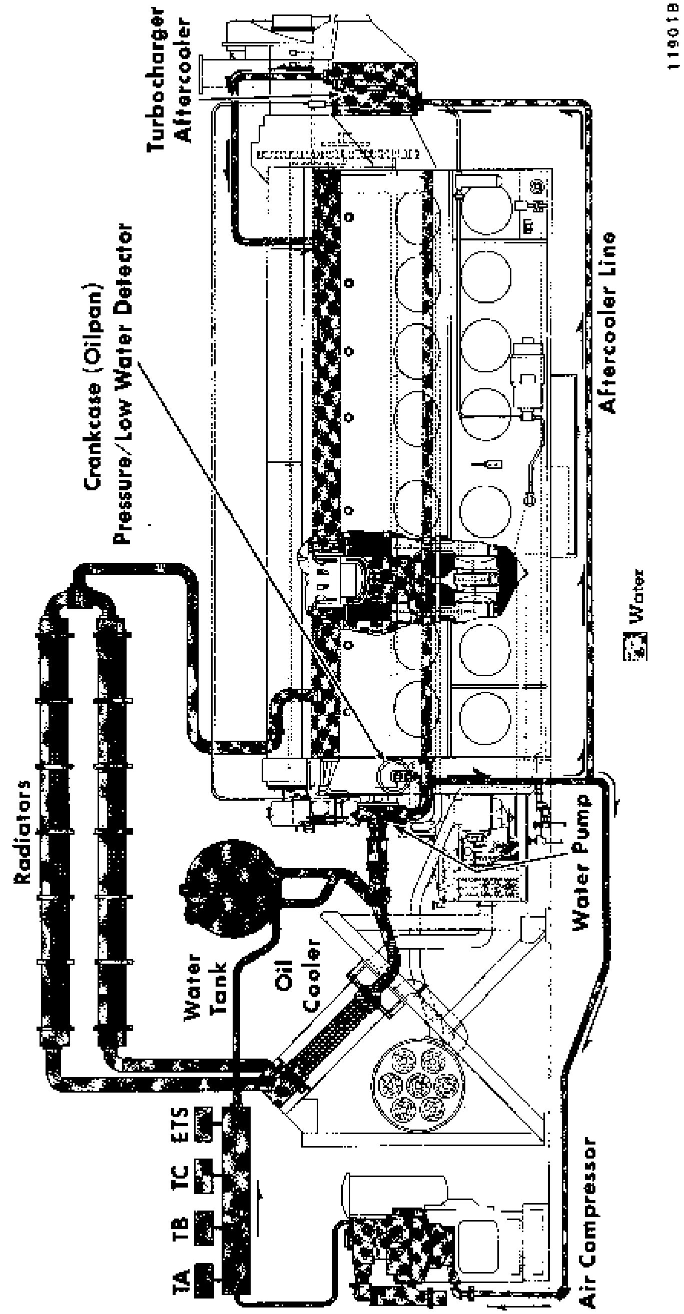


Fig. 4-2 — Cooling System Schematic Diagram

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 accessory drive gear train of the engine.

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

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.

The turbocharger aftercoolers receive water directly from the cross connection on the discharge side of the engine water pumps. As shown in Fig. 4-2, the flow of water goes to each aftercooler. Each aftercooler has its own return pipe 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.

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. 4-2. 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.

TEMPERATURE CONTROL

During circulation through the diesel engine and air compressor, 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 radiators are assembled in a hatch in the top of the long hood end of the locomotive. The hatch contains radiator sections which are grouped in two banks. Three AC motor driven cooling fans are located in the roof above the radiators. They are numbered 1 to 3 from front to rear, with the No. 1 fan being closest to the cab. Shutters, located along the sides of the hood, adjacent to the radiators, are operated by air cylinders controlled by the shutter magnet valve SMV. Control of the fans and shutters, and thus of the water temperature, is entirely automatic.

In operation, outside air comes in through the shutters and is drawn up through 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, Fig. 4-3, are designated TA, TB, and TC. These switches are located at the equipment rack and are flange mounted to a manifold that is installed in the cooling system piping. As the water discharges from the compressor, 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.

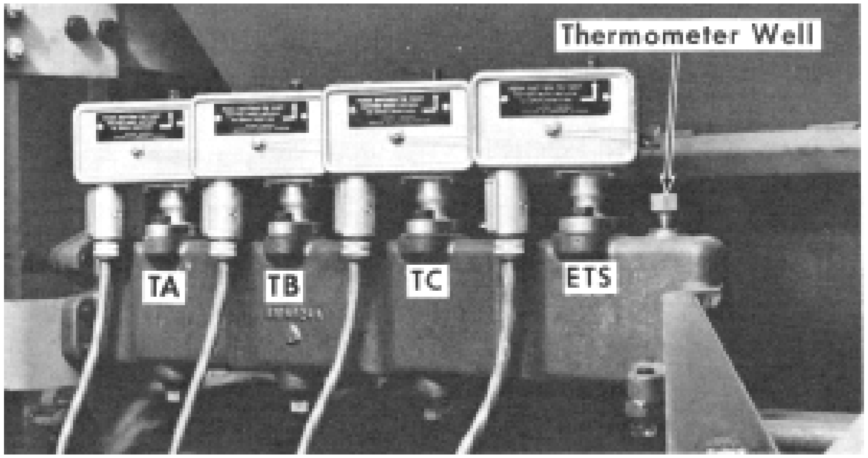


Fig. 4-3 - Engine Temperature Switches

The cooling fan contactors are designated AC1, AC2, and AC3. These contactors are located in a cabinet mounted on the equipment rack, see Fig. 4-4. When energized, they electrically connect their respective AC cooling fans to the alternating current supply from the alternator to run the fans.

The automatic temperature control functions as follows: TA picks up at 155° F. This establishes AC1, which starts the No. 1 cooling fan and establishes the first part of a holding circuit to AC2 and AC3. It simultaneously energizes shutter magnet valve SMV, applying air pressure to open the shutters and allowing passage of air through the radiators. TA drops out at 140° F. This de-energizes AC1, which in turn releases SMV and breaks the holding circuit to AC2 and AC3.

TB picks up at 163° F. This energizes AC2, which starts No. 2 cooling fan and completes the holding circuit to AC2. It also establishes a jumper circuit to SMV to open the shutters in case TA should fail to operate.

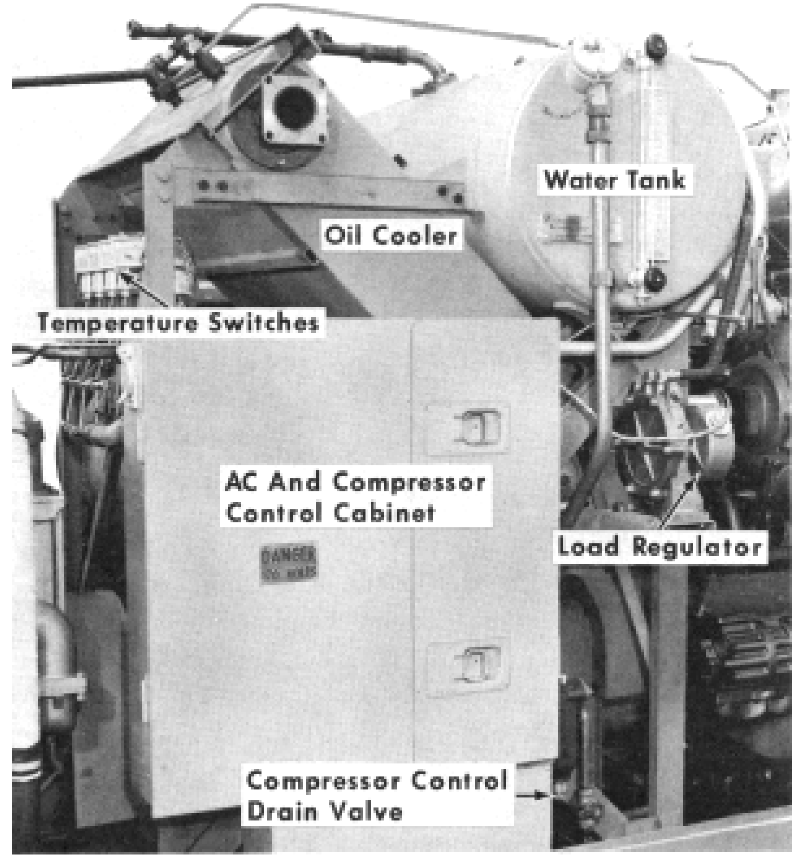


Fig. 4-4 - Equipment Rack

TB drops out at 148°F., however the holding circuit keeps AC2 energized.

TC picks up at 171 ° F. This energizes AC3, which starts No. 3 fan and completes the holding circuit to AC3. Action of AC3 does not provide a jumper circuit to SMV because of the probability of both TA and TB failing at one time is negligible. TC drops out at 156° F., however the holding circuit keeps AC3 energized. Once started, all fans operate until TA drops out to break the holding circuit.

HOT ENGINE ALARM

A hot engine alarm switch will close when water temperature at the engine temperature switch rises to approximately 200* F. This will cause the alarm bells to ring in all units and will light the hot engine light (red) on the engine control panel of the unit affected. The alarm can be silenced only by reducing the cooling system temperature below 190' F., at which point the switch contacts open.

Engine water temperature may be readily checked by means of a gauge located 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.

LOW WATER SHUTDOWN

A low water detecting device, Fig. 3-2, balances water pressure against airbox pressure. When water pressure falls within 1 psi of airbox pressure the device dumps oil from the governor supply line, causing an engine shutdown.

OPERATING WATER LEVEL

An operating water level instruction plate is provided next to the water level sight glass. The instructions indicate minimum and maximum water level with the engine running or stopped. The water level mark should not be permitted to go below the applicable "low" water level mark.

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 to add water to the cooling system, except at extended intervals.

FILLING COOLING SYSTEM

The system is filled through a filler opening located at the top of the engine water expansion tank. Water is added until it reaches the full mark on the upper instruction plate at the water sight glass. Care must be taken during the final stages of filling to prevent overfilling.

An overfill drain pipe is provided to allow run-off in the event of overfilling or excessive water expansion during operation.

After filling a dry or nearly dry system, the engine should be run, with the filler cap removed, to eliminate any air pockets in the system. After running the engine, check the water level and if necessary add water to the system.

NOTE: Draining of the cooling system will trip the low water shutdown device; therefore, when filling the cooling system the low water reset button must be pressed before engine start.

After filling operations have been completed and before starting the engine, the pressure cap should be replaced. The cap prevents loss of water due to evaporation during operation and limits the maximum pressure on the cooling system to provide better cooling for the engine. The cap is designed to open and relieve the system of excessive pressure during operation.

While the system is cooling down after operation, a slight vacuum may develop due to contraction of the water. The pressure cap is designed to release this vacuum by allowing atmospheric pressure to enter the system and replace the vacuum.

DRAINING COOLING SYSTEM

The engine cooling system should be drained inthe event that the diesel engine is stopped and danger of freezing exists. The draining procedure is as follows:

1. Remove fill cap.
2. 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.
3. The water pump on the right side of the engine will not completely drain through the main drain valves. To drain remaining water trapped in the pump, open the drain provided at the bottom of the pump housing.
4. With the cab heater supply valve open, cab heaters and associated piping are drained by opening drain valves located under the left side walkway.

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.

A 1/12th HP variable speed fan motor, controlled by a rheostat type switch, draws in fresh air or recirculates cab air. The fan forces air through a hot water radiator and exhausts the heated air out toward 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 left bank water pump discharge at the front end of the engine. To obtain circulation of water through the cab heaters, the supply valve must be opened.

LUBRICATING OIL SYSTEM

ENGINE OIL SYSTEM

A schematic diagram of the lubricating oil system is shown in Fig. 4-5. 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. 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 available 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.

TURBOCHARGER

The turbocharger lubricating oil is obtained from the engine lubrication system at a connection to the center of the upper idler gear stub-shaft. From this connection the oil is piped to a filter and returned to the area around the upper idler gear stub shaft. The oil is then externally channeled to a cover plate where external piping delivers the lube oil to the turbocharger body to supply the turbine with lubricating oil. Oil leaving the turbocharger empties into the rear gear train housing and drains back into the engine oil pan sump. A lube oil line from the turbocharger lubrication system, as shown in Fig. 4-5, connects to the engine governor for low oil pressure shutdown.

A separate automatically started motor driven turbocharger auxiliary lube oil pump is used to supply oil to the turbocharger prior to starting the engine and whenever the engine is shut down. The motor is timed to operate approximately 15 minutes after each time it is started. Oil circulation through the turbocharger is necessary prior to starting the engine and during the period when engine oil pressure is building up to provide proper lubrication. After the engine is shut down, continued oil circulation is necessary to remove residual heat from the turbo and return the hot oil to the oil pan sump. For this auxiliary pump to do the work for which it is intended, the main battery switch and the turbocharger auxiliary pump circuit breaker must be closed.

The turbocharger auxiliary lube oil pump draws oil from the oil pan sump, as shown in Fig. 4-5. Discharge from the pump is then filtered and fed into the turbocharger at a tee connection with the low oil shutdown line from the turbocharger to the governor. A check valve is located in the line between the tee connection and the pump to prevent feed back into the pump when it is not operating.

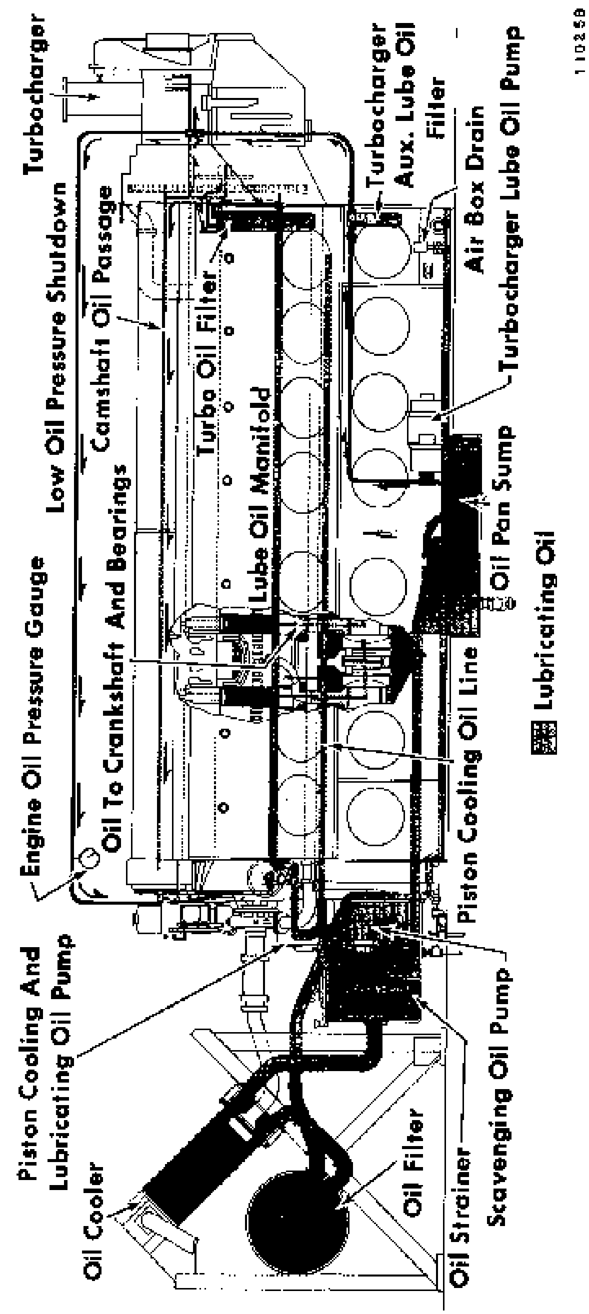


Fig. 4-5 — Lubricating Oil System Schematic Diagram

OIL LEVEL

The engine oil level should be checked with the engine hot and running at idle speed. A dipstick, Fig. 4-6, is located on the right side of the engine. It should show a level between LOW and FULL with the engine running. If the oil level is checked with the engine stopped, the reading on the dipstick will usually be above the FULL mark.

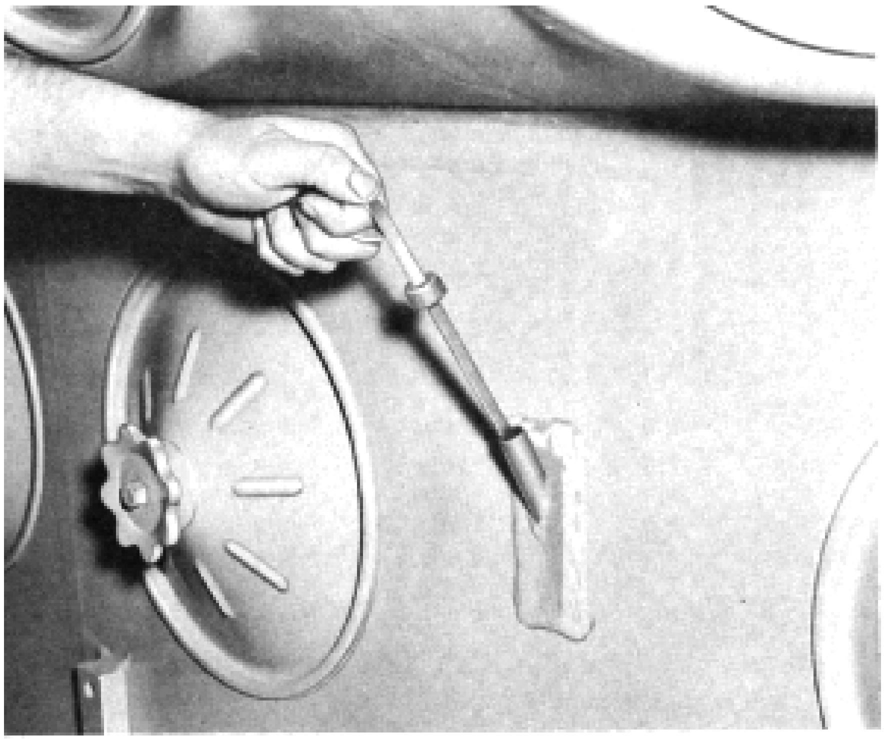


Fig. 4-6 - Checking Oil Level

ADDING OIL TO SYSTEM

Oil may be added with the engine running or stopped. When oil is added to the system, it MUST be poured into the strainer housing

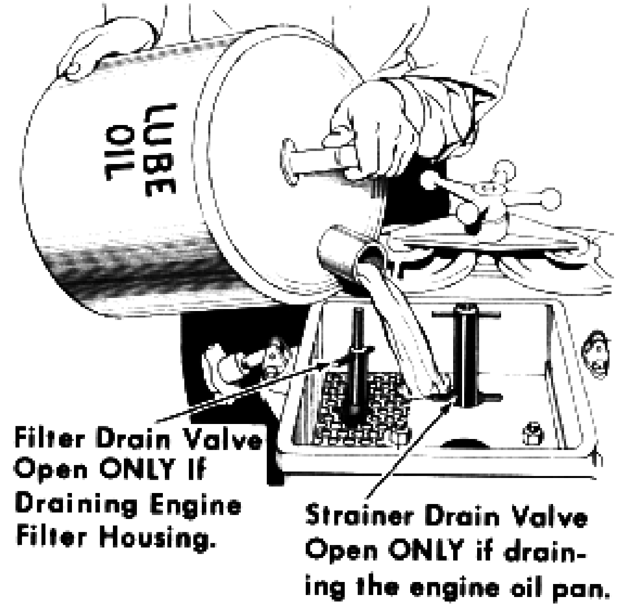


Fig. 4-7 - Adding Oil To The Engine

through the opening having the square cap, as shown in Fig. 4-7. Only lubricating oils qualified for use in EMD engines should be used. Total system capacity is 243 gallons with the basic oil pan and 395 gallons with the optional deep sump oil pan.

WARNING: Do not remove the round caps from the oil strainer while the engine is running. Hot oil under pressure will flow from the openings and possibly cause personal injury.

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 100 psi at full engine speed and about 35 psi at idle speed. These pressures may be somewhat lower however, 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 detected by 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. 4-8, 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 come on in the unit affected. The light will go out when the governor button is manually reset. The alarm can be silenced by placing the isolation switch in start position.

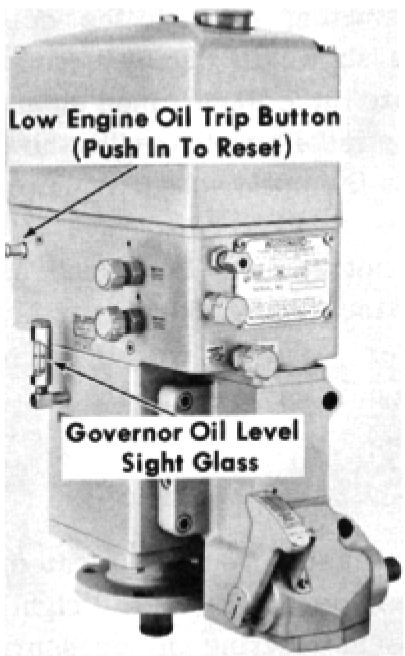


Fig. 4-8 - Engine Governor

An engine shutdown with a low oil indication does not necessarily mean that a low oil condition is the true cause of shutdown. This is because the low water and crankcase (oilpan) pressure detecting device releases oil pressure from the supply line to the engine governor when the detecting device is tripped due to lack of water pressure or due to a change from negative to positive pressure in the engine oilpan. Whenever a low oil shutdown occurs, the low water and oilpan pressure detector should be checked.

FUEL OIL SYSTEM

GENERAL. DESCRIPTION

A schematic diagram of the fuel oil system is shown in Fig. 4-9. 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 through a large vertical fuel filter to the engine mounted filter. 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.

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.

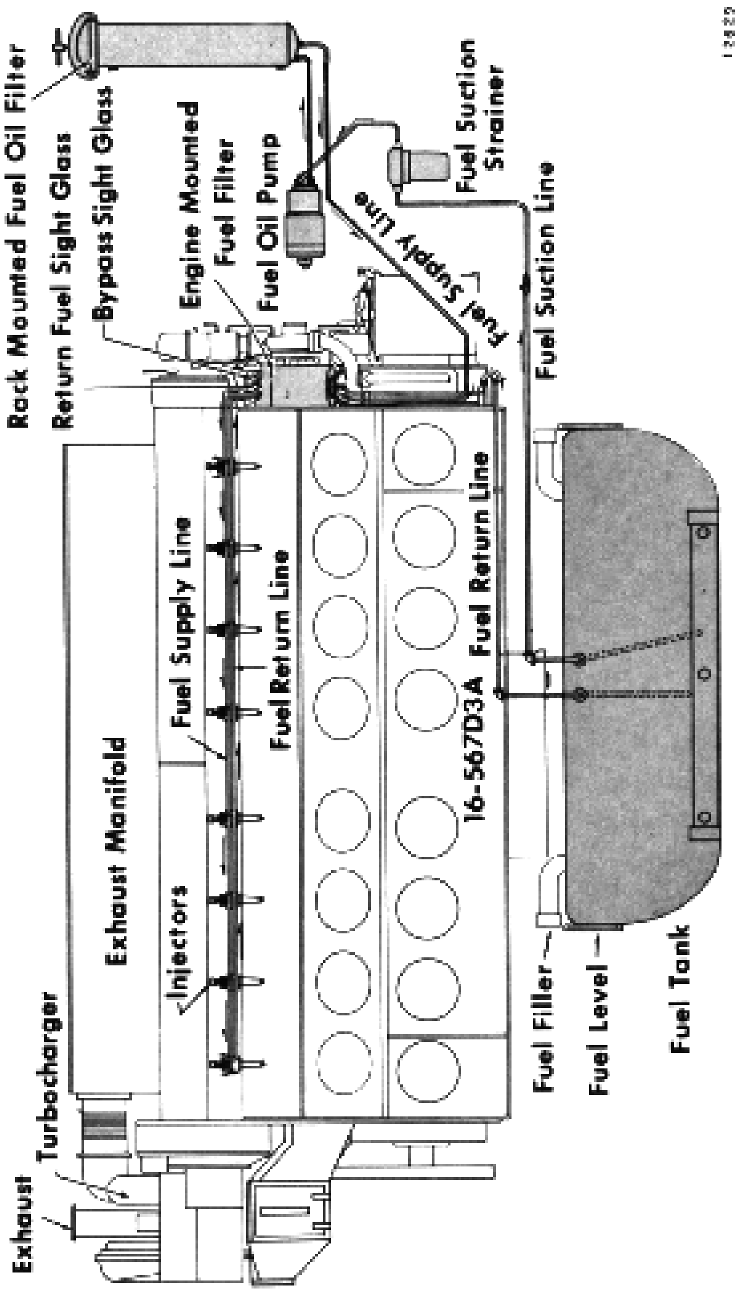


Fig. 4-9 — Fuel Oil System Schematic Diagram

FUEL SIGHT GLASSES

Two sight glasses, Fig. 4-10, are located on the engine mounted filter housing to give visual indication of fuel system condition.

For proper engine operation the return fuel sight glass (the glass nearer the engine) should be full, clear, and free of bubbles. 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.

The engine mounted filter is also equipped with a bypass relief valve and sight glass. This sight glass, farther from the engine, is normally

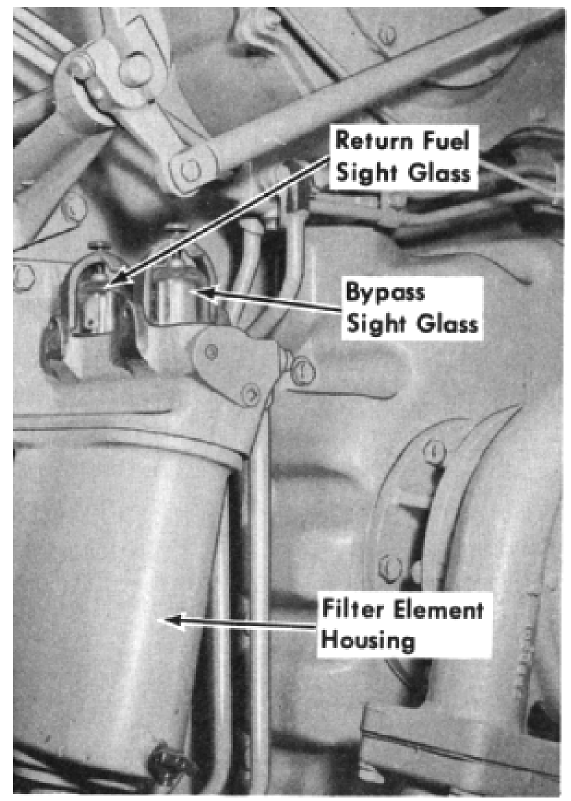


Fig. 4-10 - Fuel Oil Sight Glasses

empty. When more than a trickle of fuel is seen in the bypass sight glass, it indicates that the relief valve is open. Fuel will pass through the bypass sight glass and relief valve to bypass the engine and return to the fuel tank in case the filter elements become clogged. This condition may become serious and cause the engine to shut down from lack of fuel.

FILLING THE 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 of the tank to about 4-1/2" below the top and should be observed while filling the tank to prevent overfilling. DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

EMERGENCY FUEL CUTOFF SWITCHES

In the event of an emergency, the fuel supply to the engine can be stopped by pressing in on any one of the three emergency fuel cutoff switches. Two switches are located, one on either side of the locomotive, at the fuel tank, and the third switch is located at the upper left hand side of the electrical cabinet in the cab. The switches are connected in series with the fuel pump contactor FPC. Pressing in on any of the switch buttons momentarily will de-energize the FPC, stop the fuel pump and shut down the engine. The buttons are spring loaded and do not need to be reset.

COMPRESSED AIR SYSTEM

DESCRIPTION

Compressed air is used on a diesel locomotive for operating the air brakes and sanders, as well as the

shutter operating cylinders, horn, bell and windshield wipers. Air is also required for atomizing the fuel oil supplied to the steam generator (if so equipped). The basic locomotive is equipped with a three-cylinder compressor. A six-cylinder compressor maybe provided as optional extra equipment.

AIR COMPRESSOR

Compressed air is received from the water cooled two-stage compressor. The compressor is driven through a flexible coupling from the front end of the engine crankshaft. It has its own oil pump and pressure lubricating system. The level of oil in the compressor crankcase can be checked while the engine is running by observing the float-type indicator on the compressor base. At idle speed, with the compressor crankcase hot, the lubricating oil pressure should be approximately 15 to 20 psi. A plugged opening is provided for an oil pressure gauge.

The compressor has two low pressure and one high pressure cylinders. The pistons of all three cylinders are driven by a common crankshaft. Two low pressure cylinders are set at an angle to the one vertical high pressure cylinder. Air from the low pressure cylinders goes to a water cooled intercooler to be cooled before entering the high pressure cylinder. The intercooler is provided with a relief valve and a plugged opening for a pressure gauge. The intercooler pressure should measure from 50 to 55 psi when the compressor is loaded, and the relief valve should release at 65 psi.

COMPRESSOR CONTROL

Since the air compressor is directly connected to the engine, the compressor is in operation (although not always pumping air) whenever the engine is running. An unloader piston that cuts out the compressing action when actuated by air pressure from the compressor governor control, is provided in the head of each high and low pressure cylinder. The unloader accomplishes this by blocking open the intake valves in 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.

When the locomotive is furnished with the optional extra of compressor synchronization, each locomotive unit is equipped with an electro-pneumatic system for compressor governor control. The electrical arrangement is such that the compressor in each unit of a consist pumps air to its own main reservoirs whenever the main reservoir pressure in any single unit drops to 130 psi. All units will continue to pump until main reservoir pressure in each and every unit reaches 140 psi.

On special order the compressor control system may be equipped with a dual compressor control switch that acts to unload the compressor on an individual unit when main reservoir pressure for that unit reaches 145 psi. This prevents individual compressors from working against the main reservoir safety valve when other units in the consist have not yet accumulated sufficient main reservoir pressure to signal unloading of the compressors.

A manual means is also provided for keeping the air compressor unloaded. In this case, the method used is to mechanically hold the compressor control air valve open.

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

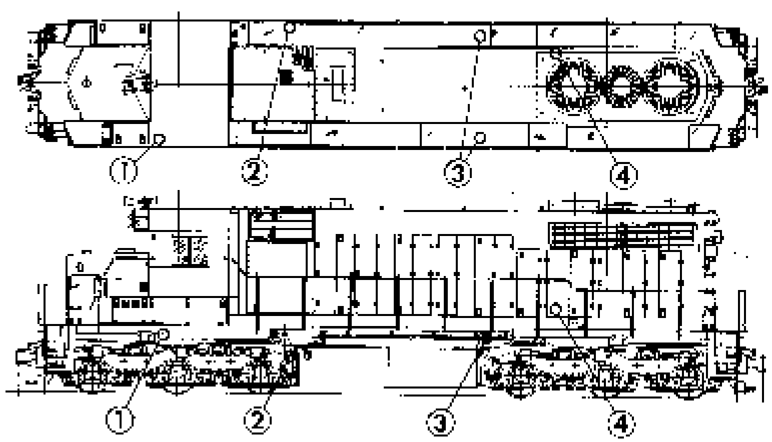
frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at least once a day until a definite schedule can be determined by the individual railroad.

Drain valves should be operated at the following locations:

1. Momentarily open the drain cock for the centrifugal dirt filter, 1, Fig. 4-11 and Fig. 4-12.

2. Momentarily open the "H" filter drain valve, 2, Fig. 4-11 and Fig. 4-13.

3. Momentarily open the main reservoir drain valves, 3, Fig. 4-11.



1. Aux. Main Reservoir Centrifugal Filter
2. "H" Filter Drain Valve
3. Main Reservoir Drain Valve
4. Compressor Control Strainer Drain Valve

Fig. 4-11 - Compressed Air System Drain Valve Locations

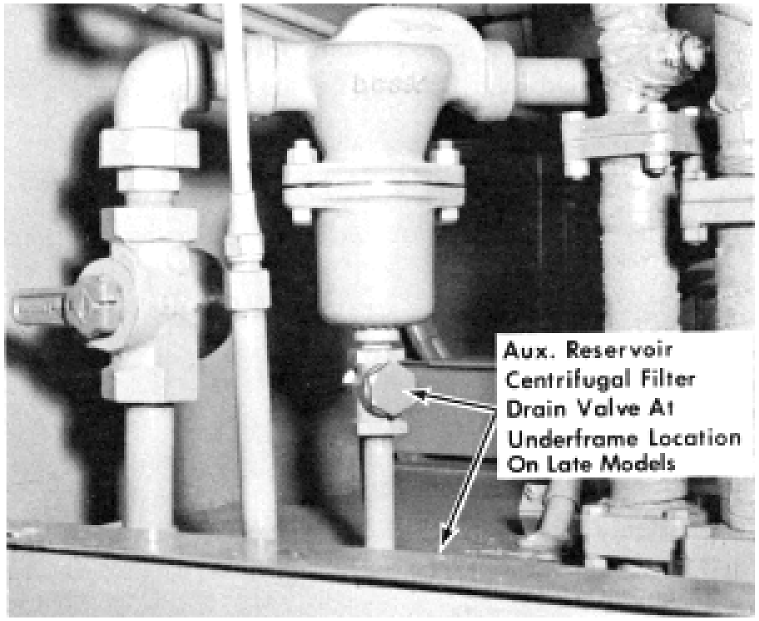


Fig. 4-12 - Aux. Main Reservoir Centrifugal Filter

Fig. 4-13 - "H" Type Filter

SYSTEMS

5. Press up on the pushbutton at the base of the compressor control strainer, 4, Fig. 4-11 and Fig. 4-4.

CARBODY AIR SYSTEMS

Air is taken into the carbody (hood) for three separate systems; one for engine cooling; one for dynamic brake grid cooling; and a third for motor and generator cooling, engine fuel combustion, and compartment pressurization.

Engine Cooling

Radiator cooling air shutters high on either side of the hood end of the locomotive control the flow of air to a compartment separated from the engineroom by a drop ceiling. This compartment houses the engine cooling radiators and fans. Air for engine cooling purposes is therefore separate from other air systems. Refer to the article on the cooling system for information on fan and shutter operation.

Brake Grid Cooling

If the locomotive is equipped with dynamic brakes, a separate compartment above the engine houses the dynamic brake grids and cooling fans. Air intakes high on either side and at the center of the locomotive hood open into the grid compartment. Refer to the article on dynamic braking for information covering operation of the system.

Central Carbody System

Two air intakes located high on the sides of the hood and directly behind the control cab open into a compartment from which air is drawn by the following devices:

1. Turbocharger. Intake filters in ducts leading to the turbocharger are placed within the compartment.

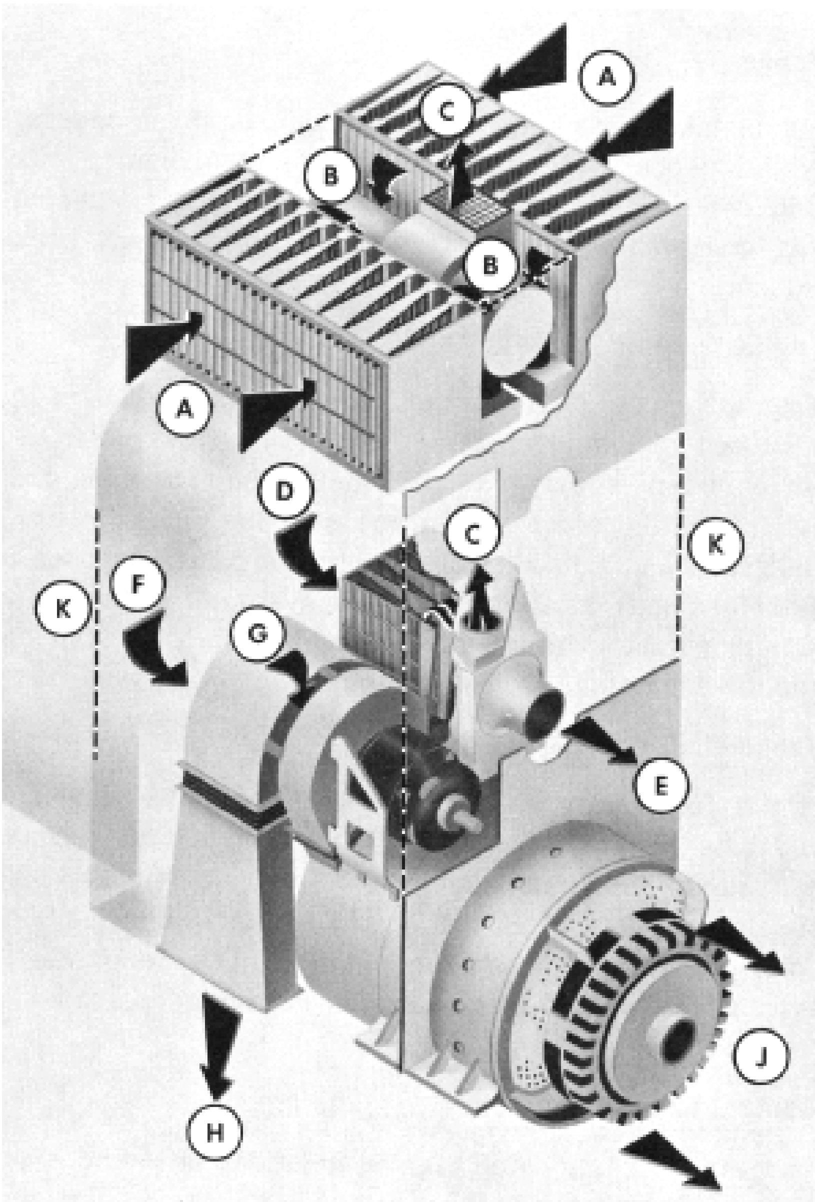
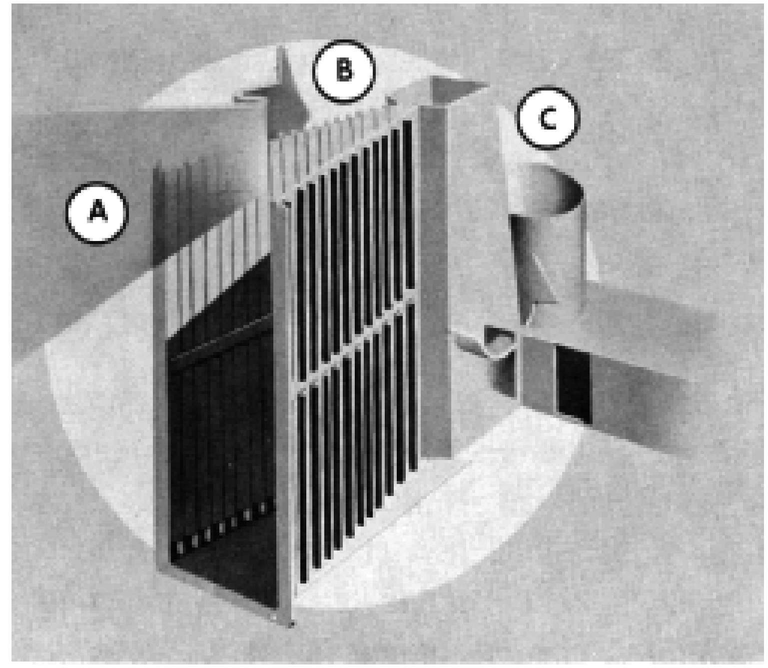


Fig. 4-14 - Central Carbody Air System



A Outside Air Intake To Primary Inertial Filters
B Clean Air Into Sealed Compartment
C Blower Driven Air Carrying Dirt
D Intake For Engine Air Inertial Filter
E Clean Air To Engine
F Intake To Traction Motor Blower
G Intake To Generator Blower
H Cooling Air Ducted To Traction Motors
J Generator Cooling Air Pressurizes Engine Compartment
K Outline Of Sealed Central Air Compartment

Fig. 4-14 - Central Carbody Air System

2. Traction Motor Blower. This blower provides cooling air to the traction motors.

3. Generator Blower. Air from this blower is forced through the generator and into the engine room, thereby cooling the generator and pressurizing the engineroom to prevent entry of dust.

AIR FILTRATION

Intakes to the engine cooling compartment and the dynamic brake grid compartment are not provided with filters. However, two multi-cell inertial air filters, one in each intake opening, filter air entering the central compartment. The demands of the devices that draw air from the compartment cause outside air to flow rapidly through wedge-shaped filter cells, Fig. 4-14. Dirty air enters at the wide ends of the cells, and dust particles, because they are heavier than air, tend to travel in a straight line and are carried into a bleed duct by the flow of bleed air. The main portion of the air, separated by the action of inertia from the dirt it carries, changes direction abruptly, passes through narrow side passages in the filter cell and enters the compartment as clean air. The bleed air containing dirt is drawn through an electrically driven bleed blower and is expelled through the roof of the locomotive.

Additional filtering of air directed to the turbocharger is provided by filters that also employ the inertial separation principle. Clean air is directed to the turbocharger, and dirt is carried by bleed air through the bleed blower mentioned previously.

An impingement type filter mounted on the air compressor provides additional filtering of compressor intake air.

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 excite the main generator and to drive auxiliaries such as fans and blowers; the auxiliary generator supplies low voltage electricity for the control circuits, lights, motor driven pumps, and alternator excitation. On SDP35 locomotives a heavy duty auxiliary generator is provided to supply power to operate the steam generator.

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, reactors, switches, circuit breakers and regulators. As a group, such equipment is referred to as electrical switchgear. This switchgear is housed in three electrical cabinets.

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. The equipment functions automatically, without any attention required on the part of the operator.

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 output, if the voltage increases the amperage decreases, and vice versa.

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

The following field windings are built into the generator.

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 current from the magnetic amplifier. It is energized by the closing of the battery field BFA contactor to provide initial generator excitation. The electrical output of the generator is controlled by varying the excitation of this field.

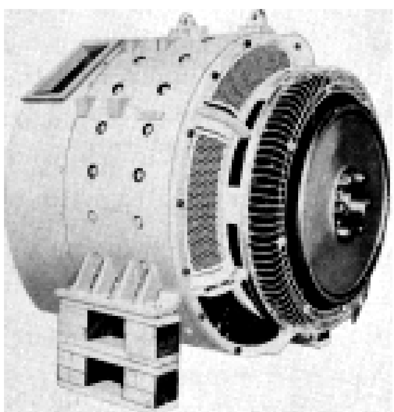


Fig. 5-1 - Main Generator-Alternator

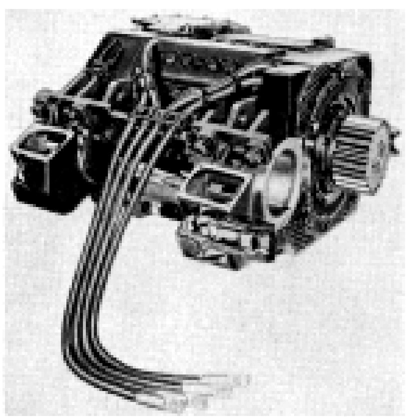


Fig. 5-2 Traction Motor

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. Electromagnetic power contactors connect the main generator to the motors through circuits that control operating characteristics. 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 electromagnetic reversing contactors. These contactors establish the circuits necessary for operation in either direction.

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 cooled by means of an external blower located in the locomotive unit and mechanically driven from the engine.

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 900 RPM, alternator output is 195 volts AC at 120 cycles per second.

The alternator rotor (field) is excited by low voltage current which it receives from the auxiliary generator through a pair of slip rings and brushes.

With the exception of a 60 ampere protective fuse 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

All low voltage direct current electricity required during locomotive operation comes from the auxiliary generator, Fig. 5-3. This current is used for excitation of the 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.

LOAD REGULATOR

The load regulator, Fig. 5-4, is a wire-wound type rheostat that is driven by a hydraulically operated vane motor. A pilot valve in the engine governor controls a flow of engine oil under pressure to drive the vane motor clockwise or counterclockwise through a maximum arc of about 300 degrees, thereby positioning the rheostat brush arm and regulating the output of the main generator by varying excitation of its battery field.

The load regulator pilot valve in the engine governor moves up to open one port or down to open another port and directs the flow of

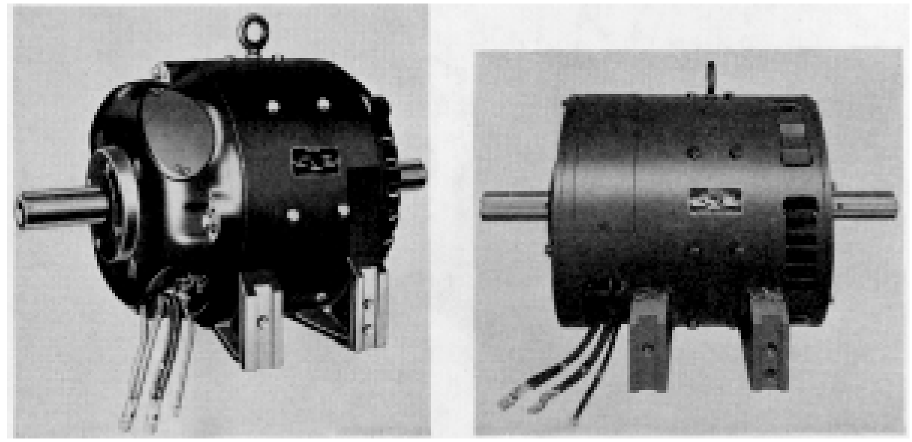


Fig. 5-3 - Auxiliary Generator

oil to the proper side of the vane motor whenever the load on the engine demands more or less fuel than the engine is set (by adjustments in the governor) to receive at a given throttle position.

For example, increased load, as when a train begins to climb a hill, will cause a momentary slowdown in engine rotating speed. Immediately the governor will react to increase the injection of fuel and maintain the specific engine speed called for by a given throttle position. The governor mechanism that moves to provide more fuel also opens the load regulator pilot valve, directing the flow of oil to drive the load regulator in a direction that causes reduced generator output (reduced engine load).

The combination of increased fuel and reduced generator output causes engine speed to increase; and as engine speed returns to that called for by the throttle setting, the governor mechanism assumes normal fuel position for the throttle setting, thereby closing the pilot

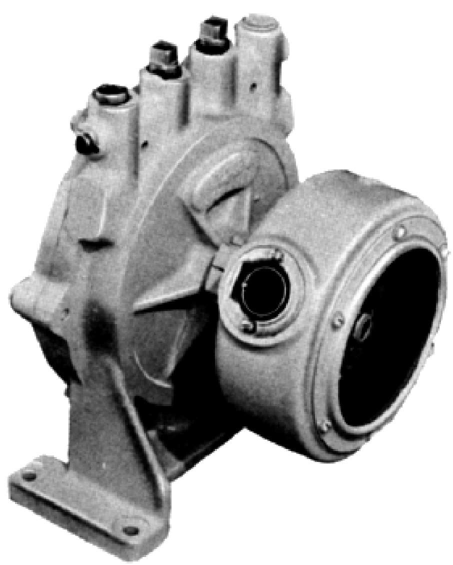


Fig. 5-4 - Load Regulator

valve and stopping the load regulator at a stable position. In this manner the load regulator allows the engine to maintain a constant rotating speed and power output for each throttle setting.

Factors such as temperature of the main generator windings and traction motor rotating speed also affect engine load. These factors as well as changes in grade or train weight are compensated for by load regulator action.

An overriding solenoid ORS, located in the governor, can override the normal action of the load regulator pilot valve. When ORS is energized it forces the load regulator pilot valve open, causing the load regulator to move toward the minimum field excitation position. The ORS is energized during transition, during wheel slip, and when the throttle is in IDLE position.

NOTE: The ORS coil is energized by local power through the local control circuit breaker, but its negative side is connected through the control circuit breaker. For this reason, the control circuit breaker must remain ON in trailing units of a multiple unit consist.

ELECTRICAL CABINET

The electrical cabinets, Fig. 5-5, 5-6, and 5-7, house the majority of the locomotive electrical switch gear and static devices. The following articles provide a brief description of these electrical components.

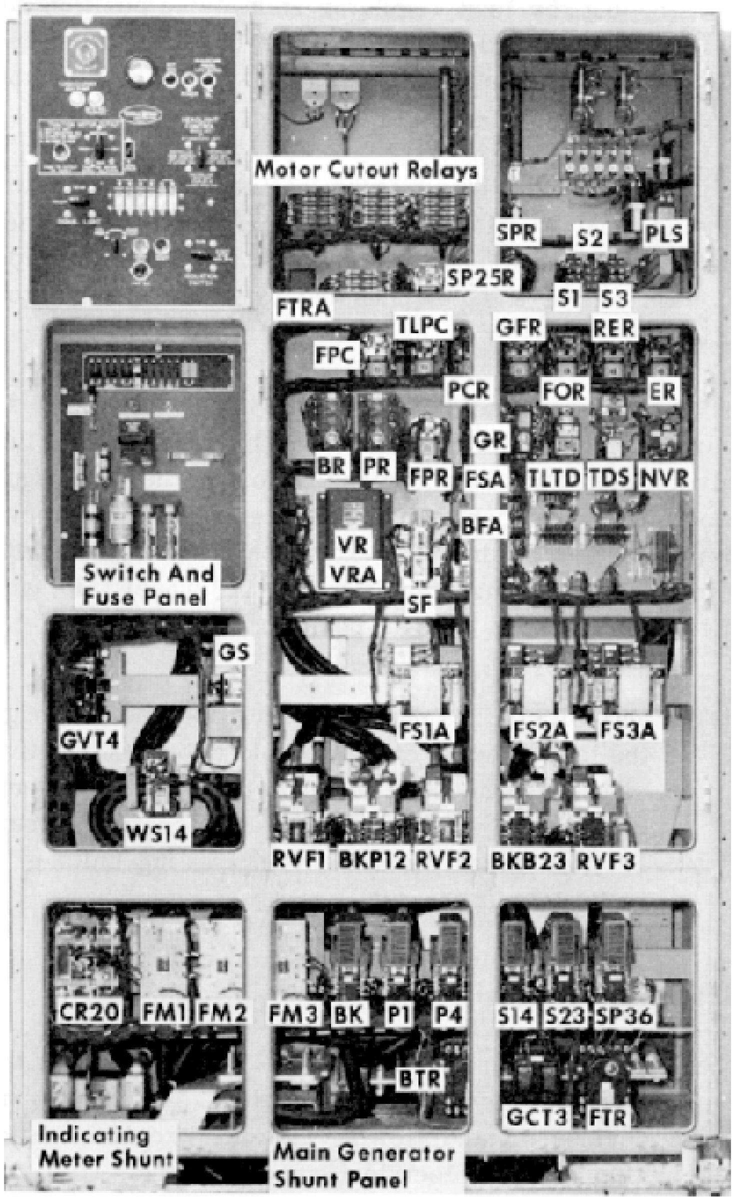


Fig. 5-5 - No. 1 Electrical Cabinet
Cab Side

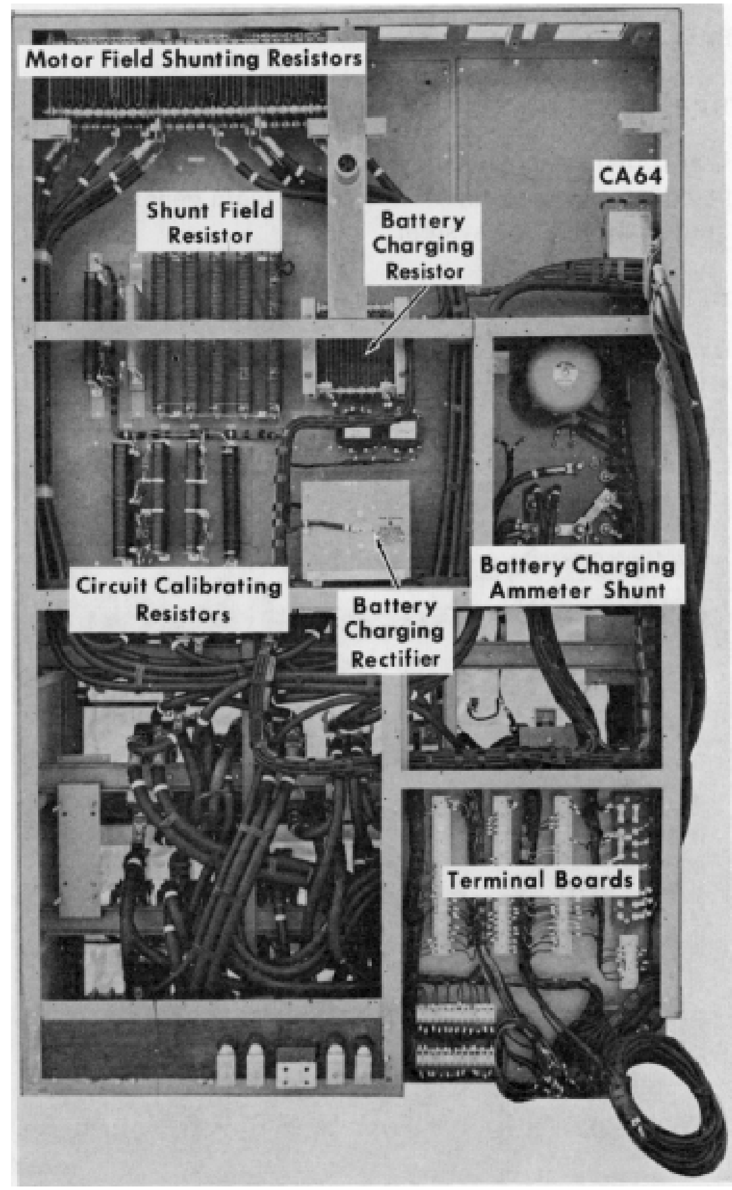


Fig. 5-6 - No. 1 Electrical Cabinet
Engine Room Side

BASIC COMPONENTS

BFA, BATTERY FIELD CONTACTOR

Controlled by interlocks of the shunt field contactor, BFA provides primary excitation of the main generator from the locomotive AC system.

BTR, BACKWARD TRANSITION RELAY

Dropout and subsequent pickup of this relay initiates all steps of backward transition.

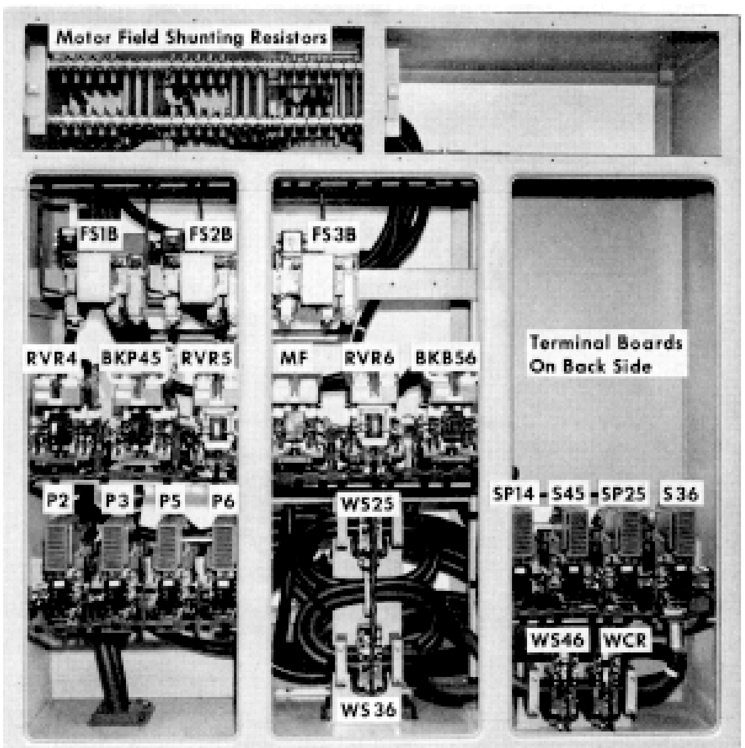


Fig. 5-7 - Electrical Cabinet Side Away From Engine Room

CR-BC, BATTERY CHARGING RECTIFIER

The battery charging rectifier consists of a pair of heat-sink mounted silicon diodes in parallel with a selenium suppression rectifier that protects the silicon diodes from high voltage spikes. The rectifier prevents battery current from flowing through the windings of the auxiliary generator and alternator when the diesel engine is stopped.

ER, ENGINE RUN RELAY

The function of the engine run relay is to set up control circuits to governor speed setting solenoids. Therefore, if the engine run relay is de-energized, such as during operation of certain safety devices, the diesel engine will not run above idle speed.

FM1, FM2, FM3; REACTORS

A reactor is simply a coil connected in an alternating current circuit. When the coil is wound on an iron core, the magnetic lines of flux oppose changes in polarity, and current flow through the coil will increase only slightly if the applied voltage is increased. However, if the voltage applied is great enough to saturate the core, current will then increase rapidly as voltage is increased.

The degree of saturation may be controlled independently by placing a DC control winding on the core. If this winding contains more turns than the AC winding, a small amount of DC current can be made to control a large amount of AC current. This gain can be further increased by placing a rectifier in the AC circuit. The rectifier causes a pulsating DC current to flow through the reactor and the desaturating effect of changes in polarity is eliminated.

In addition to one or more control windings, a bias winding may be applied to the reactor to shift the output to a better control point. For example, the bias winding may achieve minimum output when control current is zero. Reactors FM1, FM2, and FM3, together with three phase silicon rectifiers CR20 make up the magnetic amplifier used on the SD35 locomotive. This amplifier provides main generator excitation using alternator output controlled through windings employing DC control current.

FOR, RER, FORWARD AND REVERSE RELAYS

These relays control the direction in which the locomotive will move. The designations FOR and RE R are related to the No. 1 end of the unit. The relays are energized by trainlined control current when the reversing lever is placed in the appropriate position. Contacts of the relays make or break circuits using local current to actuate heavy duty electromagnetic switchgear. The switchgear establishes the direction of high voltage main generator current flow through the traction motor fields.

Crossover wires at each of the jumper cable receptacles between units of a locomotive consist are so arranged that whatever the makeup of the consist, the appropriate relays in trailing units will be energized.

FPC, FUEL PUMP CONTACTOR

The purpose of the fuel pump contactor is to bring about shutdown of the diesel engine when the STOP button or one of the EMERGENCY FUEL CUTOFF buttons is pressed. Dropout of FPC accomplishes shutdown by breaking circuits to the governor speed setting solenoids and at the same time independently energizing the shutdown solenoid DV.

FPR, FUEL PUMP RELAY

This relay prevents engine start until control circuits are established. It also provides trainlined control of the fuel pump motor through the control and fuel pump switch.

FSA, FIELD SHUNT AUXILIARY RELAY

This relay is used in the transition sequence circuits to prevent transition until all shunt has been removed from traction motor fields.

FSIA THROUGH FS3B, FIELD SHUNTING CONTACTORS, Fig. 5-8

These contactors connect the field shunting resistors in parallel with traction motor fields. The contactors are energized singly and in combination to provide the required percentage of motor field shunt.

FTR, FORWARD TRANSITION RELAY

Pickup and subsequent dropout of this relay initiates all steps of forward transition.

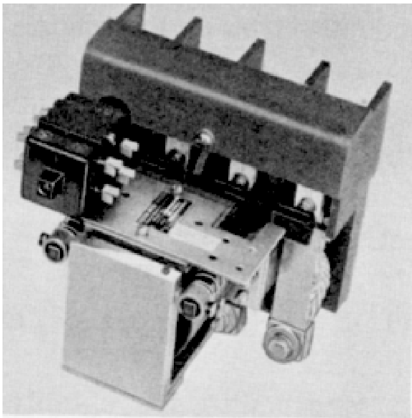


Fig. 5-8 - Field Shunting Contactor

GFR, GENERATOR FIELD RELAY

This auxiliary relay is energized when the throttle is opened for power. It is not energized during dynamic braking. It functions to prevent the engine from shutting down when a safety function occurs, to shut the engine down when the throttle is placed in STOP position, to provide local power to the transition sequence circuits when the throttle is opened, and it prevents braking contactors picking up when the throttle is opened for power. During dynamic braking, GFR contacts short out the signal from the main generator voltage sensing transductors and they remove a short from around the dynamic brake regulator contacts.

GR, GROUND RELAY

The ground relay is a protective device used to detect low voltage grounds when starting the engine or high voltage grounds when operating under power. When the relay is tripped, the ground relay light comes on, the alarm bell rings, and the diesel engine is restricted to idle speed. The relay is held in its tripped position by a mechanical latch and must be reset by pressing the ground relay reset button on the engine control panel.

If the locomotive is operating with the motor fields shunted and the ground relay trips, GR contacts pick up to prevent the motor field shunting contactor from opening on high current.

GS, GENERATOR (ENGINE) STARTING CONTACTOR

When the control circuits are established and the fuel prime/engine start switch is placed in the engine start position, the GS contactor closes to provide battery current to the starting winding of the main generator. Auxiliary

of GS operate to energize the fuel pump contactor and to preclude battery operation of the traction motors.

GVT, GENERATOR VOLTAGE TRANSDUCTOR

The generator voltage transductor is used to supply a signal proportional to generator voltage. That signal is directed to the primary winding of transformer T4.

NVR, NO (AC) VOLTAGE RELAY

This relay is energized by AC current during operation. In the event that the alternator fails or AC power is otherwise lost, NVR drops out to set up circuits to sound an alarm, restrict the engine to idle speed, and start the turbine lube oil pump motor. The turbine lube oil pump light comes on when NVR contacts drop; the no power light will also come on if the isolation switch is in RUN position.

PCR, PNEUMATIC CONTROL RELAY

The function of PCR is to reduce the diesel engine to IDLE speed when a penalty or emergency application of the brakes occurs.

PLS, STATIC POWER CONTROLLER

The PLS is a transistorized fully static device, Figs. 5-9 and 6-10, that controls current through the drive windings 11-12 of the reactors that are part of the magnetic amplifier. This controls magnetic amplifier output to the battery field windings of the main generator and thereby controls locomotive power.

The PLS compares the following signals (a with b) across the base and emitter of a "signal detecting" transistor.

a. Signal from the main generator voltage and current transductors that is proportional to generator voltage and current.

b. Signal from the load regulator during operation under power, or from the brake control rheostat during operation in dynamic brake.

When the load regulator or brake control signal is greater than the transductor signal (system calling for more power), the "signal detecting" transistor is switched on, and current flows through the transistor,, When the "signal detecting" transistor conducts, a "signal changing"' transistor is switched on, and this in turn switches on a "power" transistor. Current flows through the drive windings

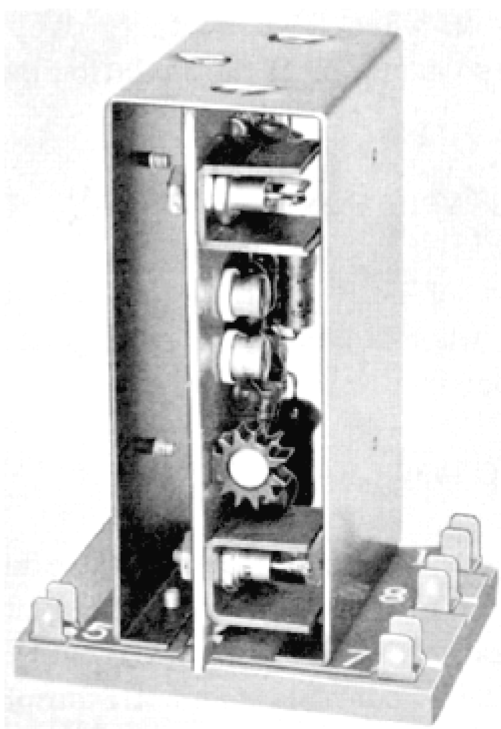


Fig. 5-9 - Static Power Controller, PL.S

11-12 of the magnetic amplifier and throughthe "power" transistor. Main generator battery field current is increased, with a consequent increase in generator output. As a result of increased generator output, the signal from the main generator current and voltage transductors increases, and when the potential at the "signal detecting" transistor is reversed the transistor is switched off. The "signal changing" and the "power" transistors are in turn switched off, and generator excitation decreases.

This system accomplishes power control through the use of solid state electronic devices without the use of the polarized relay that was a part of early and intermediate power control systems using a magnetic amplifier,

PR, PARALLEL RELAY

The contacts of the parallel relay operate in the transition sequence circuits to ensure proper transition from series-parallel to parallel and back to series-parallel and to ensure proper motor field shunting when operating in parallel. PR contacts also control generator excitation during transition and they set up the circuit for detection of 6-axle simultaneous wheel slip.

P1 THROUGH P4, PARALLEL POWER CONTACTORS, Fig. 5-10.

These electro-magnetic contactors are energized and closed to connect all of the traction motors in full parallel with the main generator. Auxiliary contacts of these contactors perform various functions in the control circuits.

RVF1, RVF2; REVERSER SWITCHGEAR, FORWARD, Fig. 5-11.

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

RVR3, RVR4; REVERSER SWITCHGEAR, REVERSE

The electro-magnetic reversing switches are actuated by the reverse relay RER in response to reverse lever position in the cab. The switches are energized by local control power from the low voltage system in each unit. They control the direction of current flow through the motors for reverse rotation.

SF, SHUNT FIELD CONTACTOR

This contactor closes during operation under power when the throttle is opened and the generator field switch is closed, Its main

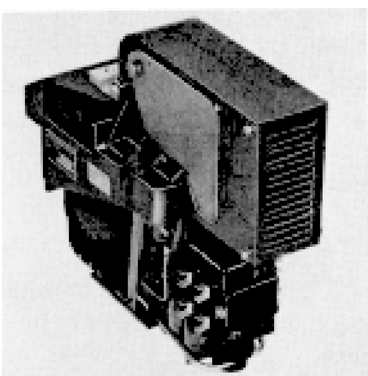


Fig. 5-10 - Power Contactor

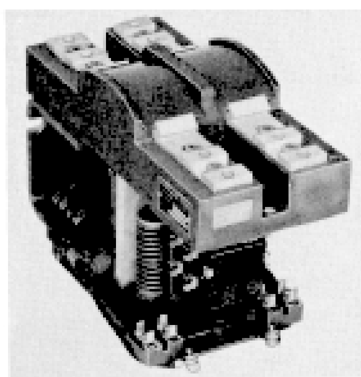


Fig. 5-11 - Reversing Switchgear

contacts complete the self excitation circuit of the main generator; its auxiliary contacts act to establish the main generator battery field circuit.

SPR, SERIES-PARALLEL RELAY

The contacts of the series-parallel relay operate in the transition sequence circuits to ensure proper transition from series to series-parallel and then to parallel and back to series. They also ensure proper motor field shunting and they control generator excitation during transition.

SP14, SP25, SP35; SERIES-PARALLEL POWER CONTACTORS

These contactors are energized and closed to connect the traction motors in three groups of two motors in series. The three groups are connected in parallel across the main generator.

SP25R, SERIES-PARALLEL AUXILIARY RELAY

The contacts of this relay perform as an extension of SP25 contactor interlocks. They perform in the transition sequencing circuits.

S1, S2, AND S3; STEP RELAYS

These relays respond to FTR pickup and RTR dropout. Their contacts set up the circuits for pickup of appropriate motor field shunting contactors. In turn, interlocks of the motor field shunting contactors set up the circuits for pickup of series-parallel relay SPR or parallel relay PR.

S14, S23, S45, S36; SERIES POWER CONTACTORS

These contactors are energized and closed to connect the traction motors in two groups of three motors in series. The two groups are connected in parallel across the main generator.

TDL, TIME DELAY SANDING LIGHT RELAY

This relay is energized whenever the wheel slip control system functions to correct a wheel slip, but delayed pickup of its contacts prevents the wheel slip light from coming on unless the slip is of long duration (approximately 4 seconds). The relay prevents wheel slip light indications when slips are normally corrected by the wheel slip control system.

TDS, TIME DELAY SANDING RELAY

Pickup of the wheel creep or wheel slip relays energizes TDS, causing a timed application of sand.

TLPC, TURBINE LUBE PUMP CONTACTOR

The function of TLPC is to energize the turbine auxiliary lube oil pump at engine start and at engine shutdown and to prevent engine start until the auxiliary lube oil pump is operating.

TLTD, TURBINE LUBE TIME DELAY RELAY

The TLTD is energized whenever the main battery switch is moved from open to closed position and the turbine lube pump motor circuit breaker is closed. TLTD contacts close for a period of approximately 15 minutes to energize the turbine lube oil pump contactor TLPC, which in turn controls

the turbine lube oil pump. TLTD is recycled if the circuit is interrupted by the engine start or stop switch or if an engine shutdown causes NVR interlocks to close.

T3, TRANSFORMER

The primary of T3 receives its energy from the alternator through coils of main generator current transductor GCT. The output of T3 is proportional to main generator current and is used to control locomotive power.

T4, TRANSFORMER

The primary of T4 receives its energy from the alternator through coils of main generator voltage transductor GVT. The output of T4 is proportional to main generator voltage and is used to control locomotive power.

VR, VOLTAGE REGULATOR, Fig. 5-12

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 during operation. The regulator utilizes solid state electronic components to regulate auxiliary generator voltage. The regulator does this by rapidly turning the generator field circuit on and off. Time "on" in relation to time "off' establishes auxiliary generator voltage. The regulator is called a static voltage regulator because with the exception of a starting relay it uses no moving parts.

It is often desirable to change auxiliary generator voltage in order to change the charging rate at the locomotive batteries. It is however, necessary to maintain a stable reference voltage at the locomotive excitation and power control circuits. For these reasons the voltage regulator is provided with a rheostat that may be turned to adjust generator voltage between 72 and 76 volts while a stable 72 volt reference is maintained at the terminal marked 72V REF.

The voltage regulator function is unchanged whether the particular model has the 72V REF terminal on its face or whether the 72V REF terminal appears on the voltage regulator auxiliary VRA that is affixed to the face of the earlier model basic regulator. Fig. 5-11

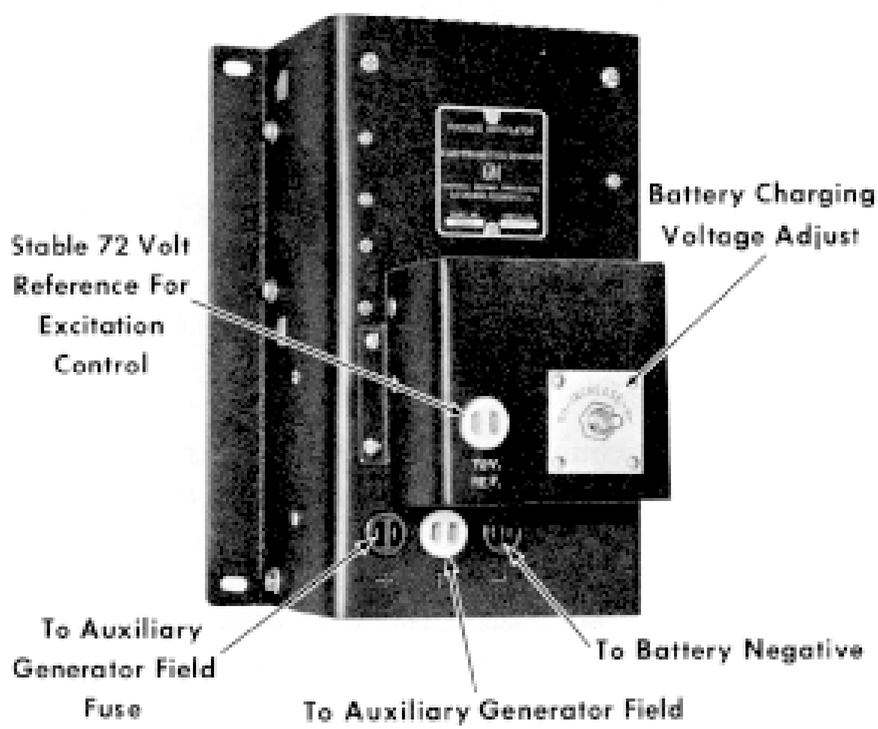


Fig. 5-12 - Auxiliary Generator Static
Voltage Regulator Equipped With VRA

illustrates the earlier model regulator with VRA affixed to the face of the basic regulator.

VRA, VOLTAGE REGULATOR ADAPTER

The voltage regulator adapter is affixed to the face of the basic voltage regulator. It provides a stable 72 volt reference terminal while allowing auxiliary generator voltage to be adjusted between 72 and 76 volts.

The basic voltage regulator is set at the factory to regulate at 72 volts, and the physical placement of VRA on the basic regulator prevents inadvertent change of the basic voltage adjustment. This fixed 72 volts is not, however, the output of the auxiliary generator, because VRA inserts variable resistance to secure a known and controlled voltage drop between the auxiliary generator and the voltage regulator detecting circuits. Auxiliary generator voltage will therefore normally be higher than the basic VR setting of 72 volts.

WCR, WHEEL CREEP RELAY

The wheel creep relay detects slight electrical unbalance between traction motors. It initiates automatic sanding before an actual slip occurs, but it does not act to reduce locomotive power. WCR action does not cause the wheel slip light to come on.

WCR is most sensitive when operating current levels are high. However, during series-parallel traction motor connection, wheel slip bridge circuits become more sensitive than WCR as train speed increases and current levels drop. Finally, during full parallel traction motor connection, WCR action is superfluous.

On locomotives equipped with dynamic brakes, the voltage coil of WCR is connected in series with limiting resistance across the main generator. If generator voltage increases to a high level due to overheated motor fields, WCR will trip and reduce generator excitation, thereby protecting the motors.

WS14, WS25, WS36; WHEEL SLIP RELAYS

During series-parallel traction motor connection with the main generator, the voltage coils of these relays are connected in bridge circuits with paired traction motors and fixed resistors. Electrical unbalance of the bridge caused by traction motors rotating at different speeds, as is the case during wheel slip, results in current flow through the relay coil. Pickup of the relay interrupts generator excitation, initiates a timed application of sand, and energizes the time delay wheel slip light relay.

During parallel motor connection the voltage coils of the relays are disconnected, and the relays are activated by current differentials in the cables passing within the relay frames in the same manner as with WS46 and WCR. However, since current levels are low during parallel motor connection, each cable is wound double to pass twice through the relay frame. This doubles the sensitivity of the relays, making them more sensitive than either WS46 or WCR.

WS46, WHEEL SLIP RELAY

WS46 is connected to sense the same current differentials as WCR, but the sensitivity of WS46 is less than WCR. Therefore when WS46 is actuated, a true wheel slip has occurred and battery field contactor BFA is dropped out to bring about a partial reduction of power. A timed application of sand occurs also.

The voltage coil of WS46 is connected across local power if transition relay FTR picks up after the final step of motor field shunting

has been made during parallel motor connection. FTR pickup at that time indicates train overspeed or 6-axle simultaneous slip and WS46 operates to protect the motors.

AC AND COMPRESSOR CONTROL CABINET, Fig. 5-13

AC1, AC2, AND AC3; CONTACTORS

Temperature switches control operation of these contactors which operate radiator cooling fans and the radiator shutters.

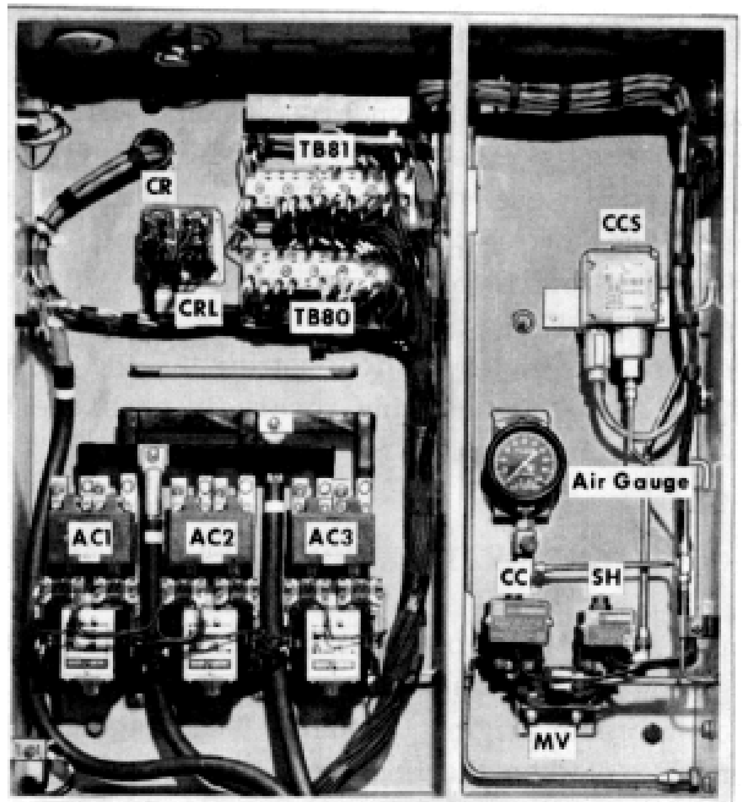


Fig. 5-13 - AC And Compressor
Control Cabinet

CCS, COMPRESSOR CONTROL SWITCH

The compressor control switch senses main reservoir pressure. It trips to energize the compressor relay in all units of a consist when main reservoir in any one unit falls below the desired pressure.
On special order a second sensing device can be included in the compressor control switch. This device will de-energize the compressor relay in any individual unit if main reservoir pressure in that unit approaches the safety valve setting of that unit.

CR, CRL; COMPRESSOR RELAYS

On units equipped with synchronization of all compressors in a consist, the compressor relays in all units of the consist are energized when the main air reservoir pressure in any unit falls below a preset level. The compressor relays in the individual units will remain energized until the pressure at the individual units approaches the safety valve setting of the individual units, or until the initiating reservoir pressure builds up to the normal level.

MV-CC; MAGNET VALVE, COMPRESSOR CONTROL

When the compressor control magnet valve is deenergized, the air compressor unloader valve opens and the compressor begins to pump. The magnet valve is de-energized when the compressor relay is energized, and the compressor relay responds to the compressor control switch in the individual unit or to the compressor control switch in each or any unit of a consist.

MV-SH; MAGNET VALVE, SHUTTER CONTROL

When the No. 1 cooling fan begins to operate, interlocks of the cooling fan contactor pickup to energize the shutter magnet valve and compressed air is admitted to a shutter operating piston.

MISCELLANEOUS EQUIPMENT AND DEVICES

TEST JACKS

The cabinet mounted test jacks are located in the high voltage system. When telephone plugs or 7/32" metal rods are inserted in the jacks, the transition relay voltage coils are disconnected from the main generator. This enables calibration of the transition relay circuits through the use of a fixed voltage from an MG seta

SHUNT PANEL BUS

The bus can be disconnected and an ammeter shunt can be applied in its place or cables can be connected for load testing. The shunt panel is located in the vicinity of the generator negative bus. This allows placement of a meter shunt to short circuit the main generator during circuit calibration.

OPTIONAL DEVICES

DYNAMIC BRAKE SWITCHGEAR

On locomotives equipped with basic or extended range dynamic brakes, the switchgear is for the most part located on the dynamic brake panel, Fig. 5-14, which is located behind the engine control panel.

BK, BRAKE MOTOR FIELD CONTACTOR

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

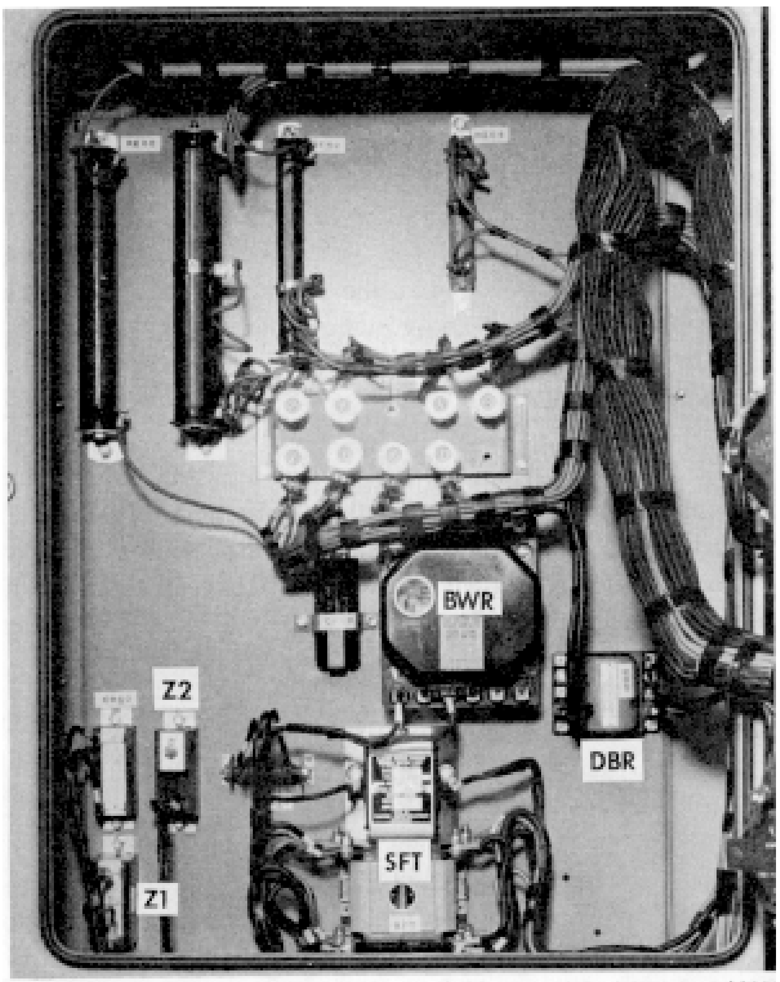


Fig. 5-14 - Dynamic Brake Panel

BKB, BRAKE-POWER SWITCHGEAR

When this switchgear is energized, one pole of this double-pole double-throw switch connects traction motor fields in series with the main generator during dynamic braking. The other pole connects dynamic braking grids in series with traction motors. During operation under power the switchgear is de-energized and the other pole closes to partially complete traction motor connections during series and series-parallel transition conditions.

BKP, POWER-BRAKE SWITCHGEAR

These heavy duty switches are energized under power to make high voltage connections between the main generator and the traction motors. When de-energized, the switches drop to break connections between the traction motors and the main generator and to make connections to the dynamic braking grids and grid cooling fan.

BR, BRAKE RELAY

The brake relay is energized when the selector handle is placed in brake position. Its contacts set up the dynamic braking circuits.

BRA, BRAKE RELAY AUXILIARY

This relay is provided on units equipped to trail in consists using field loop control of dynamic brakes. Pickup of BRA sets up the field loop control if the operation selector switch is in FIELD LOOP position.

BWR, BRAKE WARNING RELAY

The brake warning relay is provided on units equipped with dynamic brakes. It is energized whenever maximum braking effort of 700 amperes is exceeded. It functions to reduce generator excitation and to light a warning light on the locomotive controller. The light goes out when braking current is reduced to a safe level.

DBR, DYNAMIC BRAKE REGULATOR

The dynamic brake regulator functions to maintain generator excitation at a level that holds braking current to a maximum of 700 amperes.

FL, FIELD LOOP RELAY

The field loop relay, when energized in the lead unit of a consist, allows field loop control of dynamic brakes on units so equipped.

FLT, FIELD LOOP TRANSDUCTOR

The field loop transductor consists of concentrically wound primary and secondary windings on an iron core. The field loop signal is directed to the primary winding. The strength of the field loop signal controls the impedance of the secondary winding of FLT; and the output of a transformer, which is connected in series with FLT and the alternator, is proportional to the strength of the field loop signal. The output of the transformer is directed to the dynamic brake control circuits in the same manner as the signal from the brake control rheostat. In trailing units the signal from the transformer corresponds to the signal from the brake control rheostat on the lead unit.

MF, BRAKE MOTOR FIELD CONTACTOR

This contactor is energized during dynamic braking. It completes the series circuit with the traction motor fields and the main generator.

SFT, SHUNT FIELD TRANSFER RELAY

This relay operates during dynamic braking to disconnect the main generator shunt field from across the main generator armature and connect it across the auxiliary generator. The relay also connects the compensating windings of the magnetic amplifier across the shunt field. These connections are made to insure smooth operation of the dynamic brakes.

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. Nominally 180 volts.

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

The low voltage system contains the circuits that control the flow of power in the high voltage system, and those auxiliary circuits conducting power to the locomotive lights, heater fans, turbocharger auxiliary lube oil pump, and the fuel pump. A 64-volt battery in the low voltage system, is the source from which power is taken to start the diesel engine and operate the fuel pump during priming and engine starting. 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, a dust discharge blower, various transductors, and the magnetic amplifier that provides excitation control and power for the main generator.

Functions of the individual electrical devices that operate in the locomotive electrical systems are discussed elsewhere in this manual. This particular section explains the locomotive schematic diagram and some sample electrical circuits. This information is presented to aid in the tracing of schematic wiring diagrams. Such knowledge is helpful to anyone desiring a better knowledge of the electrical operation of the locomotive and is valuable for purposes of trouble shooting electrical difficulties.

TRACING SCHEMATIC WIRING DIAGRAMS

The circuits that will be explained are those basic to the operation of the locomotive or in common use as optional equipment. Remember that the diagrams shown are samples and do not necessarily agree with the circuitry used on specific locomotives. Before tracing these circuits the following fundamentals should be understood.

1. A complete circuit or path must exist before electricity will flow and perform a desired function. Therefore, 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 a coil 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 together with the main contacts by the energizing or de-energizing of the operating coil. They function to make or break low voltage control circuits to achieve desired results.

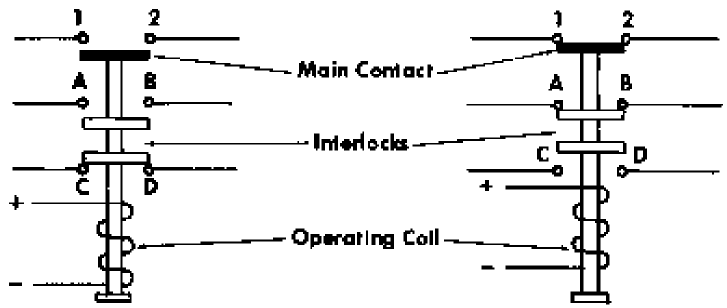
   These interlocks will be in their normal position when the operating coil is not energized. When the coil is energized, the normally closed interlocks will open. When the coil is de-energized, the interlocks return to their previous normal position.

4. Schematic wiring diagrams are drawn illustrating a "dead" locomotive, that is, with all switches open, controls off, and electrical contactors and relays deenergized. Therefore, all contacts and interlocks are shown in their normal position. The 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 electrical equipment legend be studied in detail. This will prove valuable in identifying the various electrical components on the diagrams.

LEGEND OF ELECTRICAL EQUIPMENT

AC	Cooling Fan Contactor
BFA	Battery Field Contactor
BK	Brake Contactor, Motor Field



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.

On auxiliary contacts only, when the symbols for the contacts are shown as shaded bars, the opening and closing of the interlocks so shown overlap. That is, during operation the normally open contacts close before the normally closed contacts open.

NOTE: Multiple pole cam operated switches may be made up of numerous individual switch elements. The contacts of these individual switch elements as shown on the locomotive schematic diagram relate to the position the switches assume when the camshaft of the cam operated switch assembly is in its normal (locomotive at rest) position.

Fig. 6-1 - Contact And Interlock Operation

LEGEND OF ELECTRICAL EQUIPMENT (Cont'd)

BKB	Brake-Power Switchgear, Brake
BKP	Power-Brake Switchgear, Power
BR	Brake Relay
BRA	Brake Relay, Auxiliary
BTR	Backward Transition Relay
BWR	Brake Warning Relay
CCS	Compressor Control Switch
CR	Compressor Relay
CRL	Compressor Relay
DBR	Dynamic Brake Regulator
E R	Engine Run Relay
FCT	Field Current Transductor
FL	Field Loop Relay
FLT	Field Loop Transductor FM Reactor
FOR	Directional Relay, Forward
FPC	Fuel Pump Contactor
FPR	Fuel Pump Relay
FS	Motor Field Shunting Contactor
FSA	Field Shunting Auxiliary Relay
FTR	Forward Transition Relay
GCT	Generator Current Transductor
GFR	Generator Field Relay
GR	Ground Relay
GS	Generator (Engine) Starting Contactor
GVT	Generator Voltage Transductor
LR	Load Regulator
MV	Magnet Valve
	CC Compressor Control
	DBI Dynamic Brake Interlock OS Overspeed
	SH Shutter Control
NVR	No (AC) Voltage Relay
P	Power Contactor, Parallel
PCR	Pneumatic Control Relay

LEGEND OF ELECTRICAL EQUIPMENT (Cont'd)

PCs	Pneumatic Control Switch
PLS	Static Power Controller
PR	Parallel Relay
RER	Directional Relay, Reverse
RVF	Reverser Switchgear, Forward
RVR	Reverser Switchgear, Reverse
S	Step Relay
S	Power Contactor, Series
SF	Shunt Field Relay
SFT	Shunt Field Transfer Relay
SP	Series-Parallel Power Contactor
SPR	Series-Parallel Relay
T	Transformer
TB	Terminal Board
TDS	Time Delay Relay, Automatic Sanding
TLPC	Turbine Lube Oil Pump Contactor
TLTD	Time Delay Relay, Turbine Lube Pump
VR	Voltage Regulator
VRA	Voltage Regulator Adapter
WCR	Wheel Creep Relay
WS	Wheel Slip Relay
Z	Zener Diode

The wiring diagrams used in this manual are simplified for use in presenting and understanding particular circuits. They should be considered only as guides and not as working drawings.

FUEL PUMP AND STARTING CIRCUITS

FUEL PUMP CIRCUIT, Fig. 6-2.

When the main battery switch is closed, the circuit to the No. 1 terminal of the fuel prime/ engine start switch is energized. Power is supplied to the fuel pump motor through the fuel pump motor circuit breaker when the fuel

prime/ engine start switch is held in FUEL PRIME position. When it is turned to the ENGINE START position, the fuel pump motor stops because the battery charging rectifier CR-BC prevents a reverse flow of current. After the engine has started and the auxiliary generator is delivering power, current to operate the fuel pump motor flows through the 5-6 contacts of the fuel prime/ engine start switch and through contacts of the fuel pump relay FPR and fuel pump contactor FPC. The engine can not be started if FPR has not picked up nor can it be started if FPC fails to pick up at engine start.

TURBOCHARGER AUXILIARY LUBE PUMP CIRCUIT

When the main battery switch is closed, with the turbo lube pump circuit breaker ON, the pump operates to supply lube oil to the turbocharger. A

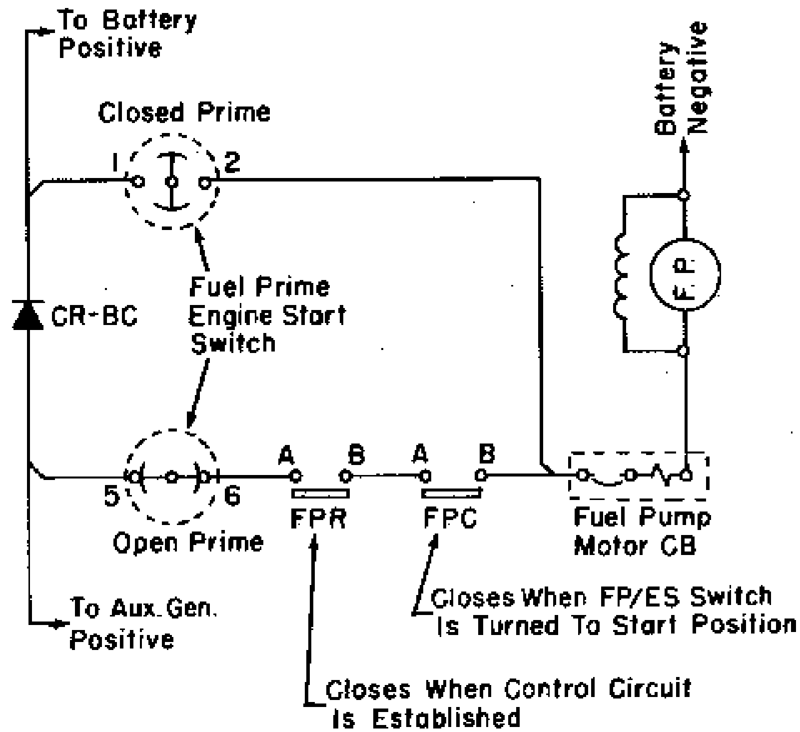


Fig. 6-2 - Fuel Pump Circuit

white light will come on at the engine control panel to indicate the pump is running.

This pump operation is necessary in order to pre-lubricate the turbocharger prior to starting the engine and to insure proper turbocharger lubrication until the engine oil pressure builds up after the engine has started. The auxiliary pump will automatically stop after a period of approximately 15 minutes operation.

Whenever the engine is shut down after operation, the pump starts automatically to supply lube oil to the turbine for cool down. The pump will run for approximately 15 minutes after the engine has stopped. The main battery switch and turbo lube pump circuit breaker must remain closed for at least 15 minutes after engine shutdown. The circuit for this operation is shown in Fig. 6-3, and a brief description follows:

Starting at the main battery switch, closing of this switch will energize the BP wire. Current will then flow through the turbo auxiliary pump circuit breaker (closed), through the normally closed contacts C-D and E-F of NVR to energize TLPC and TLTD. As TLTD is energized, it starts a timing cycle which delays pickup of contacts 3-5 and 6-4 for 15 minutes, during which time the auxiliary pump operates. Each time TLTD is re-energized it restarts a timing cycle. This is to ensure proper lubrication to the turbocharger.

When the engine starts and is running, NVR contacts C-D and E-F open. TLPD is held in through E-F contacts of TLPC. As the time cycle runs out TLTD contacts 3-5 and 6-4 open to drop out TLPC to stop the pump and cause the light to go out.

As the engine shuts down after operation, the NVR contacts C-D and E-F return to their normal closed position. The closing of these contacts allows current to flow to and energize TLPC and TLTD. The time cycle starts on

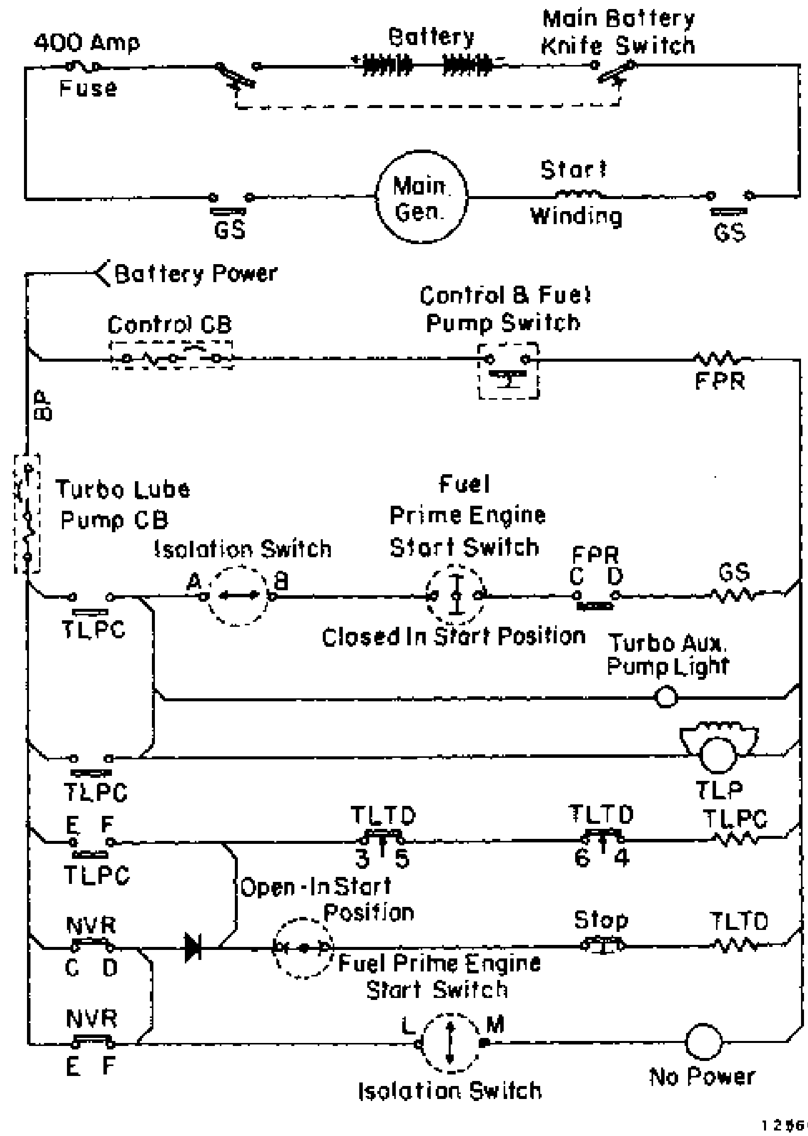


Fig. 6-3 — Turbocharger Auxiliary Lube Oil Pump And Engine Starting Circuits

Fig. 6-3 - Turbocharger Auxiliary Lube Oil Pump
And Engine Starting Circuits

TLTD contacts, which allows the auxiliary pump to supply lube oil to the turbocharger for cool down. The white light will be on and the pump will run for approximately 15 minutes before stopping.

STARTING CIRCUIT, Fig. 6-3

The fuel pump relay FPR picks up when the main battery switch is closed, the control circuit breaker is closed, and the control and fuel pump switch is placed in the ON (up) position. Then with the isolation switch in START position, the generator (engine) starting contactor picks up when the fuel prime/ engine start switch is placed in the ENGINE START position. Battery power is directed to the starting winding of the main generator. The motored main generator cranks the diesel engine.

The purpose of the C-D contacts of FPR in the starting circuit is to prevent pickup of GS if control circuits are not established, for if the engine could be started without the control circuits being energized, circuits to stop the engine would not be operative.

GENERATOR FIELD EXCITATION CIRCUIT, Fig. 6-4

Excitation of the main generator is dependent upon the shunt field contactor SF and the battery field contactor BFA. SF and BFA must be picked up before the main generator can deliver normal power. These contactors can be energized when various operating switches are properly positioned, interlocks of power contactors are closed, and the wheel slip relays are not energized. During series traction motor connection the S contactor interlocks are closed to complete the circuit path to SF. During series-parallel motor connection S14 and S36 remain picked up, and the SPR relay and SP contactor

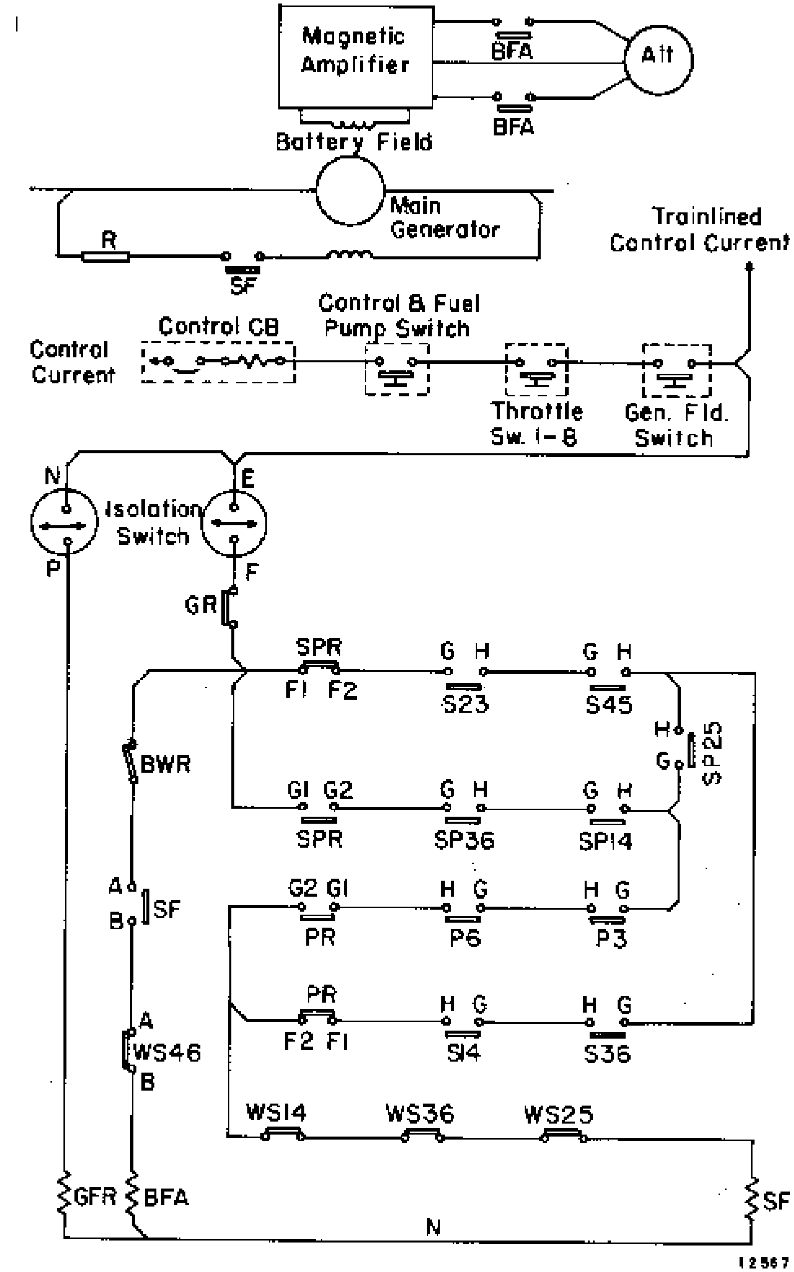


Fig. 6-4 - Generator Field Control Circuits pick up. During parallel motor connection PR relay picks up and SPR relay remains picked up. The P contactor interlocks pick up, SP36 and SP14 interlocks remain closed while all other series-parallel and series contactor interlocks open.

During normal locomotive operation SF, BFA, and the generator field contactor GFR are energized when the throttle is advanced out of IDLE position. Refer to the article in Section 5 of this manual for an explanation of GFR functions.

DIRECTIONAL CONTROL CIRCUITS, Fig. 6-5

When the control circuits are established and the reverse lever positioned for operation, the appropriate directional relay is energized. The relay picks up to energize related switchgear. Auxiliary contacts of the switchgear establish a holding circuit that prevents dropout of the switchgear until position of the reverse lever is reversed.
Notice on Fig. 6-16 that the flipper of the appropriate reverser switchgear is locked when a traction motor is cut out (on locomotives equipped for motor cutout). When the switchgear is locked, its auxiliary contacts can not operate. Therefore, the C-D and G-H auxiliary contacts are arranged so that both will be closed when the switchgear is locked centered. This permits the flow of control current to energize the other switchgear.

To allow varied positioning of locomotive units in a consist, the trainlined wires that energize the trailing unit directional relays are crossed, both within the locomotive and within the cable that connects units. Observe that the crossover arrangement, utilizing the No. 8 and No. 9 pins of the control cables and receptacles permits the proper switchgear to be energized.

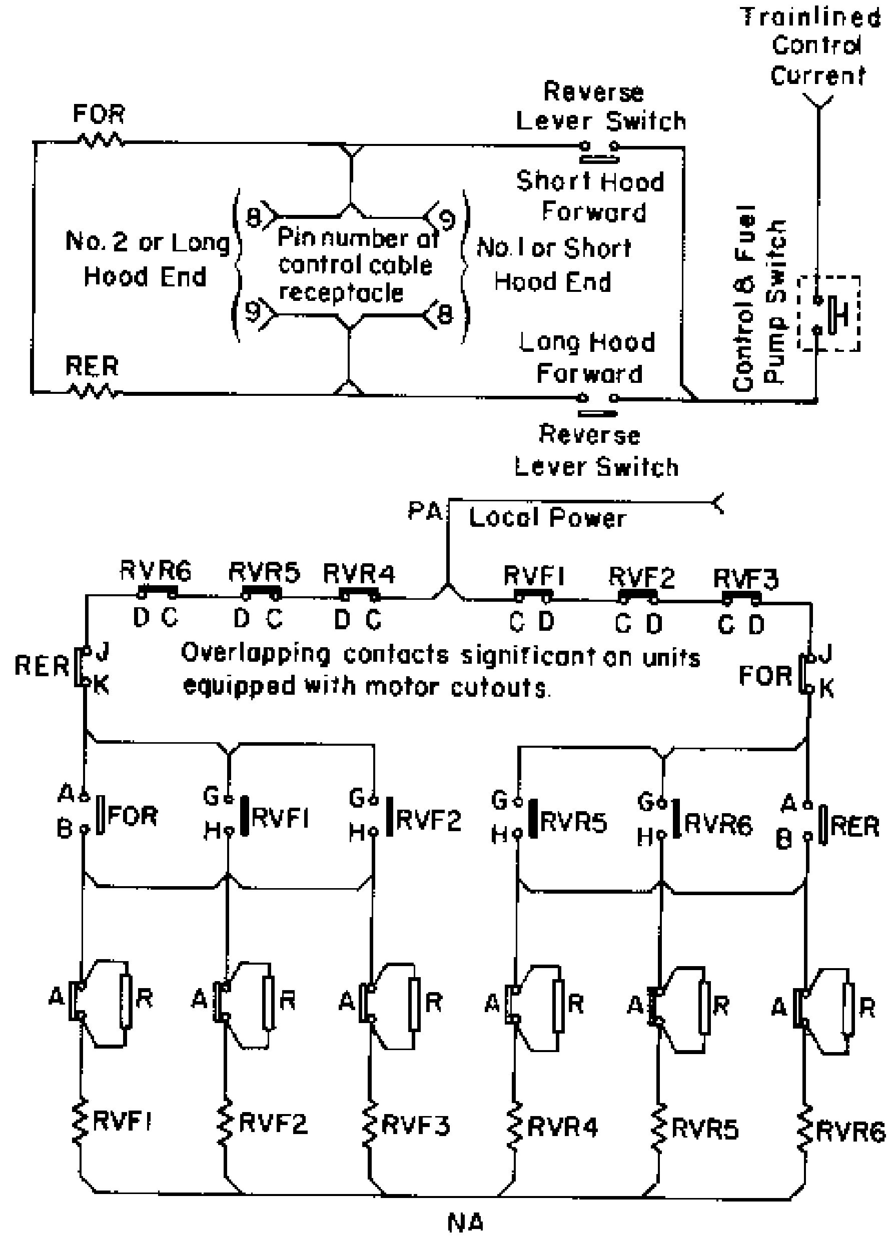


Fig. 6-5 - Directional Control Circuits

MOTOR CONNECT CONTROL, Fig. 6-6

From Fig. 6-6, it can be seen that the series and parallel power contactors can not be energized until the reverse lever and the isolation switch have been positioned for operation, and the generator start contactor is de-energized. Control current flows through GS contacts, through P2 and P4 A-B interlocks and through other interlocks to the coils of the series power contactors.

The circuits to the power contactors contain interlocks of the power contactors and contacts of various relays. These interlocks and contacts ensure that the power contactors operate in the proper sequence. Refer to the articles on the transition control system for an explanation of the transition sequence.

ENGINE RELAY CIRCUIT, Fig. 6-7

The purpose of the engine relay circuit is to provide a means of establishing or breaking engine speed control circuits through a switch on the control stand or through various safety devices. When the engine relay is energized, throttle control of engine speed is possible. When the relay is de-energized, the engine is restricted to IDLE speed. For a brief description of the safety devices in the engine relay circuit, refer to the applicable articles in Section 5 of this manual.

ENGINE SPEED CIRCUITS, Fig. 6-8

Movement of the throttle lever closes various throttle switches individually or in combination to energize governor speed setting solenoids, which in turn cause the governor to increase or decrease the amount of fuel supplied to the engine. The solenoids are energized in various combinations which result in

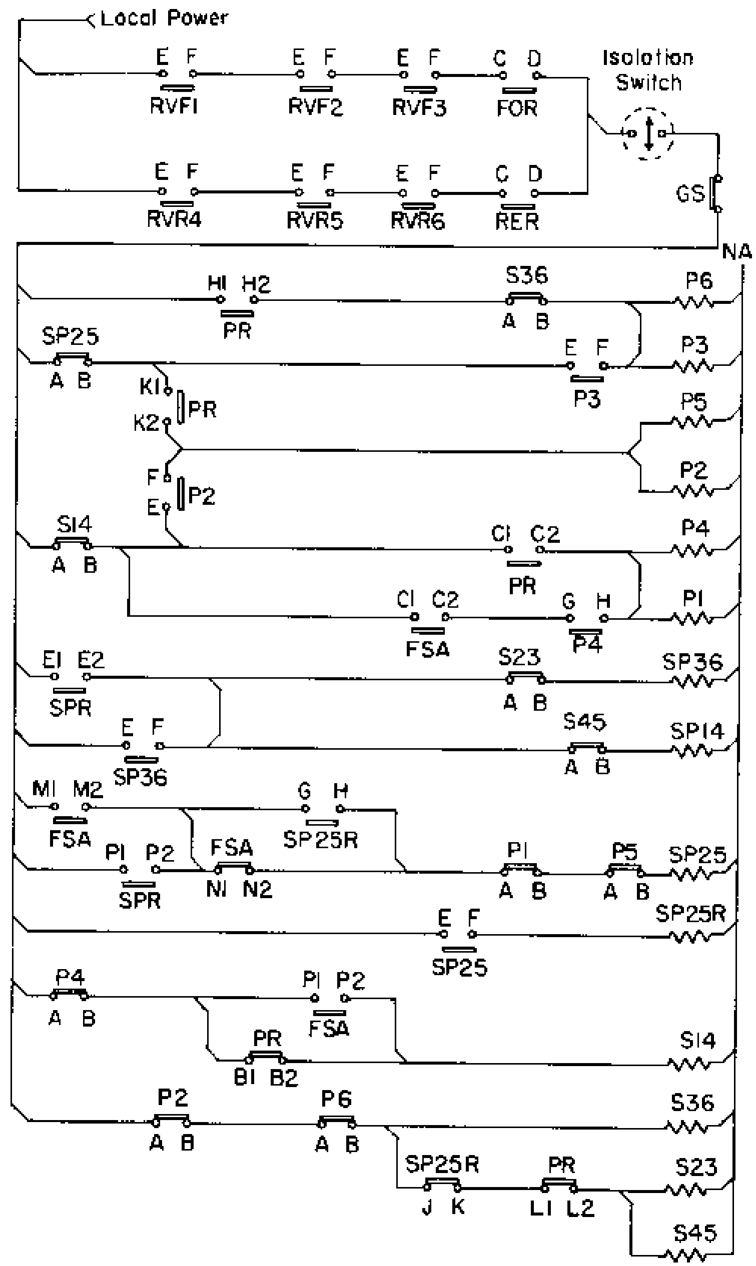


Fig. 6-6 - Motor Connect Control

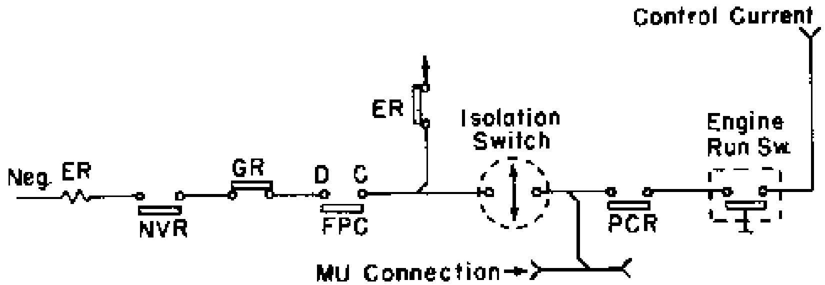


Fig. 6-7 - Engine Relay Circuit

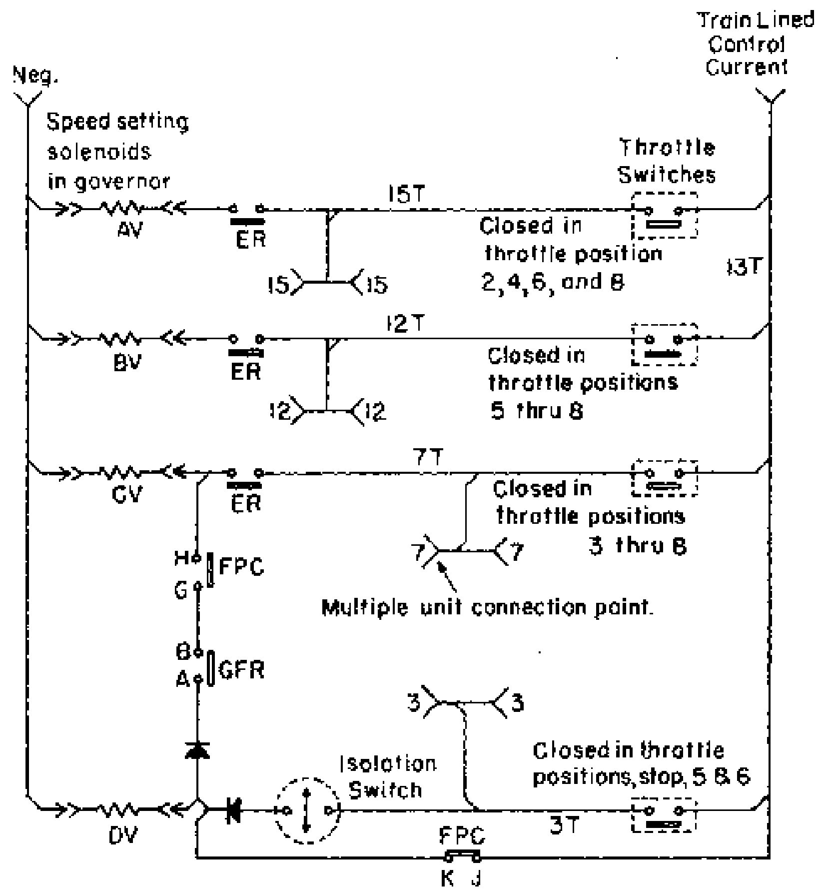


Fig. 6-8 - Engine Speed Circuit

various combinations which result in an average 80 rpm change in engine speed for each throttle position. The solenoids energized and the resulting speeds for each throttle position are as shown in the Engine Speed Chart.

ENGINE SPEED CHART

Throttle Position	Governor A	Solenoids B	C	Energized D	Engine Speed RPM
STOP				*	0
IDLE					307-323
1					307-323
2	*				390-398
3			*		475-483
4	*		*		545-575
5		*	*	*	645-653
6	*	*	*	*	730-738
7		*	*		800-830
8	*	*	*		900-908

Wire 15T –A Solenoid increases speed approximately 85 RPM
Wire 12T-B Solenoid increases speed approximately 336 RPM
Wire 7T-C Solenoid increases speed approximately 164 RPM
Wire 3T-D Solenoid decreases speed approximately 164 RPM

Referring to Figs. 6-7 and 6-8, observe that the ER relay is de-energized when C-D contacts of FPC open. At the same time that the C-D contacts open, the J -K contacts of FPC close. This occurs when the engine stop pushbutton or one of the emergency fuel cutoff push-buttons is pressed. The G-H contacts of FPC open at the same time to prevent energy from reaching the CV solenoid during engine shut-down.

The purpose of the crossover circuit between the CV and DV solenoids is to prevent engine shutdown when a safety device such as the ground relay operates when the throttle is in Run 5 or 6 position, for at that time the A-B contacts of GFR are closed as are the G-H contacts of FPC. Energy from the 3T wire can reach the CV solenoid, however, if the throttle is placed in the STOP position the A-B contacts of GFR open. Energy in the 3T wire reaches only the DV solenoid, and the engine shuts down.

GENERATOR CURRENT AND VOLTAGE SENSING CIRCUITS, Fig. 6-9

Main generator current is sensed by three devices, forward transition relay FTR, backward transition relay BTR, and generator current transductor GCT. Main generator voltage is sensed by the coils of FTR and BTR and by a generator voltage transductor. GVT.

GCT and GVT contain coils that are connected across the locomotive alternator and in series with transformer primary windings. The impedance of the coils is proportional to main generator current through the frame of GCT and to main generator volts at DC coils of GVT. The signals from the transformers T3 and T4 are rectified, connected to add, and are directed to a transistorized power control device, PLS, Fig. 6-10. The primary purpose of PLS in the SD35 locomotive is to hold horsepower at the desired nominal value by compensating for variations in quality and condition of fuel, ambient temperature and air pressure, and metering of fuel by the injectors.

Transition relays FTR and BTR pick up when voltage of a specific value is impressed through limiting resistance on two of the coils of the relays. The voltage required for relay pickup increases, however, as the value of main generator current increases in a bus passing through the transition relay frames. The transition circuits are so calibrated that the forward transition relay picks up when main generator voltage is approaching its upper limit for a given generator (and engine) rotating speed. The backward transition relay drops out, after picking up prior to FTR pickup, when generator voltage drops to a value significantly lower than the upper limit for a given generator rotating speed.

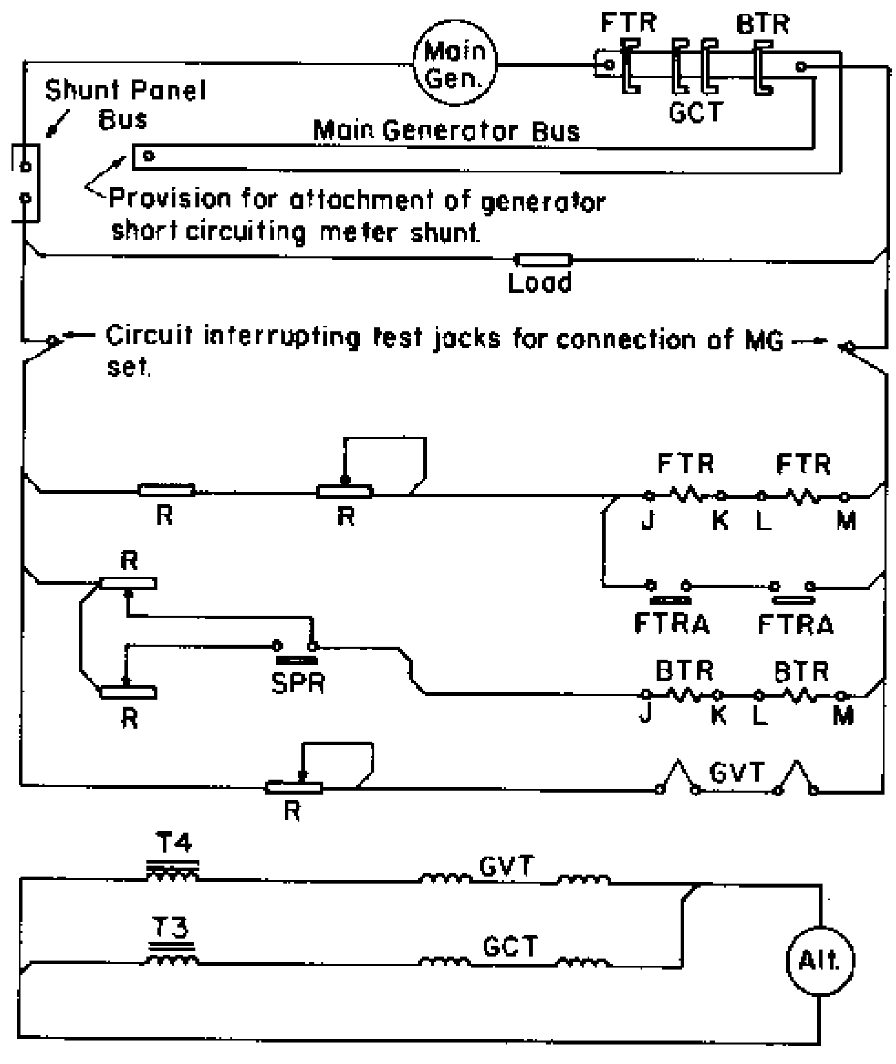


Fig. 6-9 - Generator Current And Voltage Sensing Circuits

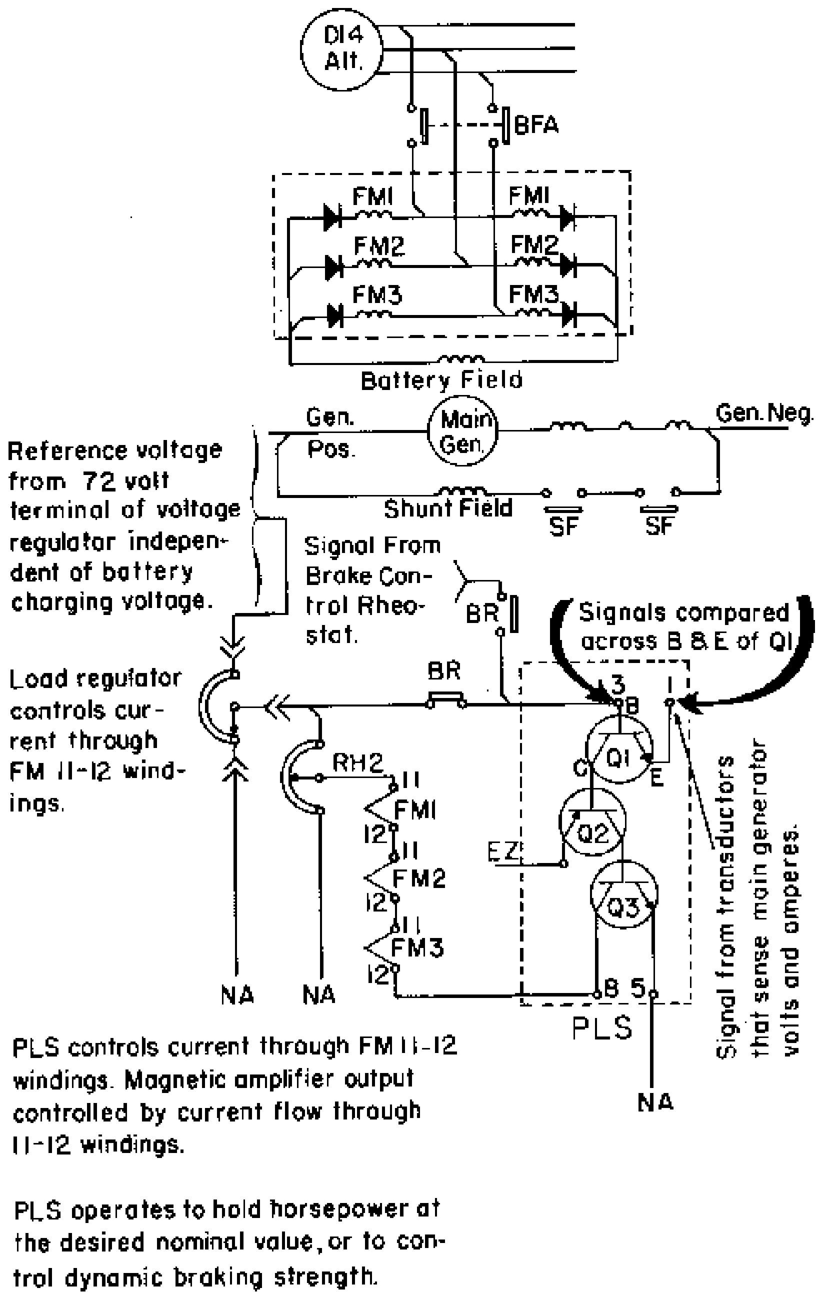


Fig. 6-10 - Excitation Control Circuit Simplified Diagram

The pickup of FTR and the dropout of BTR brings about changes in the percentage of motor field shunt and in traction motor connection across the main generator. The sequence of events is explained in articles on the transition control system.

TRANSITION CONTROL SYSTEM

The SD35 locomotive utilizes nine transition positions to cover its speed range from minimum continuous speed of 9.4 to top speed of 71 MPH (62: 15 gear ratio). The SDP35 locomotive utilizes the same transition positions to cover its speed range from minimum continuous speed of 11.8 to top speed of 89.6 MPH (59: 18 gear ratio). These positions are as follows:

SERIES - Motors are connected in two groups of three motors in series. The two groups are connected in parallel across the main generator.

1. Full Field Strength
2. 21% Motor Field Shunt
3. 39% Motor Field Shunt
4. 47% Motor Field Shunt

SERIES-PARALLEL - Motors are connected in three groups of two motors in series. The three groups are connected in parallel across the main generator.

5. Full Field Strength
6. 47% Motor Field Shunt
7. 62% Motor Field Shunt

PARALLEL - Motors are all connected in parallel across the main generator.

8. Full Field Strength

9. 47% Motor Field Shunt

Motor field shunting is obtained by action of three pairs of field shunting contactors; FS1A & B, FS2A & B, and FS3A & B. These contactors operate singly and in combination to insert a shunt of fixed resistance around the motor fields. The available combinations and percentages of shunt are as follows

1. FS1A & B	21% Motor Field Shunt
2. FS2A & B	39% Motor Field Shunt
3. FS1A & B plus FS2A & B	47% Motor Field Shunt
4. FS1A & B plus FS2A & B plus FS3A & B	62% Motor Field Shunt

The following is a step by step sequence of events that occur as the locomotive starts out from a standstill and accelerates to its speed limit, then slows down.

1. With reverse lever in neutral position, engine running, control and local control circuit breakers closed, control and fuel pump switch closed, generator field switch in ON position, and throttle in IDLE position, all reversing and power contactors remain dropped out, Fig. 6-5 and Fig. 6-6.

2. Place reverse lever in position for forward operation.

   a. Forward relay picks up.

   b. Reverse relay RER contacts J-K are closed as are RVR4, RVR5, and RVR6 contacts C-D. Forward relay FOR contacts A-B closing picks up RVF1, 2, and 3.

   c. The "A" interlocks of RVF1, 2, and 3 open, putting resistance into the RVF coil circuits to prevent excessive current drain.

   d. RVF1 and RVF2 G-H interlocks close, sealing the reversing switchgear in on local power.

   e. RVF1, 2, and 3 E -F interlocks close to establish (through the closed C-D contacts of forward relay FOR) a circuit to the power contactors. On units equipped with dynamic brakes, numerous other interlocks are placed in the circuit to ensure positive sequencing.

   f. RVF1, 2, and 3 C -D interlocks open, thus ensuring that RVR4, 5, and 6 remain out. The locomotive will now move in forward direction.

   g. FOR contacts C-D closing picks up series power contactors S13, S23, S45, and S36.

   h. The above mentioned "S" contactors closing, picks up shunt field contactor SF, and the A-B interlock of SF closes to pick up BFA, Fig. 6-4.

   i. BFA closing connects the power windings of the magnetic amplifier to the D14 alternator. Magnetic amplifier output is connected to the main generator battery field. The locomotive responds to throttle.

TRANSITION CONTROL CIRCUITS

Transitions are initiated by two current biased voltage sensitive relays, FTR and BTR. The relays contain three voltage coils, two of which are connected across the main generator and are thus sensitive to the voltage level. The current bias is obtained by passing a bus that carries total generator current inside the magnet frames of the relays. The bias is in a direction to oppose the voltage coils. The relays, therefore do not pick up on a voltage level alone, but rather on a voltage-current ratio.

The third voltage coil of the forward transition relay FTR is connected in the 74 volt local control current supply in a direction to oppose the main generator voltage pickup. This coil is energized at proper moments in the transition sequence. Circuits are so arranged that forward transition will not occur until FTR drops out after picking up.

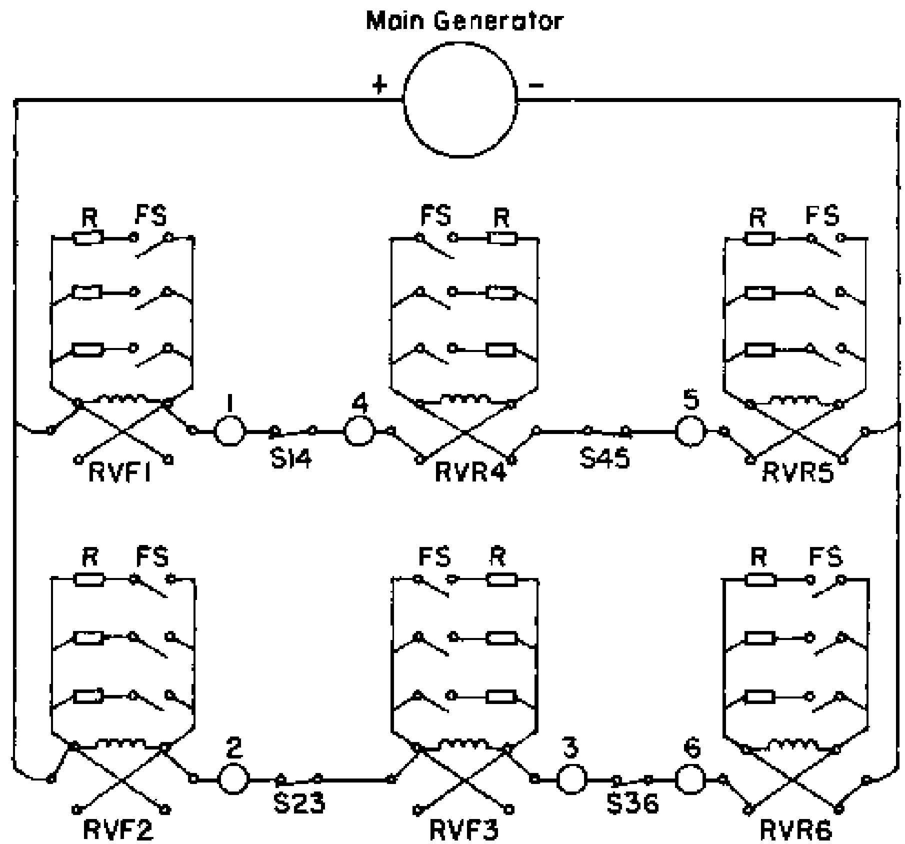
The third voltage coil of the backward transition relay BTR is also connected in the 74 volt local control current supply, but in a direction to assist main generator voltage pickup. The coil is energized at proper moments in the transition sequence. Circuits are so arranged that backward transition will not occur until BTR picks up after dropping out.

A step by step sequence of events during the various motor transitions follows. The simplified schematic wiring diagrams that are presented in this manual may be used with the text, but for ease of reference it is recommended that a separate and complete schematic diagram be used in conjunction with the following text. SERIES - Full Field To 1st Step Of Shunt
With the locomotive at a standstill and reverse lever positioned for forward operation, RVF switchgear picks up and the traction motors are connected across the main generator as shown in Fig. 6-11. After the locomotive has started and is working, BTR will pick up at low track speed. BTR pickup sets up the circuit for forward transition.

1. The first step of motor field shunting occurs after forward transition relay FTR picks up.

ELECTRICAL SYSTEM

2. FTR A-B contacts closing, Fig. 6-12, energizes the S1 relay coil through the already closed C-D contacts of GFR, A-B contacts of BTR, and the E-F interlock of S23, and through the normally closed Jl-J2 interlocks of series-parallel relay SPR and parallel relay PR.



NOTE: Circuit shown with reverse lever positioned for forward operation (RVF switchgear picked up), S contactors (series) picked up, and no FS (field shunting) contactors picked up (full motor field strength).

Fig. 6-11 - Series Traction Motor Connection

3. The A-B contacts of step relay S1 close to seal S1 in against FTR dropout.

4. The C-D contacts of S1, Fig. 6-13, close, but since FTR G-H contacts have opened, the circuits to field shunting contactors FS1A & B are not complete. The coils of FS1A & B will not be energized until FTR is knocked down.

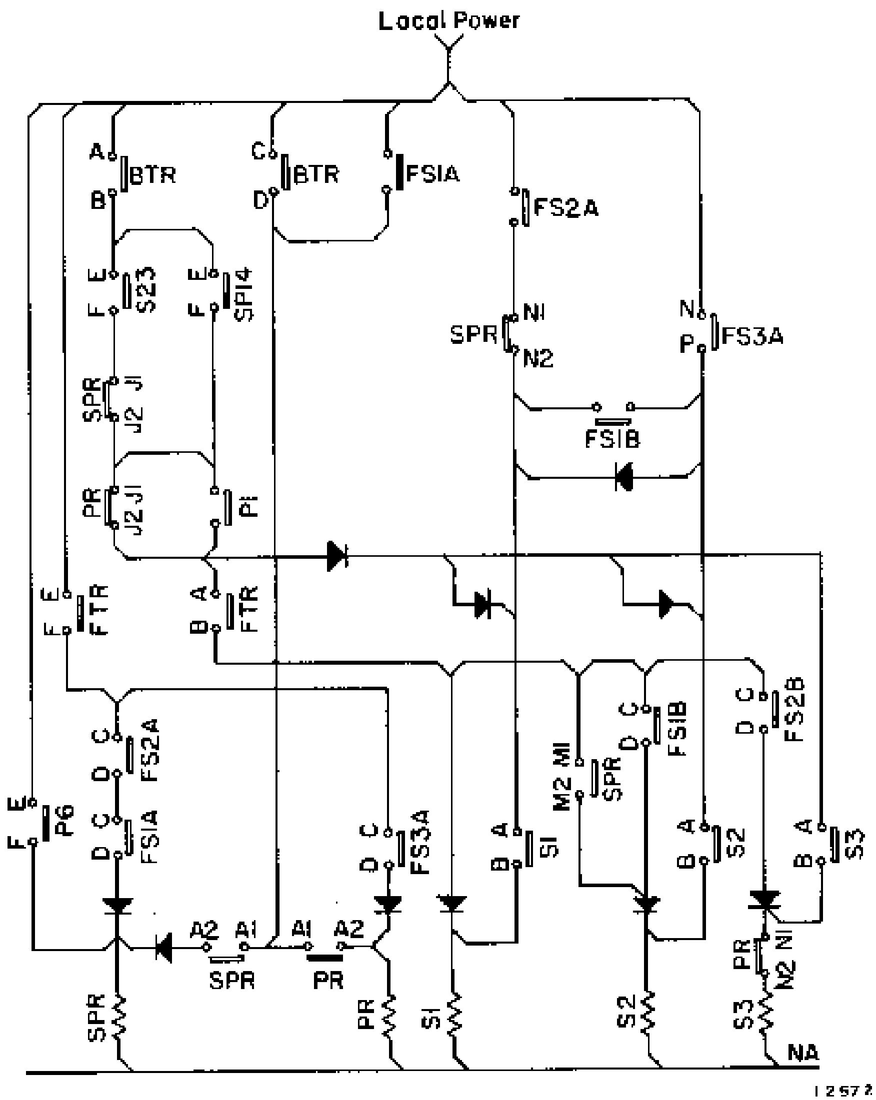


Fig. 6-12 - Transition Control Circuits

5. Knockdown of FTR is brought about by pickup of the E -F contacts of S1, Fig. 6-14, energizing the FTRA coil. FTRA contacts short out the J-K and L-M coils of FTR, Fig. 6-9 and the FTR relay drops out.

6. The G-H contacts of FTR, Fig. 6-13, closing allows control current to flow through the closed C-D contacts of S1 and the normally closed L-M contacts of S2. The coils of field shunting contactors FS1A and FSlB are energized. Pickup of FS1A and FS1B shunts approximately 21% of motor armature current around the motor fields and through the motor field shunting resistor.

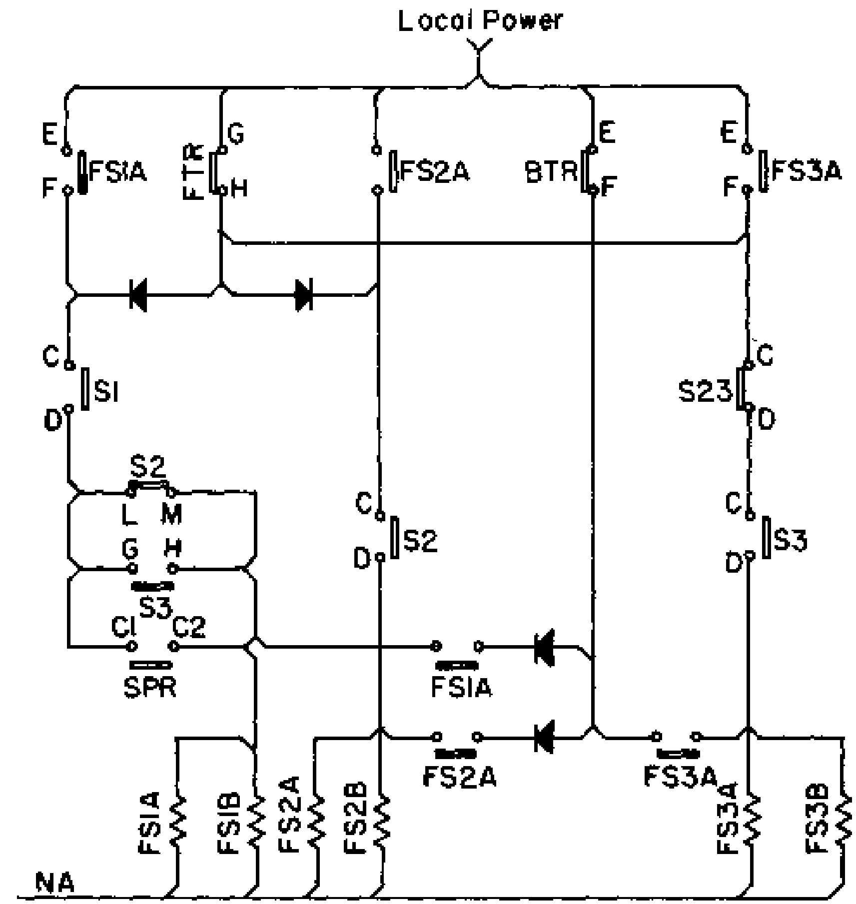


Fig. 6-13 - Motor Field Shunting Circuits

The drop in traction motor field strength drops system voltage slightly.

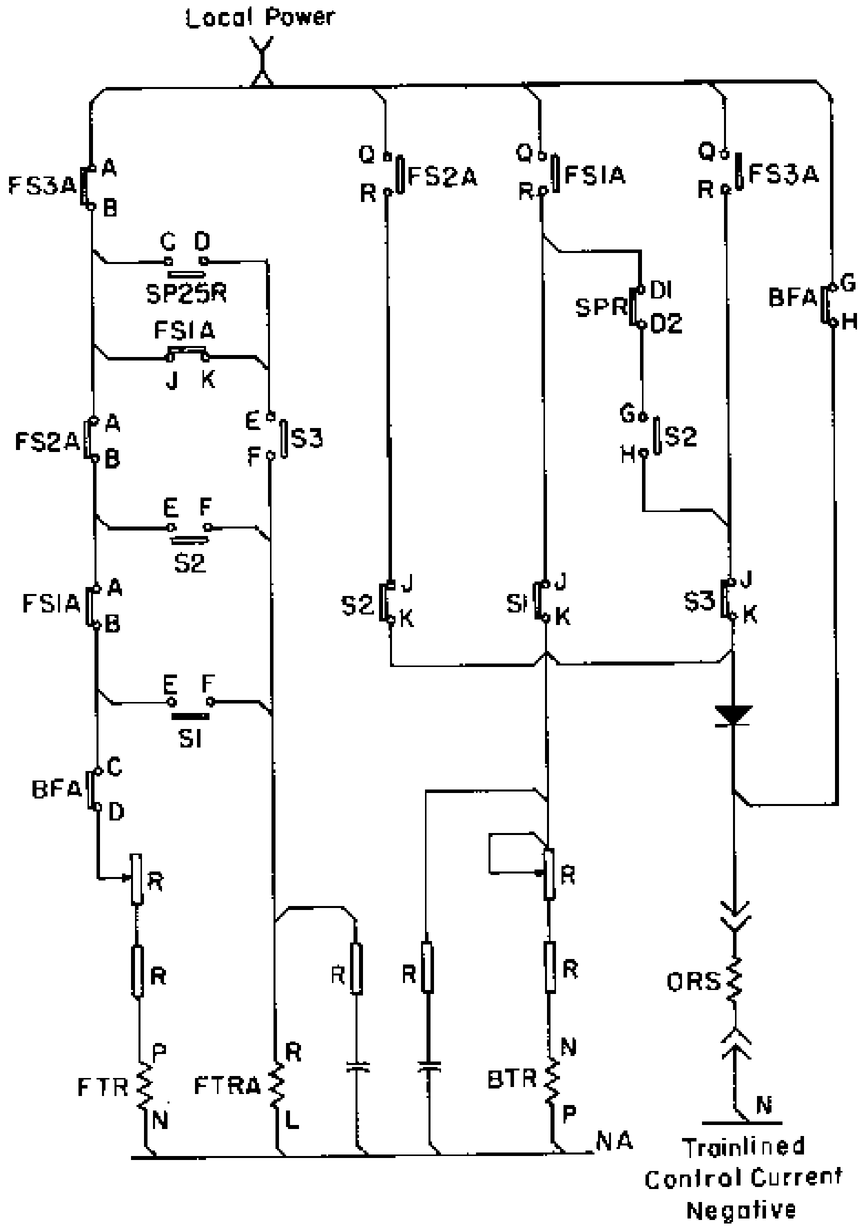


Fig. 6-14 - Transition Relay Low Voltage Coil Circuits

ELECTRICAL SYSTEM

7. The E-F interlock of FS1A closes to seal FS1A and FS1B in against FTR pickup. The Q-R interlock of FS1A, Fig. 6-14, closes to provide a circuit to the overriding solenoid should a malfunction prevent dropout of the field shunting contactor.

8. FS1A interlock G-H, Fig. 6-15, closes to energize the field shunt auxiliary relay FSA. Pickup of FSA sets up the sequencing circuits for transition from series to series-parallel.

SERIES - 2nd Step Of Shunt

1. As the locomotive continues to accelerate, system voltage increases; FTR picks up.

2. Closure of FTR A-B contacts energizes step relay S2 through now closed C-D interlock of FS1B, Fig. 6-12. The A-B contacts of S2 close to seal S2 in against FTR dropout.

3. Contacts L-M of S2 open to de-energize field shunting contactors FS1A and FS1B, Fig. 6-13.

4. Closure of S2 E-F contacts causes FTR knockdown through pickup of FTRA, Fig. 6-14, and FS2A and FS2B are energized through G-H contacts of FTR and the C-D contacts of @2, Fig.6-13. Pickup of FS2A and FS2B

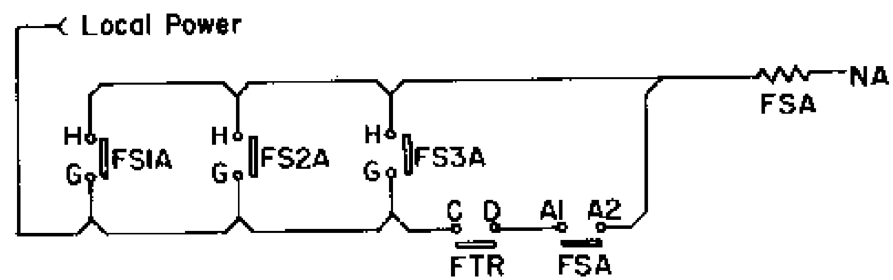


Fig. 6-15 -- Field Shunt Auxiliary Relay Holding Circuit increases motor field shunt to approximately 39% and system voltage drops slightly.

SERIES - 3rd Step Of Shunt

1. As the locomotive continues to accelerate, system voltage increases; FTR picks up.

2. Closure of FTR A-B contacts energizes step relay S3, Fig. 6-12, through now closed C-D interlock of FS2B and normally closed N1-N2 contacts of PR. The A-B interlocks of S3 close to seal S3 in against FTR dropout.

3. Closure of S3 E-F contacts causes FTR knockdown through pickup of FTRA, Fig. 6-14, and FS1A and FS1B are energized through C-D contacts of S1 and now closed G-H contacts of S3. Since FS2A and FS2B are already picked up, this places two resistors in parallel with the motor fields and increases motor field shunt to approximately 47%. System voltage drops slightly.

4. Pickup of the C-D contacts of both FS1A and FS2A. Fig. 6-12, has set up the circuit for pickup of SPR the next time FTR picks up.

SERIES-PARALLEL - Full Field

1. As the locomotive continues to accelerate, system voltage increases; FTR again picks up.

2. Closure of FTR contacts E-F energizes the SPR coil; SPR contacts Al-A2 close to hold SPR picked up with current through BTR C-D contacts.

3. Contacts J1-J2 and N1-N2 of SPR opening drops out S1, S2, and S3. S1 and S2 contacts C-D opening drop out FS1A & B and FS2A & B, Fig. 6-13.

ELECTRICAL SYSTEM

4. Contacts Fl-F2 of SPR opening, Fig. 6-4, drop out the shunt field contactor SF. Interlock A-B of SF opening drops out battery field auxiliary contactor BFA. Interlock G-H of BFA, Fig. 6-14, closing energizes the overriding solenoid in the engine, and the load regulator is driven toward minimum field position.

5. Dropout of SF and BFA bring about the decay of generator excitation. The closure of BFA interlock C-D, Fig. 6-14, recalibrates FTR relay dropout, and when voltage drops, FTR drops out.

6. Contacts C-D of FTR opening drops out FSA, Fig. 6-15, and the N1-N2 contacts of FSA close to energize the series-parallel power contactor SP25 through the now closed Pl-P2 contacts of SPR, Fig. 6-6.

7. Pickup of series-parallel power contactor SP25 energizes series-parallel relay SP25R.

8. Pickup of SP25R contacts J-K drops out series power contactors S23 and S45. S14 and S36 remain picked up.

9. Dropout of S23 and S45 picks up series-parallel power contactors SP14 and SP36. The traction motors are now connected in three groups of two in series. The groups are in parallel with the main generator, Fig. 6-16.

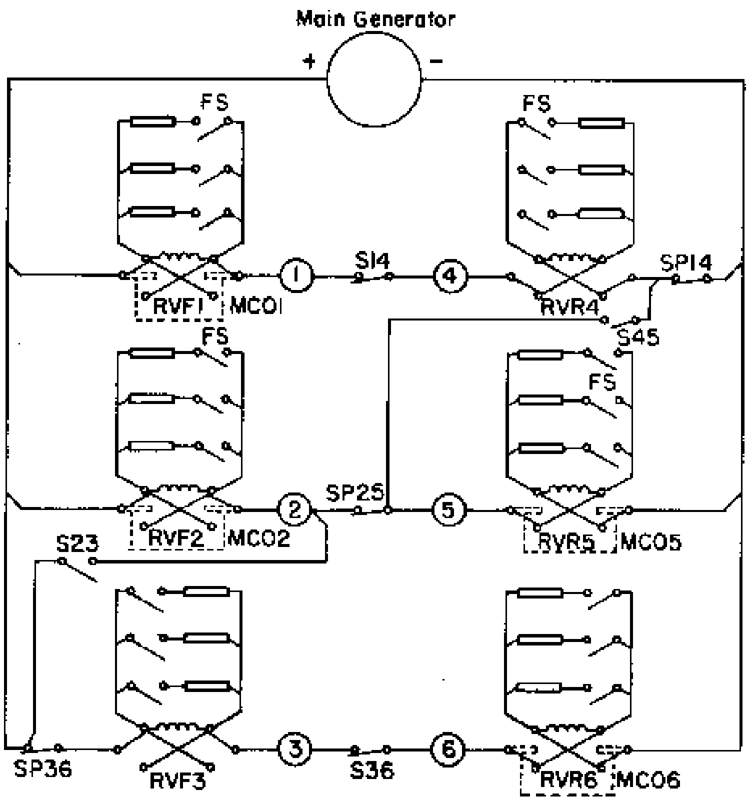
10. G1-G2 contacts of SPR and G-H interlocks of SP36, SP14, SP25, S36 and S14 are closed to pickup SF and BFA, Fig.6-4. The E-F interlock of SP14, Fig. 6-12, closes to again set up circuits to respond to further FTR pickup.

SERIES-PARALLEL - 1st Step Of Shunt

1. As the locomotive continues to accelerate, system voltage increases and FTR again picks up.

2. FTR A-B contacts closing energizes step relay S1 and (through the now closed M1-M2 contacts of SPR) step relay S2. The A-B contacts of S1 and S2 close to seal the step relays in against FTR dropout.

3. Pickup of S1 and S2 contacts E -F energizes the FTRA coil, Fig. 6-14. FTRA contacts short out the voltage coils of FTR



NOTE: Circuit shown with reverse lever positioned for forward operation (RVF switchgear picked up), SP series-parallel power contactors picked up, two of the four S contactors dropped out, and no FS (field shunting) contactors picked up (full motor field strength).

Fig. 6-16 - Series - Parallel Traction Motor Connection

And the FTR relay drops out, Fig. 6-9. FTR contacts G-H close, energizing FS1A & B, and FS2A & B through closed C-D contacts of S1 and S2, Fig. 6-13. SPR contacts C1-C2 being closed complete the circuit to FS1A & B. Motor fields are shunted about 47% and system voltage drops slightly.

4. The C-D contacts of FS2B, Fig. 6-12, closed after FTR dropped out, therefore S3 did not pick up. However, the circuit is set up for pickup of S3 the next time FTR picks up.

SERIES-PARALLEL - 2nd Step Of Shunt

1. As the locomotive continues to accelerate, FTR picks up.

2. Closure of FTR A-B contacts energizes S3, and the S3 E-F contacts close to complete a circuit through the now closed C-D contacts of SP25R to the coil of FTRA. FTR is knocked down, Fig. 6-14.

3. FTR knockdown energizes FS3A & B, and the E-F contacts of FS3A hold FS3A & B in against FTR pickup, Fig. 6-13. Motor fields are shunted approximately 62% and system voltage drops slightly.

4. The C-D interlock of FS3A, Fig. 6-12, closing after FTR drop-out, did not pick up parallel relay PR, but the circuit is set up for PR pickup the next time FTR picks up.

PARALLEL - Full Field

1. As the locomotive continues to accelerate, system voltage increases and FTR again picks up.

2. Contacts E-F of FTR close to energize the coil of parallel relay PR, Fig. 6-12, through the now closed interlock C-D of FS3A.

PR contacts Al-A2 close to hold PR picked up with current through BTR contacts C-D.

3. Contacts J1-J2 of PR opening drops out S3. The C-D contacts of S3 opening drops out FS3A, and the opening of N-P interlock of FS3A drops out S1 and S2. S1 and S2 contacts C-D opening drop out FS1A & B and FS2A & B, Fig. 6-13.

4. Contacts Fl-F2 of PR opening drops out the shunt field contactor SF. Interlock A-B of SF drops out battery field auxiliary contactor BFA, Fig. 6-4. Interlock C-D of SF drives the load regulator toward minimum field position, Fig. 6-14.

5. Dropout of SF and BFA brings about decay of generator excitation. The closure of BFA contacts, Fig. 6-14, recalibrates FTR dropout, and when voltage drops to approximately 500 volts, FTR drops out.

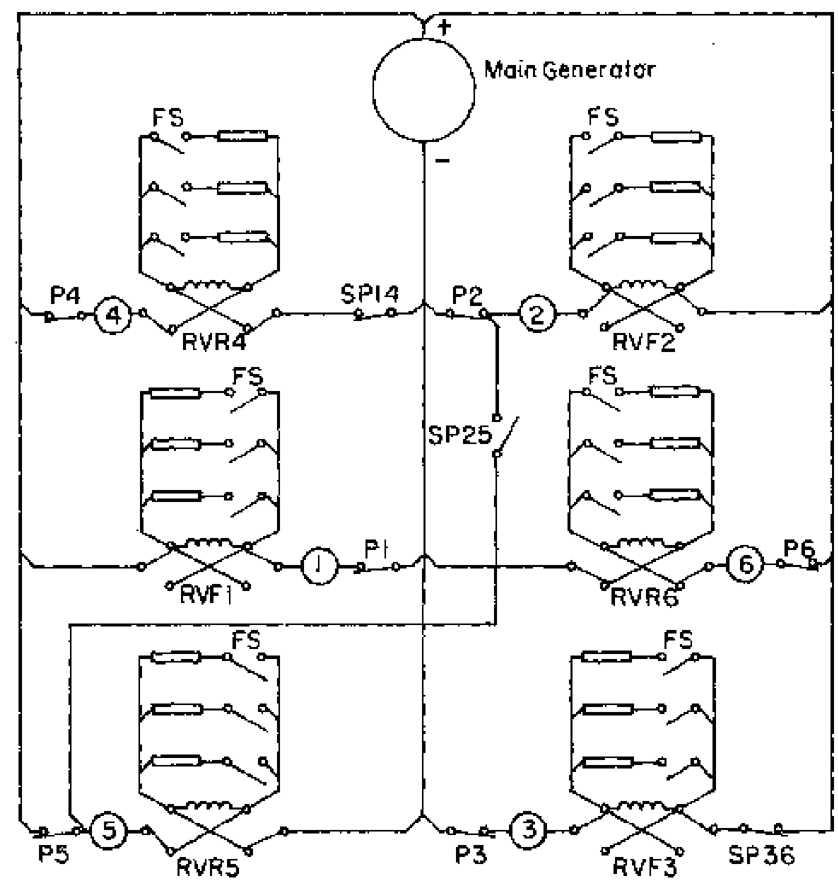
6. Contacts C-D of FTR, Fig. 6-15, opening drops out FSA, and the P1-P2 contacts of FSA, Fig. 6-6, open to remove the shunt circuit from around PR contacts Bl-B2. This de-energizes series power contactor S14.

7. The closing of the A-B interlock of S14 energizes parallel power contactors P1 and P4 through the now closed Cl-C2 contacts of parallel relay PR.

8. Interlock A-B of P1 opening drops out SP25, and the closing of the A-B interlock of SP25 picks up parallel power contactors P2 and P5.

9. The opening of the A-B interlock of P2 drops out S36, and the closing of the A-B interlock of S36 picks up parallel power contactors P3 and P6. All six traction motors are now connected in parallel with the main generator, Fig. 6-17.

10. The foregoing transition sequence is dependent upon contactor interlocks in the sequencing circuit. The sequence ensures positive action and smooth transition and precludes the possibility of short circuiting the main generator. Observe that series-



NOTE: Circuit shown with reverse lever positioned for forward operation (RVF switchgear picked up), all S series power contactors dropped out, two of three SP series-parallel power contactors picked up, and no FS (field shunting) contactors picked up (full motor field strength).

Fig. 6-17 - Parallel Traction Motor Connection parallel power contactors SP14 and SP36 remain picked up during parallel transition.

PARALLEL - Shunt

1. As the locomotive continues to accelerate, system voltage increases and FTR again picks up.

2. Control current through closed A-B contacts of BTR, Fig. 6-12, closed E-F interlocks of SP14 and P1, and through closed A-B contacts of FTR energizes step relays S1 and S2. The circuit to S2 is established by closed M1-M2 contacts of SPR. The A-B contacts of S1 and S2 close to seal the relay in against FTR dropout.

3. The C -D contacts of S1 and S2 close, Fig. 6-13, but since FTR G-H contacts are open, the field shunting contactors are not yet energized.

4. Closure of S1 and S2 E-F contacts causes FTR knockdown through FTRA action and FS1A & B and FS2A & B are energized through G-H contacts of FTR, C-D contacts of S1 and S2, and C1-C2 contacts of SPR. Motor fields are shunted approximately 47% and system voltage drops slightly. This is the final step of shunt.

5. The opening of PR contacts N1-N2, Fig. 6-12, prevent pickup of S3 should FTR pick up again.

6. The closing of FS1A interlock G-H, Fig. 6-15, picks up FSA. Closed E1-E2 contacts of FSA along with C-D interlock of FS2B and the M1-M2 contacts of PR set up the circuit for local control current to energize the wheel slip relay WS46 should FTR pick up again, Fig. 6-18. FTR pickup after the final step of transition would indicate train overspeed or 6-axle simultaneous slip.

7. Closure of the E-F interlock of P6, Fig. 6-12, prevents SPR dropout should the locomotive slow down and BTR drop out.

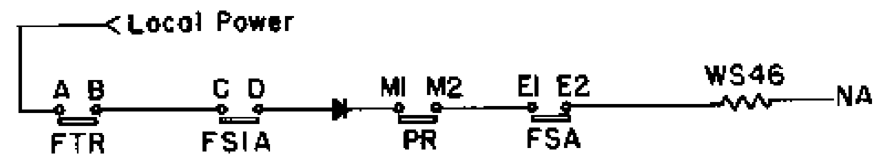


Fig. 6-18 - Simultaneous 6-Axle Wheel Slip Detection Circuit

BACKWARD TRANSITION

PARALLEL SHUNT TO PARALLEL FULL FIELD

With the locomotive operating in parallel shunt, FTR is dropped out and BTR is picked up.

1. When the locomotive begins to slow down, system voltage drops and BTR drops. The A-B contacts of BTR opening, Fig. 6-12 interrupts current flow to the magnet coils of S1 and S2.

2. The C-D contacts of S1 and S2 open, Fig. 6-13, but the E -F contacts of BTR have closed to hold FS1A & B and FS2A & B energized. However, the J -K contacts of S1, Fig. 6-14, have closed, and current flows to the N-P coil of BTR through closed Q-R contacts of FS1A.

3. BTR picks up and field shunting contactors FS1A & B and FS2A & B are de-energized. The removal of the shunt from the motor fields causes an increase in voltage and BTR remains picked up even though the Q-R contacts of FS1A are opened.

PARALLEL FULL FIELD TO SERIES-PARALLEL FULL FIELD

1. As locomotive speed further decreases, BTR again drops out. BTR C-D contacts opening de-energize PR, Fig. 6-12, but the E-F contacts of P6 hold SPR picked up. The G1-G2 contacts of PR, Fig. 6-4, opening, drops out the shunt field contactor SF and battery field auxiliary contactor BFA.

2. C1-C2 contacts of PR, Fig. 6-6, opening de-energizes power contactors P1 and P4.

3. The A-B interlock of P4 closes to energize power contactor S14. The A-B interlock of S14 opens to de-energize power contactors P2 and P5.

4. The A-B interlock of P5 closes to energize power contactor SP25. The A-B interlock of SP25 opens to drop out power contactors P3 and P6.

5. The A-B interlock of P6 closes to energize power contactor S36. The traction motors are now connected in series-parallel full field. Closure of S36 G-H interlocks, Fig. 6-4, picks up SF and BFA.

6. As excitation is regained, system voltage and amperage will increase, and BTR will pick up followed by FTR pickup. Forward transition will occur, and shunting contactors will be picked up as required by operating conditions.

7. If the locomotive continues to slow down, shunting contactors will be dropped out in much the same manner as they were during parallel motor connection. During series parallel full field operation, dropout of BTR will de-energize SPR.

BACKWARD TRANSITION, SERIES-PARALLEL SHUNTING DECREASE

Assume that the locomotive is operating in series-parallel shunt with all shunting contactors picked up (62% shunt). To arrive at this condition, transition from parallel full field down to series-parallel full field and back up to the step of series-parallel shunt will have occurred. The system does not step directly from parallel full field to series-parallel shunt.

1. When the locomotive begins to slow down, system voltage drops and BTR drops out. The A-B contacts of BTR opening, Fig. 6-12, interrupts current flow to the magnet coil of S3.

2. Step relays S1 and S2 are held energized by current through the N-P interlock of FS3A, Fig. 6-12, which is still picked up, and through holding contacts of S1 and S2.

3. Closure of the J-K contacts of S3 energizes the BTR N-P coil, Fig. 6-14, and BTR picks up. This breaks an FS3A holding circuit through BTR E-F contacts and FS3A L-M interlock, Fig. 6-13, and FS3A & B drop out.

4. FS3A dropping out does not de-energize S1 and S2 because BTR contacts A-B closed before the N-P interlock of FS3A dropped out. The decrease in percentage of shunt causes an increase in system voltage and BTR remains picked up even though the Q-R interlock of FS3A, Fig. 6-14, has opened. A further decrease in locomotive speed will cause BTR to drop out again.

5. With the locomotive operating in the first step of series-parallel shunt, dropout of BTR will de-energize step relays S1 and S2, and their C-D contacts open, Fig. 6-13. However, BTR contacts E-F

close to keep FS1A & B and FS2A & B energized through holding interlocks.

6. Closure of the J-K contacts of S1 and S2 energizes the BTR N-P coil, Fig. 6-14, and BTR picks up. This breaks the FS1 and FS2 holding circuit through BTR contacts E-F and FS1 and FS2 L-M interlocks, Fig. 6-13, and FS1A & B and FS2A & B drop out.

7. Contacts C-D of FS1 and FS2 opening drops out series-parallel relay SPR, and the transition system will step from series-parallel full field to series full field should BTR drop out again.

SERIES-PARALLEL FULL FIELD TO SERIES FULL FIELD

1. When BTR drops out with a further decrease in speed, the C-D contacts, Fig. 6-12, open to drop out SPR. G1-G2 contacts of SPR, Fig. 6-4, opening drops out the shunt field contactor SF and battery field auxiliary contactor BFA. The P1-P2 contacts of SPR, Fig. 6-6, open to drop out power contactor SP25.
2. Dropout of SP25 de-energizes SP25R. SP25R contacts J -K close to pick up series power contactors S23 and S45.

3. Pickup of S23 and S45 drops out SP14 and SP36, and the series motor connection is complete. Closure of the G-H interlocks of S23 and S45 picks up SF and BFA to regain main generator excitation.

3. As excitation is regained, system voltage and amperage will increase and BTR will pick up followed by FTR pickup. Forward transition will occur to pick up steps of shunt as required by operating conditions.

5. If the locomotive continues to slow down, shunting contactors will be dropped out in much the same manner as they were during parallel motor connection.

BACKWARD TRANSITION, SERIES SHUNTING DECREASE

Assume that the locomotive is operating in the third step of series-parallel shunt with shunting contactors FS1 and FS2 picked up (47% shunt). To arrive at this condition, transition from series-parallel full field down to series full field and back up to the third step of series shunt will have occurred. The system does not step directly from series-parallel full field to series shunt.

In the third step of series shunt, step relay S3 is picked up, but FS3 is not energized because the C-D interlock, Fig. 6-13, of series power contactor S23 is open.

1. When the locomotive begins to slow down, system voltage drops and BTR drops out. The A-B contacts of BTR opening, Fig. 6-12, interrupts current flow to the magnet coil of S3. The G-H contacts of S3 open, Fig. 6-13, but FS1A & B are held energized through BTR contacts E -F and FS1 holding interlocks. However, the J-K contacts of S3 have closed and current flows to the N-P coil of BTR through Q-R of FS1A, D1-D2 of SPR, and G-H of S2, Fig. 6-14.

2. BTR picks up and field shunting contactors FS1A & B are de-energized. Contactors FS2A & B remain energized through E-F interlock of FS2A and C-D contacts of S2. The percentage of field shunt is decreased from approximately 47% to approximately 39%. This causes an increase in system voltage and BTR remains picked up even though the Q -R interlock of FS1A has opened.

3. With continued decrease in speed, BTR again drops out. S2 is de-energized, but S1 is held in by current through N-P of FS2A, N1-N2 of SPR, and A-B of S1, Fig. 6-12. Closure of BTR contacts E-F feeds a circuit to hold FS2A in against S2 dropout, Fig. 6-13.

4. With S1 C-D and S2 L-M contacts closed, FS1A & B are energized through the now closed G-H contacts of forward transition relay FTR, Fig. 6-13. Closure of S2 J -K contacts, Fig. 6-14, energizes the BTR N-P coil. BTR contacts E-F open to break the holding circuit and drop out FS2A & B.

5. The percentage of field shunt is decreased from approximately 39% to approximately 21%, and system voltage increases. BTR remains picked up even though the opening of FS2A interlocks de-energizes the BTR N-P coil.

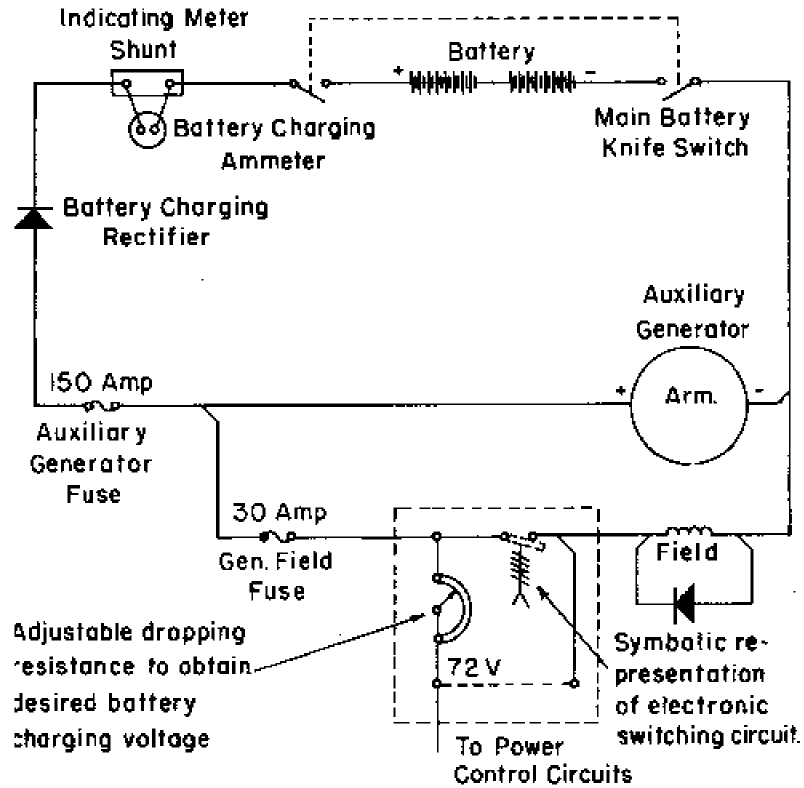
5. When BTR again drops out, the coil of S1 is de-energized and S1 C-D contacts open to dropout FS1A & B, removing all shunt from the motor fields.

BATTERY CHARGING AND VOLTAGE REGULATING CIRCUIT, Fig. 6-19

The auxiliary generator is coupled directly to the gear train of the diesel engine, therefore it rotates only when the engine is running. When the engine is stopped, a blocking rectifier called a battery charging rectifier prevents flow of current from the battery through the low resistance of the generator windings. The rectifier offers high resistance to current flow in the blocking direction and low resistance in the forward direction.

Initial excitation of the auxiliary generator is obtained from residual magnetism in the generator iron. When the generator is rotating, excitation is from a field winding connected in parallel with the generator output and in series with a static voltage regulator.

The voltage regulator is termed "static" because with the exception of a starting relay it uses no moving parts. Electronic components in the regulator sense generator voltage and regulate the voltage by rapidly opening and closing the circuit to the generator field. When the regulator senses high voltage it opens the circuit and field current decays, but relatively slowly because



Voltage regulator manufactured to maintain stable reference potential for power control circuits.

Fig. 6-19 - Battery Charging And Voltage Regulating Circuit field current flows through a rectifier connected around the field. When the regulator senses low voltage it closes the field circuit and field current increases. This switching on and off to maintain stable voltage occurs rapidly and at intervals measured in fractions of a second. The rapid response of the static voltage regulator maintains generator voltage within 1/2 volt of the desired value, regardless of load, temperature, or engine speed.

The voltage regulator is provided with two taps from which regulated voltage is obtained. One tap is connected only to the power control circuits. It maintains a stable voltage of 72 volts to the power control circuits. The regulator is manufactured and factory set to maintain the required 72 volt potential.

The second tap is connected to the locomotive low voltage system. Its voltage is variable from 72 to 76 volts by use of a voltage dropping device within the voltage regulator adapter VRA. This variation has no effect upon the operating coils of relays or contactors, but is provided for battery charging purposes.

DYNAMIC BRAKE OPERATION (Optional Equipment)

Dynamic braking is an electrical arrangement used to change some of the mechanical power developed by the momentum of a moving train into electrical power. The electrical power is converted to heat which is blown out through a hatch at the top of the locomotive. 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

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 setup 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.

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.

DYNAMIC BRAKE CIRCUIT, Fig. 6-20

Braking strength is controlled by varying the excitation of the main generator battery field and thereby controlling the strength of the traction motor fields.

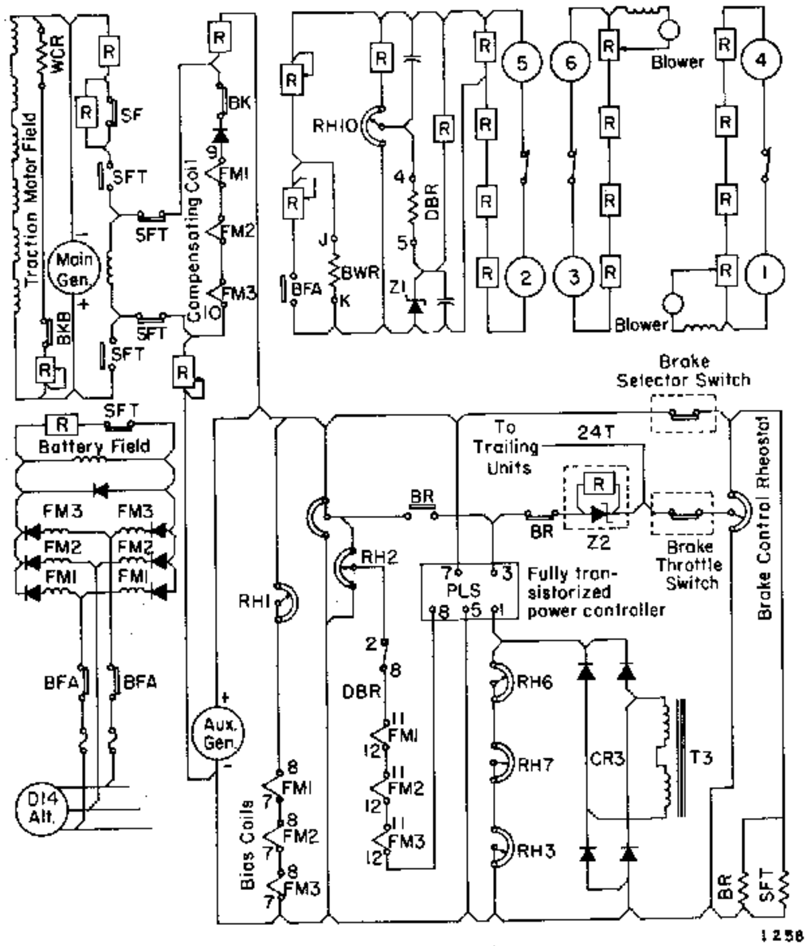


Fig. 6-20 - Dynamic Brake Circuits, Simplified Composite Diagram

The strength of the battery field is controlled by the power windings of the magnetic amplifier. The output of these power windings is controlled by the control windings of the magnetic amplifier. The amount of DC current in the control windings is determined by the position of the brake control rheostat.

With the selector lever in brake position and the throttle advanced, a voltage signal from the brake control rheostat appears at the performance control system. If the potential of that signal is greater than the potential of a signal from devices (generator current transductor GCT3 and transformer T3) that sense main generator current, full output of the magnetic amplifier is allowed by the system. When the potential of the signal from T3 equals or exceeds the potential from the brake control rheostat, the performance control system acts to reduce magnetic amplifier output. In this manner braking strength is controlled by manipulating the throttle handle.

Brake rheostat control of dynamic brakes keeps main generator current at that called for by throttle position, but varying conditions of load and grade result in varying motor armature or dynamic braking current for any given throttle position. Therefore, it is necessary to limit dynamic braking current to protect the equipment. Two protective devices are provided; a dynamic brake regulator and a brake warning relay.

The circuit to the dynamic brake regulator DBR is so calibrated that when braking current is at 700 amperes, the voltage at zener diode Z 1 is 50 volts. Z 1 is manufactured to conduct when 50 volts is applied, and as it conducts current flows through the coil of DBR. This causes DBR contacts to move 8 to 6 and interrupt the flow of current in the FM 11-12 windings. A reduction of control current results in a reduction of magnetic amplifier output to the main generator battery field. The purpose of the brake warning relay BWR is primarily to provide protection to the dynamic braking circuits should the excitation or regulating circuits lose calibration or in some way fail. Braking current slightly higher than 700 amperes will cause the brake warning relay to respond, and BFA contacts will drop out, interrupting the *flow* of alternator current to the magnetic amplifier power windings.

The compensating windings shown in the upper left hand portion of Fig. 6-12 are part of the magnetic amplifier and perform in much the same manner as the drive coils, except that current in the compensating windings is in opposition to that in the drive windings. Current flow from 11 to 12 in the drive windings increases battery field excitation. Current *flow* from 10 to 9 in the compensating windings decreases battery field excitation.

Observe that the shunt field transfer relay picks up during dynamic braking to disconnect the generator shunt field from the generator armature. However, the shunt field will become excited because of generator residual magnetism and by transformer action with the battery field. The affect of the generator residual is bucked by connecting auxiliary generator current across the shunt field. This allows the transformer action to serve a useful purpose. Whenever main generator battery field current is changed, as during wheel slip or sudden movement of the throttle handle, current is induced in the generator shunt field. This current flows through the compensating windings of the magnetic amplifier and prevents sudden loading of the power windings. The result is a smoother operating dynamic brake.

WHEEL SLIP DETECTION CIRCUITS, Fig. 6-21

Fig. 6-21 is a simplified circuit diagram showing only a portion of the wheel slip detection devices; however, the explanation for WS14 is applicable to WS25 and WS36 if the

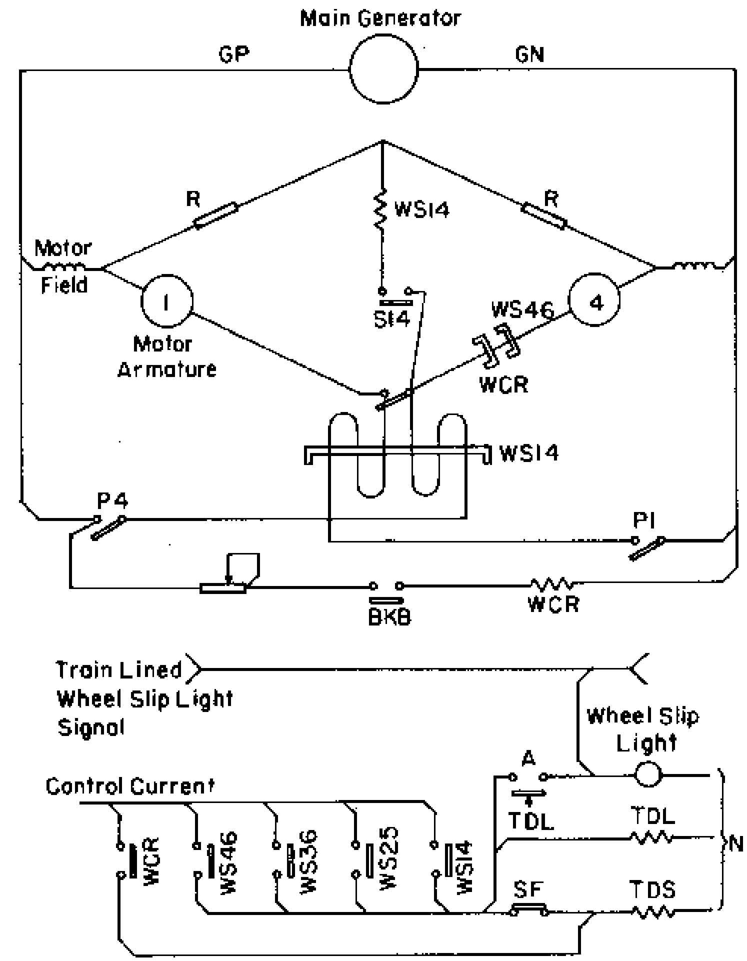


Fig. 6-21 - Wheel Slip Detection Circuits, Simplified Diagram proper contactor and motor designations are substituted. A brief explanation of individual wheel slip relay operation is provided in Section 5 of this manual.

When the locomotive is operating at very slow speed, two groups of three traction motors in series are connected across the main generator and current flow through the motors is at a high value. A cable carrying current for one group of motors passes through the frames of WCR and WS46. A cable from the other group of motors also passes through the relay frames, but current flow in the cables is in opposite directions. If current flow in one cable is greater than current flow in the other, the relay is unbalanced. When the current differential is great enough, the relay is tripped. WCR is constructed to trip at a smaller differential than WS46, and during slow speed operation when current values are high, WCR and WS46 are more sensitive than WS14, WS25, or WS36, which are connected in bridge circuits between traction motors.

Operation of WCR brings about a timed application of sand. Operation of WS46 brings about reduction of main generator excitation through pickup of BFA. Operation of any of the other WS relays causes pickup of shunt field relay SF in addition to application of sand. Fig. 6-4 shows the circuits containing contacts of the wheel slip relays. During series-parallel traction motor connection, the wheel slip detection circuits function essentially the same as during series motor connection, but system voltage and current values are such that the bridge circuits are more sensitive than the relays that operate on the through cable principle.

When traction motors are connected in parallel with the main generator the coils of the WS relays are disconnected from the system, but pickup of the parallel power contactors energizes cables that pass through the frames of

WS14, WS25, and WS36. These cables are doubled over to pass through the relay frame twice, thus doubling the sensitivity of the relays to make up for the low current values through the relays during parallel motor connection.

Notice on Fig. 6-21 that the voltage coil of WCR is connected across the main generator during dynamic braking (on units so equipped). The circuit is calibrated for pickup of WCR if generator voltage increases due to hot motor fields. Similar use is also made of the voltage coil of WS46. See Fig. 6-18 and related text for an explanation.

Also note on Fig. 6-21 that the wheel slip light circuit contains a delayed pickup contact of time delay relay TDL. This prevents the wheel slip light from coming on unless the wheel slip is of long duration (approximately 4 seconds). However, a trainlined wheel slip light signal from a unit not equipped with TDL will cause the light to blink under usual wheel slip conditions.

SANDING CIRCUITS

The basic sanding system for the SD35 locomotive is an electrical system that eliminates the need for relay valves and trainlined sanding actuating air pipes. However, if the SD35 is to be used with older locomotives equipped with only pneumatic sanding control, an optional extra pneumatic sanding system, Fig. 6-22, is superimposed upon the electrical sanding system. The two systems operate in parallel, therefore air actuating pipes should be connected whenever a consist contains any units equipped for only pneumatic sanding control.

Movement of the manual sanding lever connects control current through the proper reverser interlock to the sanding control valve solenoids, and, on locomotives equipped with the pneumatic sanding extra, to the relay valve

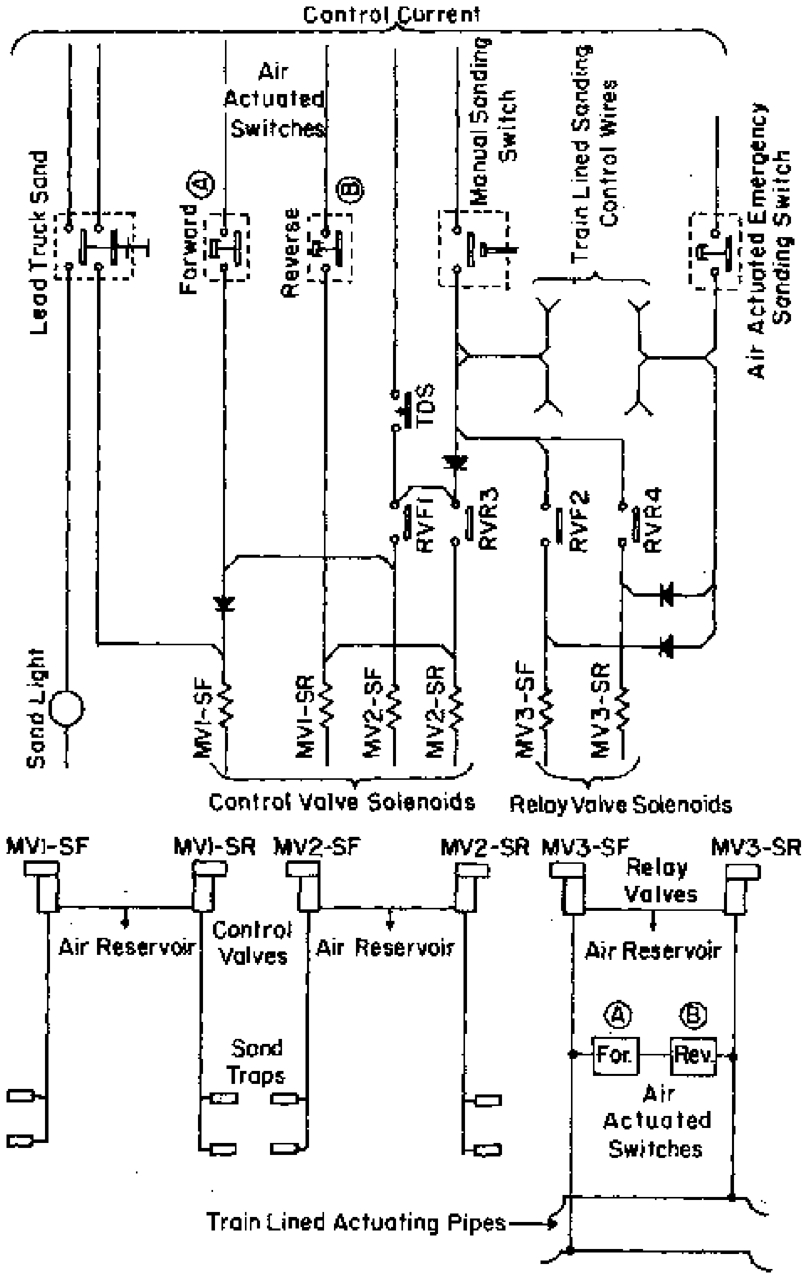


Fig. 6-22 - Sanding Circuits And Air Schematic
Pneumatic Sanding Option Included

solenoids. If the SD35 is trailing a pneumatic unit, air actuated switch A or B, Fig. 6-22, closes to provide sanding on the trailing unit.

Manual sanding at the No. 1 axle of the lead unit only is provided by operation of a toggle switch identified as SANDING No. 1 TRUCK. The SAND light comes on when the switch is closed.

During wheel slip action, time delay relay TDS is energized to provide sanding on only the slipping unit. Delayed dropout of TDS causes sanding to continue for a timed period after the slip is corrected.

Sanding during an emergency application of the brakes is provided automatically from all sand traps through action of an air operated emergency sanding switch. The circuits from the switch are so arranged that emergency sanding from all traps will continue even though the motors are "plugged" (reverse lever placed to oppose direction of travel). On the basic locomotive emergency sanding is accomplished electrically. If the locomotive is fitted with the pneumatic option relay valves and air actuated switches ensure proper sanding even with the motors "plugged."

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.

GENERAL PROCEDURE

Safety devices automatically protect the equipment in case of faulty operation of almost 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 will ring in all units of a multiple unit consist, but the signal light will be illuminated only on the unit experiencing the trouble. With this arrangement the unit in trouble can be quickly detected.

Operating difficulties sometimes occur without being indicated by alarms. In such cases 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 controlling unit.

ALARM SIGNAL LIGHTS

Colored alarm signal lights are located on the engine control panel on the rear cab wall. 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 system.

3. Check to see if cooling fans are running. (AC contactors are located in a cabinet mounted on the equipment rack.)

4. Shutters should be open. If closed, check position of shutoff valve in air supply line.

5. Local control circuit breaker must be ON, or fan contactors will not operate.

BLUE - NO POWER

Cause - Alternator failure; thus, no AC power is being generated, NVR, drops out and excitation is removed from the main generator. May be due to loss of alternator excitation or electrical difficulty in the AC system (true

TROUBLE SHOOTING

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. If the failure was due to electrical fault, the engine in the unit concerned will go to idle speed.

Correction - To silence alarms, isolate unit. -Method of correction depends upon whether failure was due to electrical or mechanical fault. Perform the following:

A. Engine Stopped (not AC failure)

1. Engine overspeed device tripped. Check lever position, reset if necessary.
2. Low water or crankcase (oilpan) pressure detector tripped. The yellow low oil light will also be on in such case.
3. Engine starving for fuel. Observe for proper fuel flow through return sight glass by operating fuel pump. If fuel is not evident, check reasons given in this section under "Insufficient Fuel."
4. Throttle lever in STOP position.
5. Low oil pressure. Yellow low oil light will be on in such case.
6. FPC de-energized (engine stops immediately).

B. AC Failure (engine idling)

1. Blown 60-ampere alternator field fuse.
2. Blown 150-ampere auxiliary generator fuse.
3. Blown 30-ampere auxiliary generator field fuse.

AMBER - 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.

A low oil pressure indication is also given when the crankcase pressure / low water detecting device is tripped. This is because the device dumps oil from the low oil pressure detector in the engine governor.

Effect - The diesel engine in the unit concerned will be stopped and the amber light on the engine control panel will be on. The push button on the governor will be out, with the red indicating band exposed. The blue NO POWER light will also come on as NVR drops out due to no AC voltage.

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

1. Isolate unit to stop alarm bells.
2. Reset governor trip button. Amber light will go 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. Check the low water and crankcase (oilpan) pressure detecting device mounted on the engine. If the lower button protrudes, the failure is due to low water. If the upper button protrudes, the failure is due to excessive oilpan pressure.

Upper Button Protrudes

Cause -Oilpan pressure exceeds a predetermined positive pressure setting. May be the result of gases entering the oilpan through cracked pistons, badly worn rings, or broken rings.

Effect - Engine shut down

Correction -Manually reset the device, and proceed with the checks shown for low oil shutdown.

Lower Button Protrudes

Cause - Low water level or sudden loss of engine water.

Effect - Engine shuts down. If water level is only slightly low, the engine may shut down only at high throttle positions.

Correction -Manually reset the device. Check for water leaks. Add water. Reset governor low oil trip button.

6. Check that lubricating oil viscosity is not reduced due to dilution with fuel oil.
7. Check that oil viscosity is not reduced due to excessive heat. In such case the hot engine alarm may also be activated.
8. Restart engine after reset buttons have been pressed and corrective action taken. Observe oil pressure on gauge. It should be a minimum of 15 psi with engine at idle. Note oil suction on color coded gauge. Indication should be in the green area.

CAUTION: In the event of continued low oil pressure, high suction or low water, the governor trip button will again move to stop the engine. The engine should not be repeatedly started or forced to run when the governor keeps shutting down the engine. 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 - WHEEL SLIP

Cause - If a locomotive consist is made up with units not equipped with a time delay wheel slip light relay TDL, an intermittently flashing wheel slip light indicates that a unit without TDL is slipping and the system is correcting the slips.

If all units in a consist are equipped with TDL, a flashing wheel slip light indicates that a wheel slip is of greater duration than approximately 4 seconds. If the flashing persists observe the WARNING below.

Effect - Sand will be applied to the rail, and power will be reduced automatically (and restored) on the slipping unit. If a wheel slip light signal is given by a trailing unit, the light in the lead unit will flash, even if the lead unit is equipped with a time delay wheel slip light relay TDL.

Correction - Throttle should be reduced only if severe lurching threatens to break a train. WARNING: 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 - 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.

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 BFA 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. 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 - PCS OPEN

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

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

Correction - The PCS 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 PCS OPEN light will then go out. 4. Return brake valve handle to running position.

NOTE: In the event of the PCS 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 PCS 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 PCS switch.

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 cycle on and off longer than three seconds.

Correction - Excess braking current is usually quickly and automatically corrected by the dynamic brake regulator. In the event the warning light blinks excessively, the throttle should be moved to reduce braking strength. The light should never be allowed to blink on and off more than three seconds.

CORRECTION OF OPERATING DIFFICULTIES

INSUFFICIENT FUEL

Insufficient fuel will cause erratic engine operation. Lack of fuel will cause engine to shut down. It will 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 closer to the engine should be full whenever the fuel pump and engine are running. The other adjacent glass should always be empty. Refer to the Fuel System portion of Section 4 for details.

FOR FUEL PUMP TO OPERATE

1. Main battery switch must be closed (during prime).

2. Control and local control circuit breakers must be ON.

3. Control and fuel pump switch must be ON.

4. Fuel pump 15-ampere circuit breaker must be ON.

5. Cable must be firmly connected to motor.

6. FPC and FPR coils must be energized.

NO FUEL WITH PUMP RUNNING

1. Lack of fuel in tank.

2. Slipping or broken coupling between motor and pump.

3. Suction leak in piping.

4. Clogged suction or discharge filters.

ENGINE CANNOT BE STARTED

Engine starting difficulties fall into two categories; namely, engine does not rotate in START position, 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. Turbo lube pump 30-ampere circuit breaker must be ON.

3. Isolation switch must be in START position.

4. Starting 400-ampere fuse must be good and in place.

5. Control and fuel pump switch must be ON, and TLPC must be picked up.

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. Fuel system must be sufficiently primed.

4. Throttle must be in IDLE position.

ENGINE STOPS SOON AFTER STARTING

1. Fuel pump circuit breaker must remain closed.

2. Control and local control circuit breakers must remain closed.

3. Low water and crankcase (oilpan) pressure detector buttons must be set.

ENGINE DOES NOT RESPOND TO THROTTLE

In instances where an engine is running normally at idle speed but does not speedup when throttle is advanced, the indication is 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. Ground relay must be set.

2. NVR must be energized.

3. Isolation switch must be in RUN.

4. PCS switch must be set.

5. Engine run switch must be ON.

6. Control circuit breaker and control and fuel pump switch must be in ON position. In addition to lack of throttle response with these devices OFF, the engine will in a few minutes shut down from lack of fuel.

LOCOMOTIVE DOES NOT LOAD UP

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

1. Reverse lever must be in either FORWARD or REVERSE.
2. Selector lever must be in power-No. 1 position.
3. Generator field switch must be ON.
4. Battery field 60-ampere fuses must be good and in place.
5. Local control 30 -ampere circuit breaker must be

ON. ENGINE GOES TO IDLE DURING OPERATION

See possible causes in preceding article entitled "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. Crankcase (oilpan) pressure / low water detector tripped.
4. Insufficient or lack of fuel. See preceding fuel system difficulties.
5. Auxiliary generator fuse may have opened.
6. FPC de-energized.

TROUBLE SHOOTING

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 fuse (150-ampere) must be good and in place (250-ampere for SDP35).

NOTE: A strong discharge reading at engine stop, followed by a burned out auxiliary generator fuse, indicates a shorted battery charging rectifier.

2. Auxiliary generator field fuse (30-ampere) must be good and in place.
3. Voltage regulator must be operative and properly adjusted.

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 instances however, when such action is not automatically taken and it may be advisable to take manual action. Since these occasions are unusual, each should be handled individually, using good judgment. The following suggestions may be helpful.

<u>Mechanical Problems</u>

1. Smoke Coming Out Of Exhaust - Operation may continue.
2. Oil Or Fire Coming Out Of Exhaust - Stop engine.

3. Smoke In Engineroom Coming From Engine - Stop engine, DO NOT REMOVE ANY INSPECTION COVERS.

4. Governor Shutdown Plunger Trips Repeatedly - This may be due to low oil, positive crankcase pressure, or low water pressure. If the shutdown is due to low oil or positive crankcase pressure do not restart the engine. If shutdown is due to low water, it may be possible to operate the engine at reduced throttle if the low water reset button on the crankcase pressure/ low water detector stays in when pressed with engine shut down.

5. Engine Cooling System Losing Water Rapidly - Stop engine.

6. Unusual Noises - Investigate source. Stop engine or discontinue operation to prevent damage if noise is pronounced.

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.

<u>Electrical Problems</u>

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. Unit Fails To Make Forward Transition - Operation may continue.

5. Unit Fails To Make Backward Transition -Load regulator will be driven to minimum field position and unit will not load. Isolate unit.

6. Locomotive Consist Lurches Forward When Throttle Is Advanced Out Of IDLE - Trailing unit control 40-ampere circuit breaker not closed.