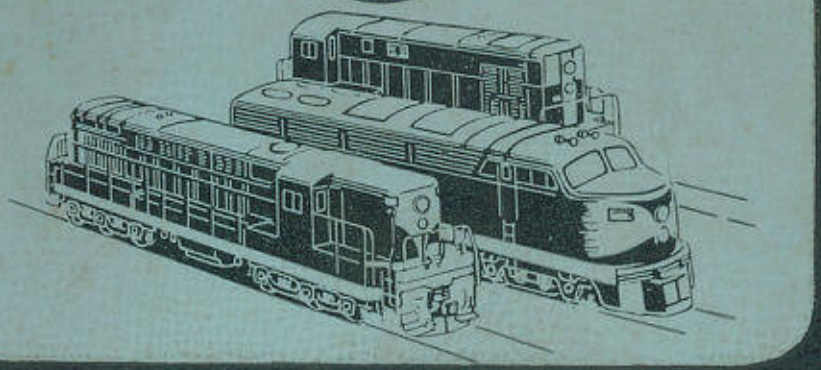


FAIRBANKS-MORSE

DIESEL ELECTRIC *Locomotives*

ENGINEMEN'S MANUAL

BULLETIN 1603A

ENGINEMEN'S MANUAL FOR OPERATING FAIRBANKS-MORSE 2400 HP TRAIN MASTER LOCOMOTIVES WITH WESTINGHOUSE ELECTRIC ROTATING AND CONTROL EQUIPMENT

for the

READING RAILROAD

Road Nos.	F-M Serial Nos.
862	24-L-865
863	24-L-882
864	24-L-883
865	24-L-884
866	24-L-863
867	24-L-864

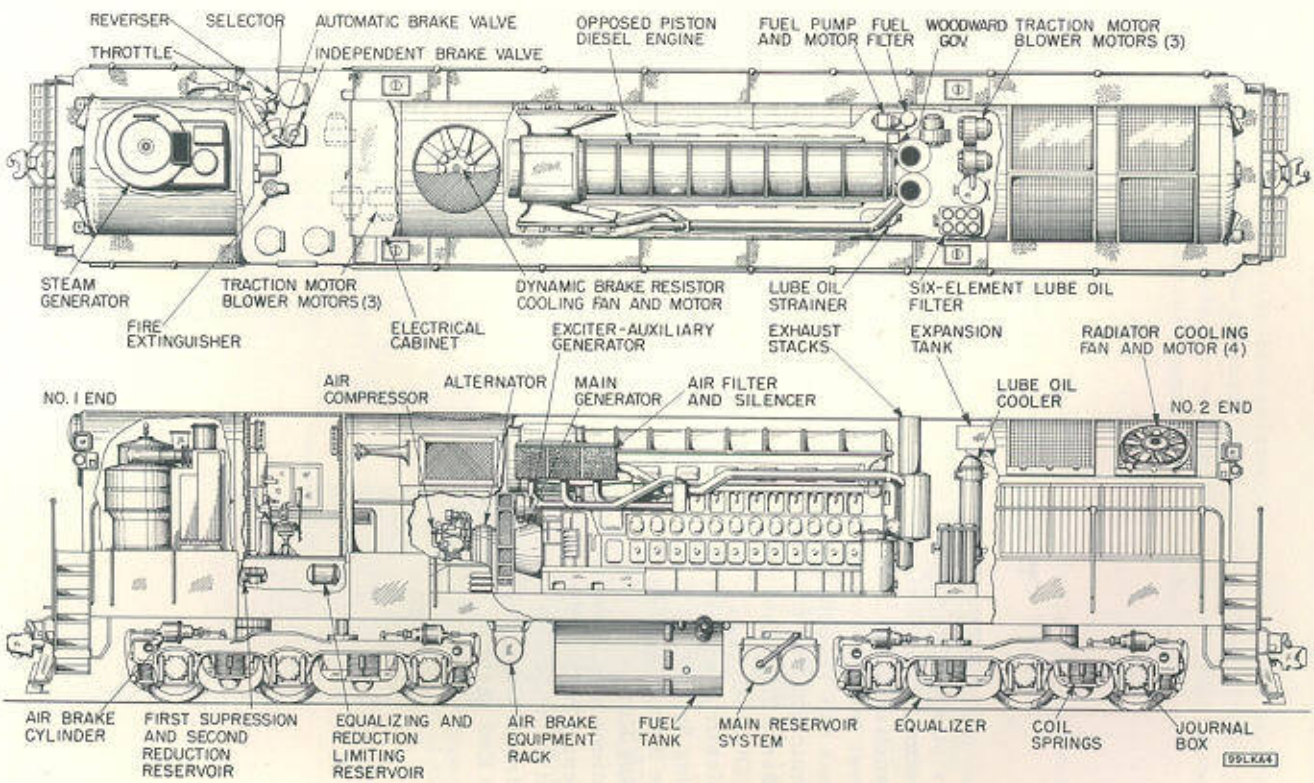
FOREWORD

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Neither is the amount of material supplied by Fairbanks, Morse & Co. increased by anything shown in these instructions or associated drawings. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to Fairbanks, Morse & Co., Diesel Locomotive Service Department, Beloit, Wis.

340450-115505C-CWM

Printed in U.S.A.

2400 HP Train Master Diesel Electric Locomotive



General Arrangement Diagram - 2400 HP Train Master - Type H24-66

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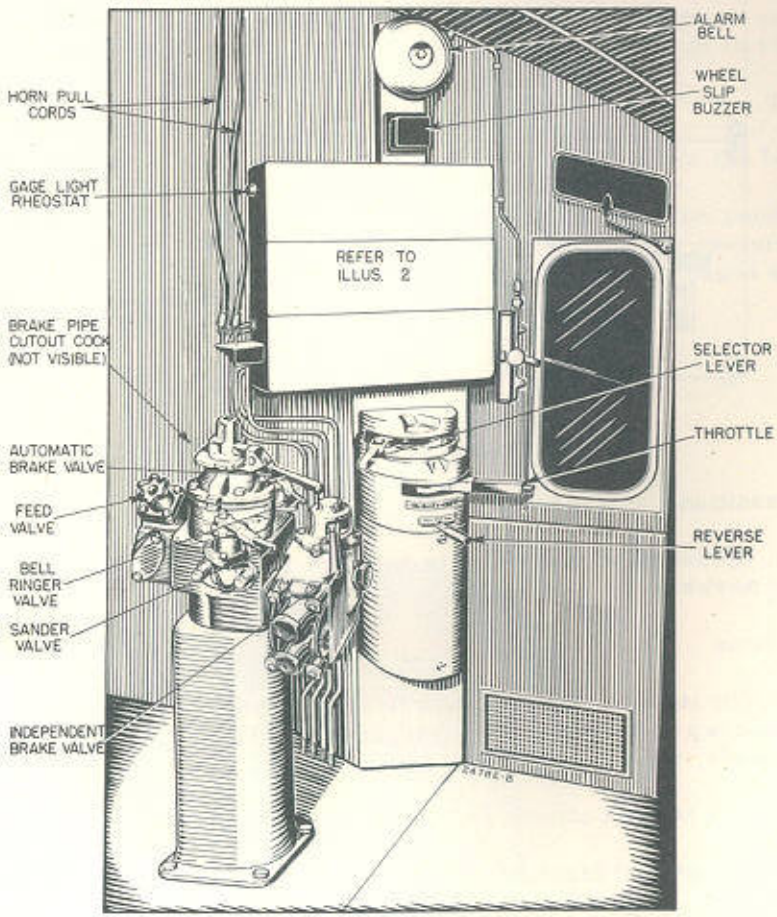
SEC. 101A. DESCRIPTION OF LOCOMOTIVE CONTROLS

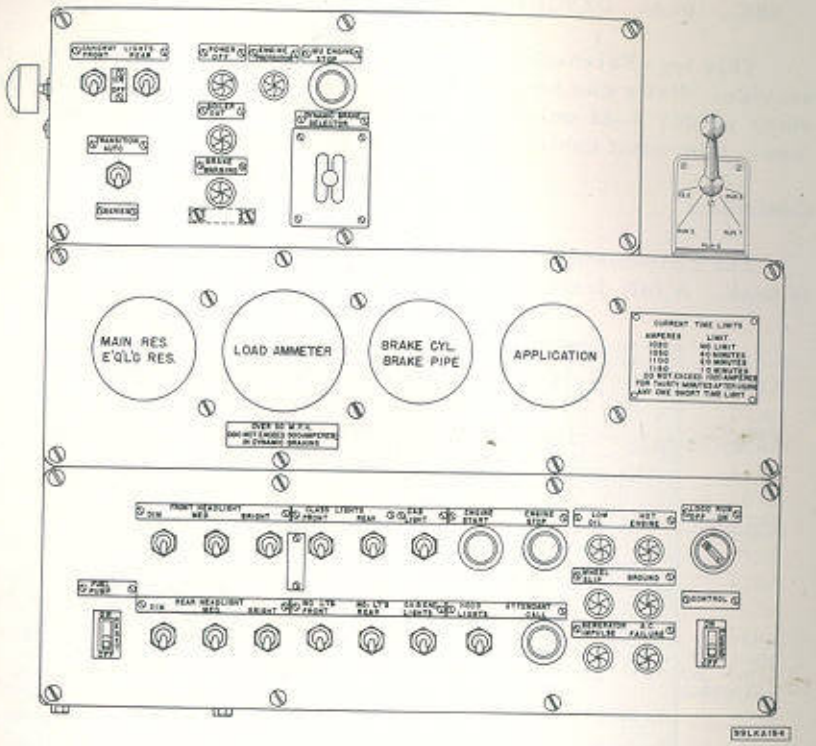
This type Fairbanks-Morse locomotive is built for all types of service. Units can be operated in multiple with each other, with other model F-M units, or with certain units of other manufacture. Inter-unit control jumpers must match.

Controller

The conventional type controller with 8-step throttle control is used. A full description is included in Sec. 105A.



Illus. 1. Typical Engineer's Control Station
A representative arrangement is shown.



Illus. 2. Typical Engineer's Control Panel

Transition

Operation of transition is included in Sec. 125A, Questions and Answers

Isolator

The isolator, Illus. 2, has five positions: "IDLE," and four engine speed running notches. See Sec. 125A, Questions and Answers, for a full description of operation.

Traction Motor Cutout Switch

Operational description in Sec. 125A, Questions and Answers.

Load Ammeter

The load ammeter, Illus. 3, indicates current to Nos. 4, 5, and 6 traction motors in 3 series, 2 parallel operation and to Nos. 5 and 6 traction motors in 2 series, 3 parallel operation.

NOTE: F-M diagrams show traction motors 1, 2, and 3 on the cab end truck and motors 3, 4, and 5 on the radiator end truck. This is our standard practice in order to eliminate confusion as some units are built with the radiator end as the No. 1 end.

Both motoring and dynamic braking currents are indicated with a separate scale for each on the dial. Refer to Illus. 3.

The two scales of the ammeter are calibrated as follows:

1. The "motoring scale" runs from 0 to 2000 amperes, each division indicating 100 amperes. The scale is green up to 1020 amperes and red from there on.

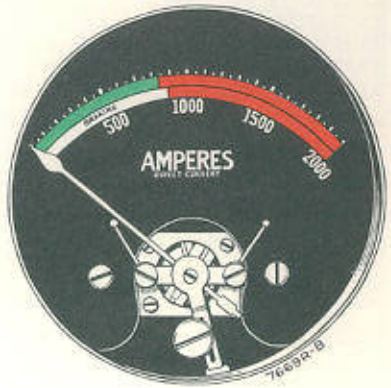
2. The "Braking Scale" runs from 0 to 2000 amperes. The scale is white up to 840 amperes, red from there on.

Tonnages must be limited to those which will allow the load ammeter pointer to remain within specified load limits.

If, after all transition steps have dropped out, the pointer goes beyond 1020 amperes except temporarily while operating under load current time limits, the locomotive is overloaded and TONNAGE MUST BE REDUCED OR HELP OBTAINED.

Load current time limits are as follows:

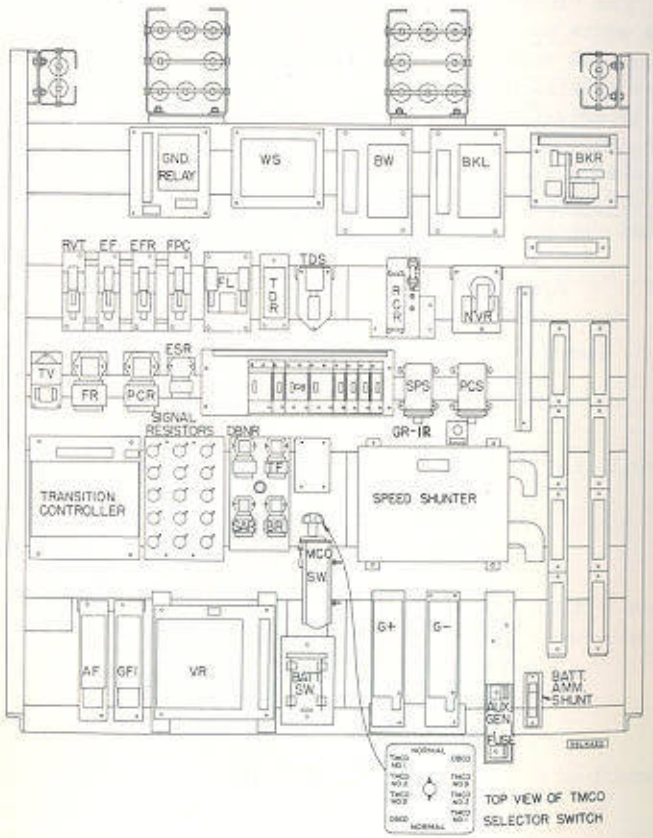
Amperes	Time Limit
1020	No Limit
1050	40 Minutes
1100	20 Minutes
1150	10 Minutes



Illus. 3. Load Ammeter

LEGEND

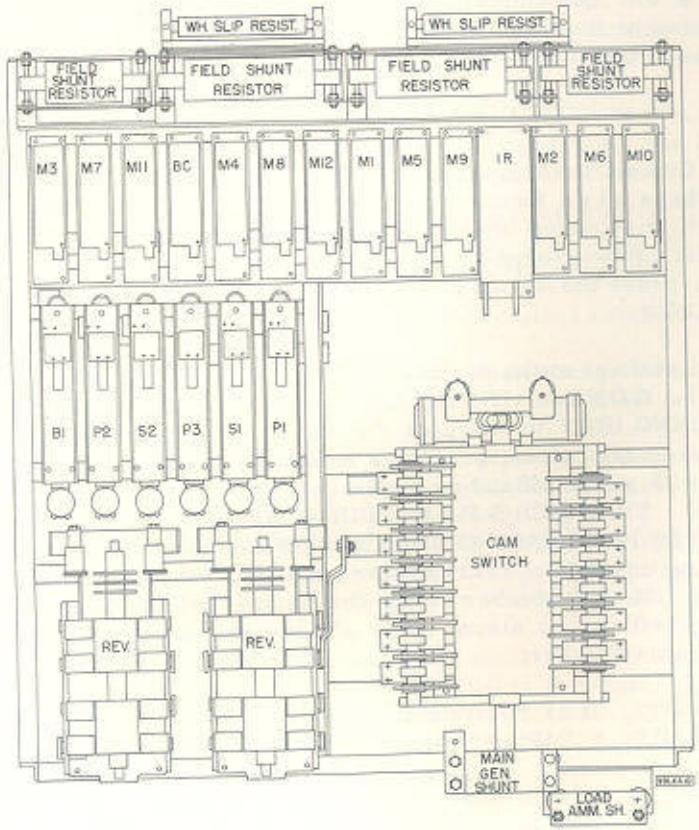
FR - Forward-Reverse Pilot Contactor
G+, G-, GF1 - Engine Starting Contactors
GF - Generator Field Contactor
GR, IR - Ground and Impulse Reset Button
M1-M12 - Traction Motor Field Shunting Contactors
NVR-No-A. C. - Voltage Relay
P1, P2, P3 - Parallel Power tactors
PCR - Pneumatic Control Relay
PCS - Pneumatic Control Switch
RCR - Reverse Current Relay
RVT - Reduce Volt. Transition Relay
S1, S2 - Series Power Contactors
SAR - Signal Alarm Relay
SPS - Sanding Pressure Switch
TDR - Time Delay Relay
TDS - Time Delay Start Relay
TF - Transition Forestalling Relay
TMCO SW - Traction Motor Cutout Switch
TV - Throttle Contactor
VR - Voltage Regulator
WS - Wheel Slip Relay



Illus. 4. Electrical Cabinet - Cab Side

LEGEND

AF - Alternator Field Contactor
B1 - Braking Contactor
BATT SW - Main Battery Switch
BC - Battery Charging Contactor
BKL - Brake Limit Relay
BKR - Brake Regulator Relay
BR - Braking Relay
BW - Brake Warning Relay
CB1 - Boiler Circuit Breaker
CB2 - Train Control Breaker
CB3 - Dynamic Brake Breaker
CB4 - Fuel Pump Breaker
CB5 - Control Cutout Breaker
CB6 - Cab Heater Breaker
CB7 - Headlight Breaker
CB8 - Locomotive Lights Breaker
CB9 - Alternator Field Breaker
DBNR - Dynamic Brake Nullifying Relay
EF - Exciter Field Contactor
EFR - Exciter Field Reduced Contactor
ESR - Engine Stop Relay
FL - Field Loop Contactor
FPC - Fuel Pump Contactor



Illus. 5. High Voltage Electrical Cabinet - Engine Side

NOTE: These apply to "3 Series 2 Parallel" (3S2P) operation only. In "2 Series 3 Parallel" (2S3P), current should not exceed 700 amperes to avoid overloading the main generator. This is normally taken care of by the automatic transition equipment.

THESE RATINGS ARE NOT CUMULATIVE.

Do not go above 1020 amperes for thirty (30) minutes after using any one short time rating.

Excessive load currents carried for long periods will result in generator and traction motor overheating. Even if immediate failure doesn't occur, insulation may be weakened to the point where failure will occur later even with the locomotive running light.

If the load ammeter is inoperative (when the leading unit is isolated or the traction motors cut out on the radiator end truck), speed at full throttle must remain above ten (10) mph.

CIRCUIT BREAKERS AND SWITCHES

Circuit breakers are used in all control circuits. These breakers also function as manually-operated switches. Automatic tripping on overload is indicated by the position of the handle midway between "OFF" and "ON." To reset after tripping, press the handle or trigger down to "OFF" and then upward to "ON."

Breakers at the engineer's position, Illus. 2, are:

1. CONTROL BREAKER, which must be "ON" IN THE LEADING UNIT to energize the PC-13 wire feeding throttle and relay control circuits. If this breaker trips, the engine will go idle with power off and no alarm.

2. ENGINEER'S FUEL PUMP BREAKER, which must be "ON" IN THE LEADING UNIT to start fuel pumps on both leading and trailing units. (This breaker energizes the FP-16 wire.)

If this breaker trips, the engines will starve for fuel. There will be no alarm since alarms are also energized from this same breaker.

NOTE: It is possible to operate with the "CONTROL" and "FUEL PUMP" breakers "ON" in the trailing instead of the leading unit. This conserves the leading unit battery if its engine is shut down (not isolated) for any reason. Avoid leaving both leading and trailing unit control and fuel pump breakers on together, as this can set up damaging battery equalizing currents, especially when starting the engine on one of the units.

Switches at the engineer's position, Illus. 2, include the following:

1. LOCOMOTIVE RUN (OR GENERATOR FIELD) SWITCH, which must be "ON" in the leading unit to move the locomotive, should be kept in "OFF" position until ready to move.

To pump up air with the locomotive standing or drifting, turn the "Locomotive Run" switch to "OFF" position, and notch up the throttle. If the unit is standing, the reverse lever should be in "OFF" position also.

2. TRANSITION FORESTALLING SWITCH, which is a toggle switch used to forestall transition from 3S2P to 2S3P when it is desired to do so. Normal position is the "AUTO" position.

The "SERIES" position is often useful on heavy drag runs which balance at a speed at or near the transition point. Refer to Sec. 125A for speed at transition.

Throwing this switch to "SERIES" on the leading or any trailing unit will forestall transition on all units when operating in multiple.

3. DYNAMIC BRAKE UNIT SELECTOR SWITCH (On units with dynamic braking). This switch has four positions and is set according to the number of units in the locomotive consist.

SETTING SHOULD BE CHANGED ONLY AS THE NUMBER OF UNITS IS CHANGED REGARDLESS OF WHETHER OR NOT A UNIT IS SHUT DOWN OR ISOLATED ENROUTE.

Locomotive control breakers in the electrical cabinet, Illus. 4, are:

1. CONTROL CUTOUT BREAKER, which energizes all control circuits on each individual unit. This breaker must be "ON" in each unit.

Tripping of this breaker will drop power and cause the engine to stop for lack of fuel. There will be no alarm as the alarms are energized from this same breaker.

2. ALTERNATOR FIELD BREAKER, which controls the 75-volt DC excitation to the alternator field. This breaker must be "ON" in each unit. Tripping will give an "A.C. Failure" alarm if the engine is on the line.

3. FUEL PUMP BREAKER, which must be "ON" in each unit for the fuel pump to run and the auxiliary generator field to be energized. Tripping of this breaker will cause the unit to starve for fuel, and if the unit is "On the line" an "A.C. Failure" alarm will occur.

Do not confuse this breaker with the Engineer's Fuel Pump Breaker at the engineer's position.

4. DYNAMIC BRAKE BREAKER, which must be "ON" in the leading unit to energize the field loop control circuit used in dynamic braking.

Pushbuttons at the engineer's position, Illus. 1, include the following:

1. Engine Start Button

This button when depressed energizes the engine starting contactors, G+, G-, and GF1, and after the following conditions have been met:

a. Main battery switch in electrical cabinet, Illus. 4, must be "ON."

b. Control cutout breaker in electrical cabinet, Illus. 4, must be "ON."

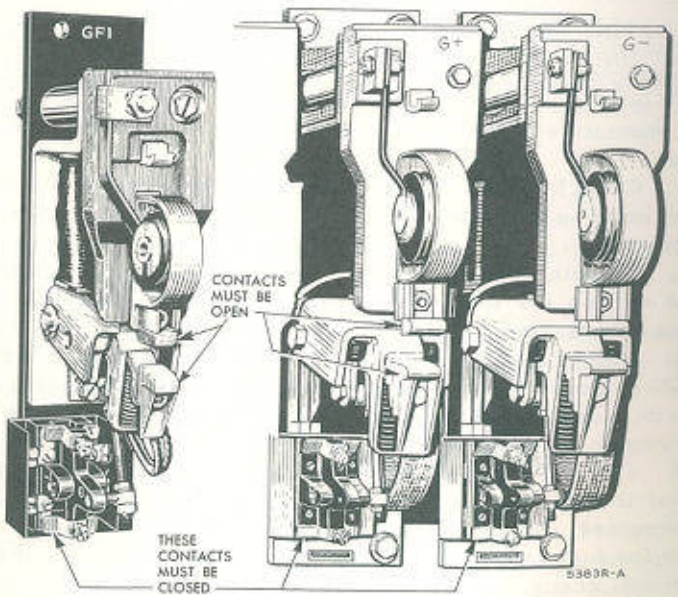
c. Engineer's fuel pump breaker, Illus. 2, must be "ON."

d. "OUT" interlocks on the "EF" and "BC" contactors, Illus. 3 and 4, must be making good contact.

e. Isolator, Illus. 2, must be in "IDLE" position.

2. Engine Stop Button

Depressing this button will stop the engine, but only after the isolator has first been brought to "IDLE" position.



Illus. 6. Starting Contactor in Contact Position with the Engine Running

Ground and Impulse Relay Reset Button
(In electrical cabinet, Illus. 4)

This button is used to reset either the ground or impulse relay after an alarm occurs.

ALWAYS ISOLATE THE ENGINE BEFORE PUSHING THIS BUTTON, or serious main generator damage may occur.

See Sec. 104A, Par. D, for the procedure in event of ground or impulse relay action.

Ground Relay Cutout Knife Switch

This knife switch is located on the ground relay panel, Illus. 4. Pulling this switch makes the ground relay inoperative and ground protection for the high voltage equipment is cut out.

Always check to make sure this switch is closed before operating the locomotive.

ALARM LIGHTS

Alarms and functions are fully described in Sec. 107A.

Alarm lights at the engineer's position include:

Wheel Slip
Ground Relay Tripped
Impulse Relay Tripped
Low Oil
Hot Engine
A.C. Failure
Engine Protector

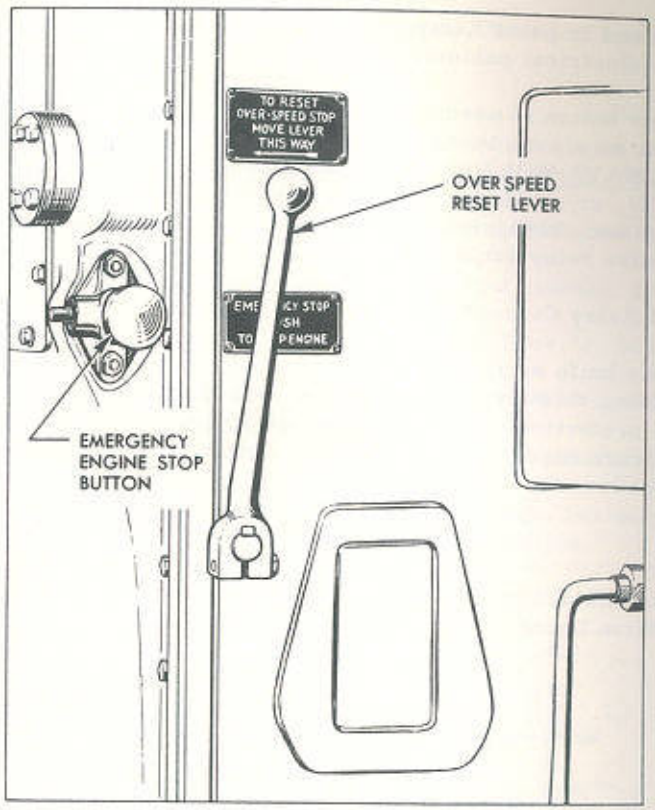
EMERGENCY FUEL CUTOFF VALVE

This valve is located on the governor side of the fuel tank. Operation is more completely described in Sec. 116A. Correct knowledge of the operation of this valve is very important, as many needless road failures have been caused by this valve being tripped or partially tripped, with crews either not knowing the trouble or blaming it on other equipment.

A partially tripped cutoff valve results in abnormally low fuel pressure (below 18 lbs.) and resultant governor surging under full load.

A completely tripped cutoff valve results in complete loss of fuel pressure, which means the engine starves for fuel and cannot be cranked until fuel pressure is restored.

The important thing to remember about this valve is that the plunger must be pulled out as far as possible, and then securely latched. (See Illus. 2, Sec. 116A.)



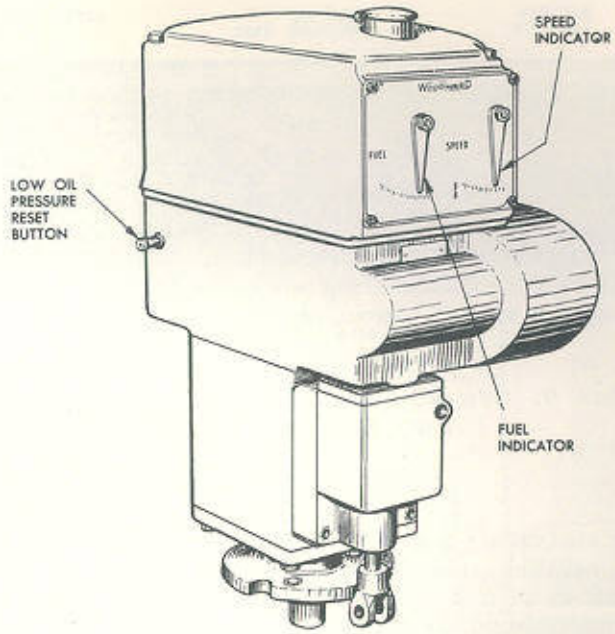
Illus. 7. Overspeed Reset Lever and Emergency Engine Stop Button

DIESEL ENGINE OVERSPEED TRIP RESET LEVER

The engine overspeed reset lever, Illus. 7, is located on the engine above the governor. If the overspeed operates, the lever does not change position. To reset, pull lever as far as possible in the direction shown by the arrow until it latches. If an engine shuts down because of the overspeed tripping, alarm bells will ring on all units and the "A.C. FAILURE" alarm light will burn on the unit affected.

Full engine speed is 850 RPM and the trip is set to operate at 950 RPM.

IN EVENT OF AN ENGINE OVERSPEED TRIP, ALWAYS CHECK THE NEARBY ENGINE LOW OIL PRESSURE RESET BUTTON ON THE GOVERNOR (Illus. 8) AS THE TWO SOMETIMES TRIP TOGETHER.



Illus. 8. Governor with Low Lube Oil Pressure Reset Button

EMERGENCY ENGINE STOP BUTTON

This is a large red pushbutton, Illus. 7, located on the engine above the governor, next to the overspeed trip reset lever. The function of the emergency button is to trip the engine overspeed manually in event of an emergency. Operation of this button is purely mechanical and is independent of all pushbutton electrical circuits.

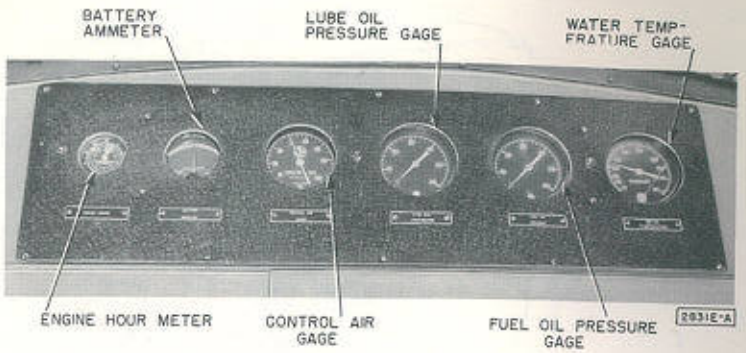
ENGINE LOW OIL PRESSURE RESET BUTTON ON GOVERNOR

(Additional operational description in Sec. 105A and 117A)

In event of the governor, Illus. 8, shutting the engine down because of low engine lube oil pressure, this button will "pop out" exposing a red band.

This button MUST be pushed in to stop the "LOW OIL" alarm and to start the engine again.

Always check the diesel engine overspeed trip above the governor as sometimes the "LOW OIL" button trips with the overspeed.



Illus. 9. Typical Operating Cab Gage Panel Located Above Electrical Cabinet

CONTROL AIR GAGE

The control air gage is located above the electrical cabinet, Illus. 9, and indicates the control air reservoir pressure. The control air is used to operate the power contactors and reverser.

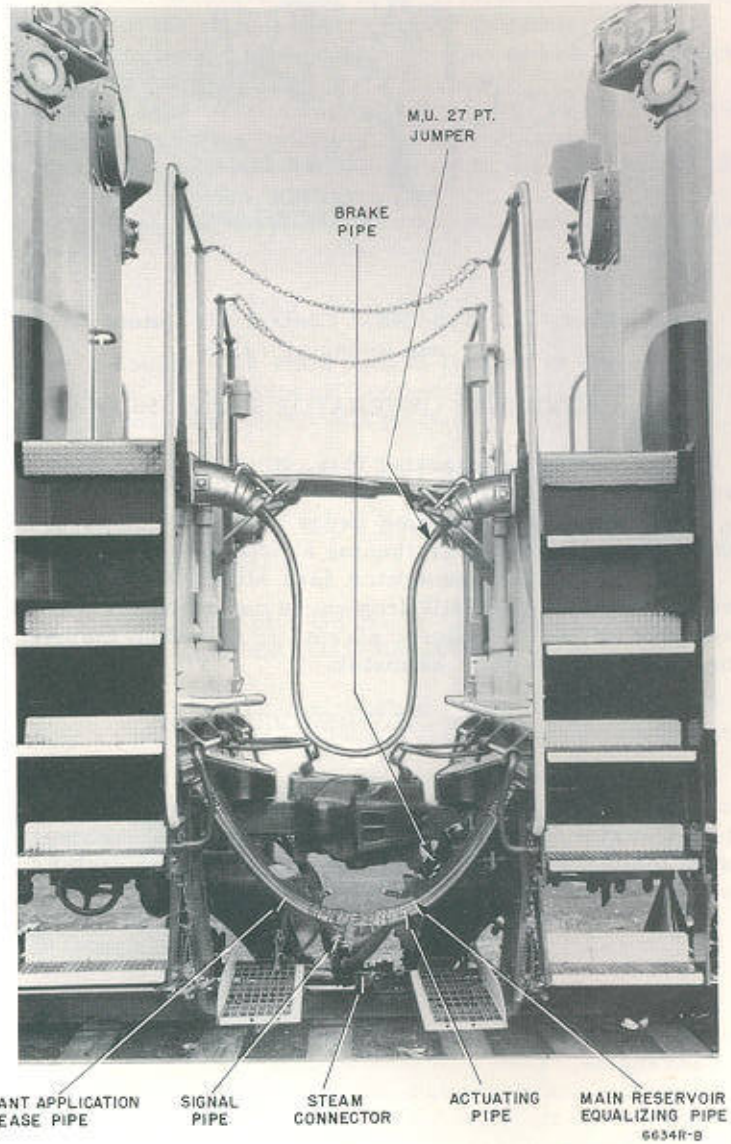
Normal control air pressure is 80 ± 5 lbs. With 80 lbs. initial pressure, control air volume is sufficient to make four or more cycles of control sequence in event of main reservoir air failure.

THE CONTROL AIR REDUCING VALVE AND MAIN SHUT-OFF COCK ARE LOCATED JUST BELOW THE WALKWAY ACROSS THE REAR OF THE ELECTRICAL CABINET, Illus. 11.

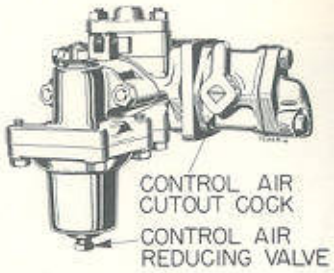
BATTERY AMMETER

The battery ammeter is located above the electrical cabinet, Illus. 9, and indicates the charging current to, or the discharging current from, the battery.

With the engine running, the ammeter pointer should always be in the charge zone. If the battery is close to being fully charged, the ammeter will indicate a very small charging current. A continuously high charge reading should be reported to maintenance. A CONTINUOUS DISCHARGE READING WITH THE ENGINE RUNNING GIVES A GOOD INDICATION THAT THE AUXILIARY GENERATOR FUSE IS "BLOWN." (See the following paragraph) OR THAT THE BC CONTACTOR IS NOT PASSING CURRENT.



Illus. 10. Electrical Jumper and Air Hose Connections



Illus. 11. Type NS-1 Control Air Cutout Cock and Reducing Valve

AUXILIARY GENERATOR FUSE (350 Amps)

The auxiliary generator fuse, Illus. 4, is located in the low voltage electrical cabinet.

Never replace this fuse under load if it can be avoided; and then only with the engine running at idle speed.

If the auxiliary generator fuse blows, the reverse current relay if properly set will drop out to cut off alternator excitation and give an "A.C. Failure" alarm. In any event the best check is to observe the battery ammeter.

FUEL OIL PRESSURE GAGE

The fuel oil pressure gage is located above the electrical cabinet, Illus. 9, and indicates the pressure of the fuel supplied to the engine fuel header. With the fuel pump running the pressure indication should be 20 to 25 lbs. with the engine idling and not below 18 lbs. with the engine loaded.

LUBRICATING OIL PRESSURE GAGE

The lubricating oil pressure gage located above the electrical cabinet, Illus. 9, is connected to the lower lubricating oil header of the engine.

Normal operating lube oil pressures are 9 to 12 lbs. at idle speed and 28 to 35 lbs. at full engine speed, depending upon engine oil temperature.

See Sec. 117A for further information on the operation of the engine lube oil system.

WATER TEMPERATURE GAGE

The water temperature gage, Illus. 9, is connected in the engine outlet line of the engine water cooling system.

Normal idling water temperature is 150° to 155° F. decreasing to 140° F. in cold weather.

Normal full load water temperature is 160° to 170° F. up to 80° F. outside increasing to 185° F. at 110° F. outside.

The hot engine alarm is set to operate in the 195° to 205° F. range.

See Sec. 118A for further information on the engine water cooling system.

MAIN BATTERY SWITCH

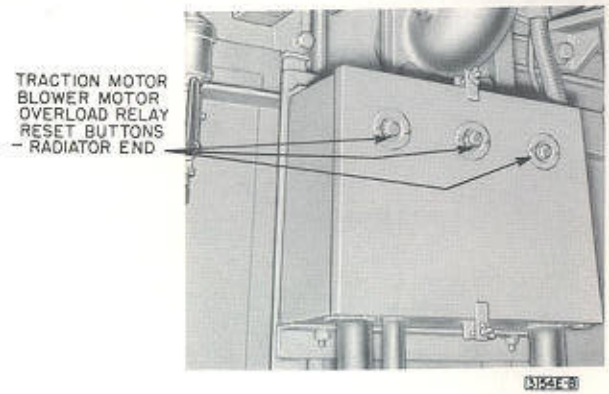
This is a double pole knife switch located in the electrical cabinet, Illus. 4. It connects all control and lighting circuits to the battery and must be "ON" in all units.

FAN AND SHUTTER CONTROLS

Fan and shutter controls are described in detail in Sec. 118A on the Engine Cooling System.

TRACTION MOTOR BLOWER MOTOR OVERLOAD RELAYS

Each of the six AC driven traction motor blower motors is protected by a thermal type overload relay with a reset push button.



Illus. 12. Radiator End Traction Motor Blower Motor Overload Relays

Reset buttons for Nos. 1, 2, and 3 traction motor blower motors (cab end) are located at the bottom of the cab side electrical panel, Illus. 4.

Reset buttons for Nos. 4, 5 & 6 traction motor blower motors (radiator end) are located on the junction box on the engine side of the bulkhead at the governor end of the engine, Illus. 12.

In event of current overload in any one phase of any of the traction motor blower motors, the thermal relay for that motor will trip to give an "A.C. FAILURE" alarm. Reset by pushing the red reset button and releasing. If button will not reset, cut out the traction motors on the affected truck, Sec. 125A, and proceed.

RADIATOR COOLING FAN MOTOR OVERLOAD RELAYS

Each of the four (three on H16-66 units) AC driven radiator cooling fan motors is protected by a thermal type overload relay with a reset push button.

Reset buttons are located on the fan motor contactor box on the bulkhead inside the radiator compartment, Illus. 2, Sec. 118A.

In event of current overload in any one phase of any of the fan motors, the thermal relay for that motor will trip. Reset by pushing the red reset button and releasing.

CAB VENTILATOR

The purpose of the cab ventilator, Illus. 9, is to provide air flow out of the cab to prevent frosting of the cab windows. Normal position is closed unless defrosting is desired.

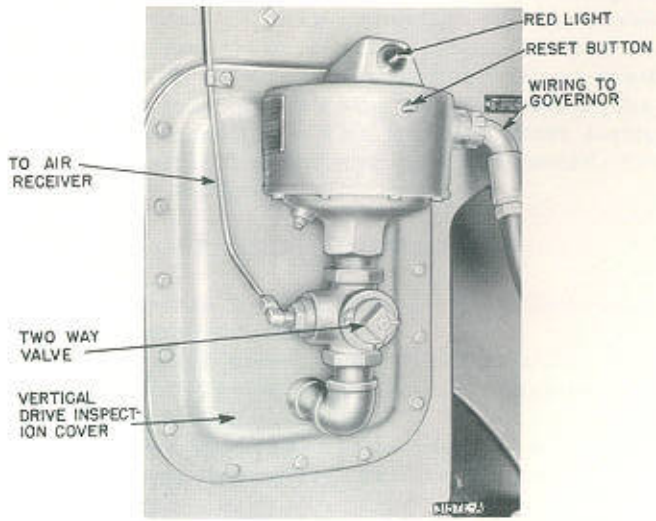
OPERATION OF THE ENGINE PROTECTOR RELAY

The engine protector relay (EPR) is mounted on the governor side engine vertical drive cover (next to the main generator) as shown in the illustration below. It is piped into the engine crankcase which is normally at a pressure of less than atmospheric. If a pressure of slightly above atmospheric develops, the EPR will shut down the engine by de-energizing the TV relay and energizing governor solenoid DV. A reset button on the switch is provided for resetting. The red light on the switch is to indicate when the switch is tripped, and there is also an "ENGINE PROTECTOR" alarm light on the engineer's control panel.

A two-way valve is provided at the switch so that the operation may be checked by admitting air under pressure from the engine air receiver with the engine running.

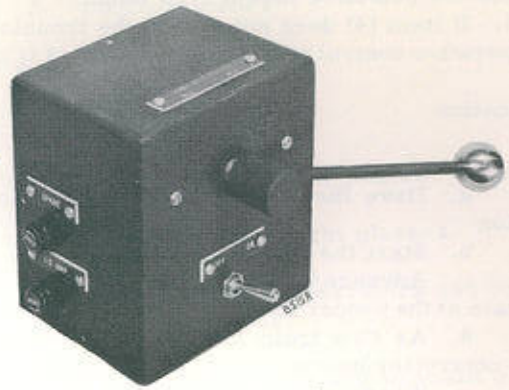
The EPR may occasionally trip during cranking of the engine before the engine blower has a chance to produce the normal vacuum within the crankcase. Reset the EPR and crank again, there being no cause for concern unless the EPR continually trips with the engine running.

Building up of pressure in the crankcase after the engine has been running normally indicates a defective part with the engine such as a broken piston. Immediate detection by EPR is designed to protect the internal engine damage that otherwise would occur.



Illus. 1. Engine Protector Relay

SECTION 101A2. HUMP CONTROLLER



Illus. 1. Cab Controller for Hump Service

This device is a means by which the engineman can obtain precise control of tractive effort. Its use also provides the maximum tractive effort with full engine rpm at a very low train speed for humping service. In general service, its use will be very helpful in starting trains under difficult conditions and arresting wheel slips when pulling heavy tonnage at low speeds.

A small controller is the means by which hump control is obtained. The handle of this controller can be moved from a "MAX" or maximum tractive effort position thru a decreasing range to the "MIN" or minimum tractive effort position. By moving the handle backward from the "MAX" position, the tractive effort will be reduced below the tractive effort setting of the throttle. The further the handle is moved backward, the greater the tractive effort reduction.

OPERATING INSTRUCTIONS

1. On-Off switch (refer to above illustration) must be "ON" at the operating control station.
2. On-Off switch (refer to above illustration) MUST be in "OFF" position at the inoperative control station (dual cab units) and in all trailing units.
3. The hump controller is protected by a screw-in type fuse located on the hump controller. This is the bottom fuse, the top fuse being a spare.
4. If the tractive effort goes to minimum when operating the hump controller and tractive effort cannot be restored, inspect all inoperative control stations in the lead and trailing units to make

sure that the hump controller switch is in "OFF," that the fuse is not blown and that the locomotive run switch is in "OFF" position. Replace the defective fuse if it is found.

5. If item (4) does not reveal the trouble, inspect the fuse at the operative control station and replace it if it is found defective.

Application

1. For humping service:
   a. Have the handle of the hump controller in "MAX" position.
   b. Start the train in the normal manner.
   c. Advance the throttle only to the notch required to move the train at the proper humping speed and leave it in this position.
   d. As the train becomes lighter, gradually move the hump controller backward to hold the proper speed.
   e. When the hump controller reaches "MIN" position, reduce the throttle one notch and then move the hump controller toward "MAX" to hold the proper speed.
   f. Observe the load ammeter for short time overloads.
2. For heavy duty service:

The following are two methods of using the hump control in heavy duty service. Because of the variations in this type of service, it is difficult to predict the best method to use. Therefore, it is suggested that the engineman select the one best suited for his particular case.

   a. First method:
      1) Move the hump controller handle to "MIN."
      2) Advance the throttle handle until the 5th or 6th notch is reached. Experience may indicate that a lower notch is sufficient.
      3) Move the hump controller handle toward the "MAX" position until the train begins to move. Train speed can be further increased or controlled by the handle movements.
      4) When the train is started, the hump controller handle should be moved to "MAX" position unless the control of tractive effort is necessary to get traction without wheel slip.
   b. Second method:
      1) Start train by advancing the throttle in a normal manner.
      2) If wheel slip occurs in any notch, leave the throttle in that notch and reduce the tractive effort by moving the hump controller handle backward from the "MAX" position.
      3) After wheel slip stops, move the hump controller handle toward "MAX" position to obtain the tractive effort that can be applied without slippage.
      4) As the train picks up speed, move the hump controller handle to "MAX" position and operate normally.

SECTION 104A. LOCOMOTIVE OPERATION

A. PRELIMINARY

Outside Check of Units

Before boarding locomotive, check for:

1. Oil and water leaks, and loose or dragging equipment.

2. Fuel supply as shown on fuel tank sight glasses.

3. Condensation in main reservoirs. Reservoirs are located under the frame near the fuel tank.

IMPORTANT NOTE: With the added cooling of main reservoir air on these units, water will collect rapidly in the main reservoirs and will not continue thru to the air brake system AS LONG AS RESERVOIRS ARE FREQUENTLY DRAINED.

Interior Check on Each Unit

If engine is not already running, items 1 (a thru d), 2, and 6 should be checked before starting.

1. Check supplies.

   a) Engine lubricating oil - bayonet gage on right side of engine, subbase.
   b) Governor oil - sight glass on governor.
   c) Air compressor lubricating oil - bayonet gage in compressor crankcase.
   d) Engine water level - sight glass on engine water tank.
   e) Steam generator water level - liquidometer gage in floor to rear of steam generator.
   f) Sand - four sand boxes.

2. See that all safe guards are in place, and that all foreign material such as rags, tools, etc. have been removed from all shafts, belts, openings, moving parts, and electrical compartments.

3. Check for leaks in piping systems.

4. Release hand brake.

5. Check air compressor oil pressure. Should run from 15 to 25 lbs. idle to full engine speed.

6. Check breakers and switches in each unit as follows:

	Trailing Unit	Leading Unit
Main Battery Switch	On	On
*Throttle Handle	Idle	Idle
*Selector Handle	Off	1 or 4
*Reverse Handle	Removed	Off
Rotair Valve (24-RL Brake Equipment)	Pass. Lap or Freight Lap	Pass. or Freight
*Brake Pipe Cutout Cock (24-RL)	Closed	Open
Brake Pipe Cutout Cock (6-SL)	Trail	Lead
Engineer's Switch Panel		
Control Breaker	Off	On
Fuel Pump Breaker	Off	On
* Locomotive Run Switch	Off	On
Electrical Cabinet Breaker Panel		
Alternator Field Breaker	On	On
Locomotive Lights Breaker	On	On
Heater and Defroster Breaker	On	On
Control Cutout Breaker	On	On
Dynamic Brake Breaker (if used)	On	On
Train Control Breaker (if used)	Off	On
Traction Motor Cutout Switch	As desired	As desired
Ground Relay Cutout Switch	Sealed "Closed"	Sealed "Closed"
Dynamic Brake Unit Switch	Set for no. of units in locomotive	Set for no. of units in locomotive
Isolator	"Isolate" To start engine; "Run" To put unit on line	"Isolate" To start engine; "Run" To put unit on line

* On dual control units, check asterisked items at the inoperative control station same as on a trailing unit.

To Start Engine and Put on Line

1. Check breakers and switches for correct position in each unit.

2. Snap "ON" fuel pump breaker at engineer's switch panel on leading unit.

3. Check engine overspeed trip and governor low oil shutdown button.

4. Snap "ON" fuel pump breaker in electrical cabinet and note

that fuel oil pressure builds up to 18-25 lbs.

5. Turn isolator to "Isolate" position.

6. Push engine start pushbutton firmly. If the engine rotates but fails to fire check the ENGINE OVERSPEED TRIP AND GOVERNOR LOW OIL PRESSURE BUTTON. If these are properly set and the engine still fails to fire, starting can be speeded up by manually opening the engine fuel racks. If trouble persists, investigate for cause. See Sec. 107A. Continued unsuccessful attempts to start the engine will run down the batteries.

7. To put engine on the line, turn isolator to "Run" position. NOTE: ENGINE WILL NOT DELIVER POWER IF STARTING CONTACTORS (G+, G-, or GF1) STICK CLOSED. (No GF1 contactor on 1600 hp General Service Units.)

DO NOT PUT AN ENGINE ON THE LINE OR TAKE OFF LINE WHILE DYNAMIC BRAKE IS APPLIED. Otherwise voltage surges may break down power circuit insulation, or control of train may be upset.

8. Check that the battery ammeter shows a charging current. See Sec. 101A for operational description.

B. STARTING AND ACCELERATING

Before Moving Locomotive

1. Check that main reservoir pressure is being maintained at 130-140 lbs., and control air at 80 lbs.

2. Make air brake tests.

3. Check the horn, bell, and sanders.

4. Check that fuel pressure is 18 lbs. or more.

5. Release hand brake.

6. Check that engine water temperature is 100 degrees or more.

7. Move reverse lever to desired position.

8. Move selector lever to:

a) Position 1 when locomotive consists entirely of Train Master, General Service, or C-Line units.

b) Position required for operation of trailing units when locomotive includes units of different model or manufacture.

To Move Locomotive

1. Place foot on safety control pedal (if used).

2. Release independent brake.

3. Open throttle as required.

Pumping Up Train Line After Coupling to Train

1. Snap "OFF" Locomotive Run switch.

2. Move reverse lever to neutral.

3. Open throttle as needed but not beyond 6th notch.

Starting Freight Trains

1. Place foot on safety control pedal and release brake. On a 100-car train releasing brakes may take as long as eight or nine minutes, although normally only four or five minutes.

2. Open throttle one notch at a time until locomotive moves. If slack is bunched, be careful to avoid damage to knuckles and drawbars. Going beyond the 2nd notch should not be necessary to start. If so, look for sticking brakes, or coupler damage may result.

3. The power required to start the train may move the load ammeter pointer into the red zone. This is permissible on starting and is recommended for good performance where conditions permit. However, the ammeter needle must steadily return to the green zone or the tonnage is excessive.

See Sec. 101A for current-time limits.

Starting Passenger Trains

1. Place foot on safety control pedal and release brakes.

2. Open throttle, considering

a) Train weight, which may vary greatly in trains of the same length.

b) Slack action, depending upon how many cars have tight-lock couplers and length of train.

c) Rail conditions. Throttle may be opened as rapidly as train and rail conditions will permit.

3. Maximum load meter amperage in the red zone is permissible on starting and acceleration provided the pointer steadily returns to the green (continuous) zone.

See Sec. 101A for current-time limits.

C. WHEEL SLIPPAGE

1. If either of the three wheel slip relays pick up, the exciter 4-pole battery field is shunted by contactor EFR, and the load regulator is returned within three seconds to minimum field.

2. After the slip relay drops out, power is thus restored at a minimum value, and with the timing of the load regulator used, it will take at least three seconds to restore full power.

3. If slipping persists, reduce the throttle until slipping stops.

4. Wheel slip relays will not pick up if adjacent axles slip closely together. For this reason it is wise to keep alert for wheel screeching and sudden "dipping" of the load ammeter needle, which are signs of wheel slipping even if the wheel slip buzzer is not sounding.

In this case slipping can only be arrested by reducing the throttle.

D. GROUND OR IMPULSE RELAY ACTION

1. If ground or impulse relay trips, isolate unit, press reset button in electrical cabinet, and put unit back on line ONE ISOLATOR POSITION AT A TIME, that is, try the Run 5 position first, then Run 6, 7, and 8.

2. If either relay again trips, isolate and reset again and repeat procedure, keeping unit at a reduced isolator position if necessary to prevent relay from tripping. Inspect main generator for flashover if possible.

3. If relay still trips after three trials, leave unit isolated.

4. ALWAYS ISOLATE THE UNIT BEFORE PRESSING THE BUTTON.

E. CUTTING OUT TRACTION MOTORS

See Sec. 125A for description of conditions under which traction motor cutout switch should be used.

F. AIR BRAKING WITH POWER APPLIED

If power is left on to keep slack out when applying brakes for slow down, use reduced throttle and keep independent brake fully released while applying train brakes. THROTTLE MUST BE IN "IDLE" WHEN LOCOMOTIVE STOPS.

G. THROTTLE IN IDLE FOR STOPS

Be certain that the throttle is in "IDLE" position before train comes to a stop and during a stop. CONTINUED APPLICATION OF POWER TO TRACTION MOTORS WHEN LOCOMOTIVE IS STATIONARY, EVEN FOR A SHORT PERIOD OF TIME, CAN RESULT IN SERIOUS BURNS ON TRACTION MOTOR COMMUTATORS.

H. VISUAL INSPECTION DURING STOPS

If time permits during stops, make visual inspection of under part of locomotive to detect any signs of trouble. Watch especially for HOT JOURNALS, HOT MOTOR AXLE BEARINGS, AND HOT ARMATURE BEARINGS.

Note any fuel oil, lube oil, water, air or steam leaks. Also check for loose or dragging parts.

It will be noted that the exhaust snubber oil drain line will discharge a small amount of exhaust smoke underneath the unit. This is entirely normal and in fact is a good sign, showing that the drain line is operating and is not plugged.

I. REVERSING

BRING LOCOMOTIVE TO A DEAD STOP BEFORE MOVING REVERSE HANDLE FOR OPPOSITE LOCOMOTIVE MOVEMENT. Applying power in reverse direction, before locomotives stops, may cause serious damage to traction motors.

J. PASSING OVER RAILROAD CROSSINGS

When approaching a railroad crossing, throttle should be moved to notch 3 or below and kept in that position until all locomotive units have passed over the crossing. This will minimize

the possibility of traction motor flashovers because of brushes being jolted off commutators.

K. OPERATING THROUGH WATER

Do not operate locomotive thru water more than two (2) inches over top of rail, and then at a speed not exceeding 3 MPH. After passing thru water, snap off locomotive run switch, move reverse handle to "OFF," and open throttle to 6th notch for about ten minutes. This will allow the water to be dried off the traction motors.

L. CHANGING ENDS

Before Leaving Cab

1. Move Selector handle to "OFF" and Throttle to "IDLE." REMOVE REVERSE HANDLE.

2. Make 20 lb. brake pipe reduction. Close brake pipe cutout cock on units with 24-RL equipment, or move to "Trail" position on units with 6-SL equipment. Move rotair valve to "LAP" on 24-RL equipment. Remove brake handles.

3. Snap "OFF" Control, Locomotive Run, and Fuel Pump breakers at engineer's panel. Engines will run long enough for a man to reach the other cab.

New Leading Cab

1. Snap "ON" Fuel Pump, Control, and Locomotive Run breakers at engineer's breaker panel. Check that Dynamic Brake circuit breaker (Illus. 2, Sec. 101A) is on.

2. Check for correct position of Dynamic Brake Selector Switch (Illus. 1, Sec. 101A) on engineer's switch panel.

3. Insert brake handles, move rotair valve to "PASS" or "FRT" as required on 24-RL equipment, apply full independent brake, and open brake pipe cutout cock on 24-RL equipment, or move to "Lead" position on 6-SL equipment.

4. Insert reverse handle and make air brake tests.

5. Check position of Isolator (Illus. 1, Sec. 101A) and Traction Motor Cutout Switch (Illus. 2, Sec. 101A).

M. OPERATING WITH LEADING UNIT SHUT DOWN

Snap "OFF" Control and Fuel Pump breakers on leading unit engineer's switch panel and "ON" in trailing unit. Avoid having both ends on at same time as battery equalizing currents may be enough to damage control wiring, especially when an engine is started.

N. TO RERAIL A UNIT

Take care that the wheels do not slip off the frog on rails during rerailing. Otherwise serious damage may result to the traction motors or gear cases.

Cut out the traction motors on the derailed axles using the Traction Motor Cutout Switch. If an entire truck is derailed, the P3 contactor must also be blocked open, in order to isolate the three motors on the truck. This will leave two traction motors to pull with.

If the cab end truck is derailed, cut out Nos. 1 and 2 traction motors and block P3 contactor open.

If the radiator end truck is derailed, cut out Nos. 5 and 6 traction motors and block P3 contactor open.

O. HEAVY KNOCKING OR OTHER UNUSAL ENGINE SOUNDS

Shut down an engine at once in case any heavy knocking or other unusual engine sounds are detected.

DO NOT REMOVE ANY CRANKCASE COVERS UNTIL THE ENGINE HAS BEEN STOPPED AT LEAST TWENTY MINUTES.

P. SHUTTING DOWN AN ENGINE

1. Before stopping the engine, except in an emergency, wait until the water temperature drops to 165° F.

2. Isolate the unit and press the "Engine Stop" pushbutton on the engineer's switch panel.

3. Snap "OFF" the Fuel Pump breaker in the electrical cabinet.

4. Upon leaving a unit, put the selector handle in "OFF," remove the reverse handle, snap "OFF" the engineer's control and fuel pump breakers and set the independent and hand brakes. Pull the main battery switch.

5. An engine can also be stopped by pushing in the red "Emergency Stop" button on the side of the engine above the governor. Before the engine can again be started, after being stopped in this manner, the overspeed reset lever must be reset.

Q. FREEZING WEATHER PRECAUTIONS

If the engine is to be shut down during freezing weather, standby steam must be connected or the cooling water system drained. See "Cooling System," Sec. 118A.

R. NORMAL OPERATING PRESSURES AND TEMPERATURES

Fuel Pressure:	18 lbs. or more at all times.
Lube Oil Pressure:	8-12 lbs. at idle engine speed, depending upon temperature. 27-35 lbs. at full engine speed, depending upon temperature.
Water Temperature: (This is out of engine)	Depends on loading of engine. In general at constant full load, will be 165°-170° F. up to 85° F. outside increasing to 185° F. at 110° F. outside.
	Hot engine alarm set at 195-205° F. range.

S. TOWING

When it is necessary to prepare a locomotive for dead heading, first stop the engine in the usual manner. (See Pars. P and Q.)

Set up the brake equipment as follows:

1. Place the handle of both brake valves in "Running."

2. Remove both brake valve handles.

3. Move the brake pipe cutout cock to the "Closed" position (24-RL equipment) or to "Dead" position (6-BL and 6-SL equipment).

4. Open the dead engine cock on the control valve (24-RL equipment) or on the distributing valve (6-BL, and 6-SL equipment).

5. Set the rotair valve in "Pass-Lap" position (24-RL equipment only).

6. If for any reason, it is desired to keep the maximum braking power lower than standard on 24-RL equipment, insert a 28 lb. safety valve in the No. 16 control pipe in the tee applied for this purpose. The usual practice is to remove one of the two compressor intercooler safety valves for this purpose lowering the air pressure setting from 60 to 28 lbs. After deadheading, be sure to return the safety valve to the intercooler to raise the air pressure setting back to 60 lbs.

To keep the air brake cylinder pressure below 28 lbs. on 6-BL, or 6-SL equipment, reduce the adjustment on the safety valve located on the distributing valve.

T. THROTTLE OPERATION WHEN BRAKES GO INTO EMERGENCY

On a brake-valve initiated emergency application, return the throttle to "Idle" immediately to avoid damage to the traction motors. On locomotives equipped with a PC switch, this is taken care of automatically.

On a train initiated emergency application, the throttle should be eased off gradually to avoid flattening of the wheels on the locomotives.

U. SPLITTING OR JOINING UNITS

1. Be sure to disconnect cable jumpers before splitting units.

2. Be sure all throttles are in "Idle" before splitting or joining units.

3. Before cable jumpers are connected or disconnected, be sure engineer's control and fuel pump breakers, and the locomotive run switch, are all in "OFF" position.

SECTION 105A. DATA AND GENERAL DESCRIPTION OF EQUIPMENT

A. MASTER CONTROLLER

The master controller is equipped with a throttle lever, a reverse lever, and a selector lever for controlling dynamic braking and any trailing units equipped with manual transition.

Throttle Lever

The throttle lever has ten positions: "STOP," "IDLE," and eight running notches. "STOP" position shuts down all engines (except an engine which has been isolated) and is obtained by pressing the button on the throttle lever and pushing the lever one notch beyond idle.

Reverse Lever

The reverse lever has three positions: "FORWARD," "OFF," and "REVERSE." NEVER MOVE REVERSE LEVER WHILE LOCOMOTIVE IS IN MOTION. Doing so may cause serious flashover of traction motors and generator causing considerable damage to electrical equipment.

Selector Lever

The selector lever is the top handle on the controller and is used to change traction motor circuits from motoring to dynamic braking and vice versa. When necessary, the selector is also used to control manual transition of traction motor circuits on trailing units of different model or manufacture. Positions are 4-3-2-1 OFF-BRAKE. The selector has a latching device between "1" and "BRAKE" so that movement between motoring and braking or vice versa cannot be made without lifting the handle at each notch.

Normal operation is in position "1" when not in dynamic braking or operating with units of different model or manufacture. For operation with mixed units, follow special instructions. There is no connection between the selector lever and the automatic transition circuits of this locomotive; only to trainline wires M and P in positions other than "OFF" or "BRAKE."

Lever Interlocking

Control stand levers are interlocked as follows:

1. The reverse lever cannot be moved from "FORWARD" to "REVERSE" unless the selector handle is in "OFF, 1, or 4," and the throttle in "IDLE."

2. The reverse lever cannot be removed unless the throttle is in "IDLE" and the selector lever in "OFF."

3. The selector handle cannot be moved from 1 to "OFF" unless the throttle handle is in "IDLE." It can be moved thru positions 1-2-3-4 with the throttle handle in any position except that it cannot be moved from 2-3 or 3-2 unless the throttle is reduced to notch 6 or below.

4. The selector handle cannot be moved into the dynamic braking range except when the throttle is in "IDLE" and the reverse handle is in "FORWARD" or "REVERSE."

5. The throttle handle cannot be moved from "IDLE" unless the selector handle is in 1 or above. It cannot be advanced with the reverse handle removed but can be advanced with the reverse handle inserted and in "FORWARD," "REVERSE" or "OFF."

B. GENERAL DATA

Trucks

There are two, three-axle, three-motor trucks.

Steam Generator and Dynamic Braking

Both of these equipments can be applied together without space interference.

Either one 4500 lb. per hour, or two 2500 lb. per hour steam generators can be applied.

Steam generator water capacity is 2400 gallons and does not interfere with dynamic braking.

Dynamic braking capacity is 3000 hp.

Air Brake System

Units are equipped with two main reservoirs, with a combined capacity of 60,000 cu. in.

Maximum cooling is provided with 32 feet of finned pipe between the compressor and first main reservoir.

The main reservoir equalizing line is taken off after the first main reservoir and ahead of the check valve.

Available Gear Ratios (All wheel diameters 42")

Gear Ratio	Max. MPH	Maximum Lbs. Continuous Tractive Effort	Minimum Continuous MPH	
			1600 hp	2400 hp
15:68	65	78,750	6.0	9.2
15:63	70	72,900	6.5	9.9
17:62	80	63,300	7.5	11.4
19:60	90	54,900	9.0	13.2

Total Weight

330,000 lbs. (approximate) General Service Units
375,000 lbs. (approximate) Train Master Units
All weight is on drivers.

Supplies

	1600 hp	2400 hp
Fuel Oil	1,200 gal.	1,800 gal.
Steam Generator Water	2,400 gal.	2,400 gal.

(For freight units, extra fuel can be substituted for steam generator water giving a total fuel supply of 4,200 gals.)

Engine Lubricating Oil	315 gal.	385 gal.
Engine Cooling Water	210 gal.	250 gal.
Sand	48 cu. ft.	48 cu. ft.

Minimum Radius Curvature

1600 hp
212 ft. or 27 degrees, coupled to AAR 40'6" freight car.
191 ft. or 30 degrees, locomotive alone.

2400 hp
212 ft. or 27 degrees, coupled to AAR 40'6" freight car.
191 ft. or 30 degrees, locomotive alone.

Major Dimensions

	1600 hp	2400 hp
Wheel Base two units	107 ft. 4 in.	115 ft. 4 in.
Wheel Base one unit	45 ft. 4 in.	49 ft. 4 in.
Truck Wheel Base	13 ft. 0 in.	13 ft. 0 in.
Truck center distance	37 ft. 6 in.	41 ft. 6 in.
Overall length inside knuckles		
Two units	124 ft. 0 in.	132 ft. 0 in.
One unit	62 ft. 0 in.	66 ft. 0 in.
Overall height above rail	15 ft. 0 in.	15 ft. 0 in.
Overall width	10 ft. 5 in.	10 ft. 4 in.

C. ELECTRICAL ROTATING EQUIPMENT DATA

Main Generator

1600 hp General Service Units - Westinghouse Type 497-B - One per unit
2400 hp Train Master Units - Westinghouse Type 498-BZ - One per unit

The main generator is directly connected to the engine crankshaft thru a flexible coupling, and furnishes power to the traction motors.

The main generator is also utilized as a starting motor for the diesel engine by connecting the 25-plate storage battery to the generator starting and shunt fields, and armature.

The starting circuits are controlled by magnetic contactors (G+, G-, and GF1) which close when the engine start pushbutton is pressed. (1600 hp General Service units have no GF1 contactor.)

Traction Motors - Westinghouse Type 370 DEZ. Six per unit.

Auxiliary Machines, Direct Current

Auxiliary Generator - Exciter - Westinghouse Type YG-54-A. One per unit.

The auxiliary generator and exciter are mounted on a common armature shaft atop the main generator and are driven by eight V-belts. The exciter furnishes D.C. excitation for the main generator and the auxiliary generator provides 25 KW of D.C. power for controls, battery charging, and lighting. The auxiliary generator is regulated for 74 volts by the voltage regulator.

Dynamic Brake Blower Motor - Westinghouse Type Y-601-A. One per unit.

Auxiliary Machines, Alternating Current

Alternator - Fairbanks-Morse Type TGZO, Frame IV-6. One per unit. KVA rating is 94 at 450 rpm.

The alternator is mounted on an extension of the air compressor shaft, replacing the compressor flywheel, and is coupled to the main generator. The alternator furnishes A.C. power to the six traction motor blower motors and four radiator cooling fan motors.

Radiator Cooling Fan Motors - Fairbanks-Morse Type QZE
Frame RSL364Y hp rating.
HP rating = 25
Three on 1600 hp units.
Four on 2400 hp units.

Traction Motor Blower Motors - Fairbanks-Morse Type KZCF
Frame 254Y
Six per unit.

D. AIR COMPRESSOR

The air compressor is driven at engine speed thru a flexible coupling to the main generator shaft.

Maximum capacity is 262 cfm at full engine speed (216 cfm in dynamic braking), and 92 cfm at idle engine speed. Maximum horsepower is approximately 70 pumping at 130 psi.

E. DIESEL ENGINE

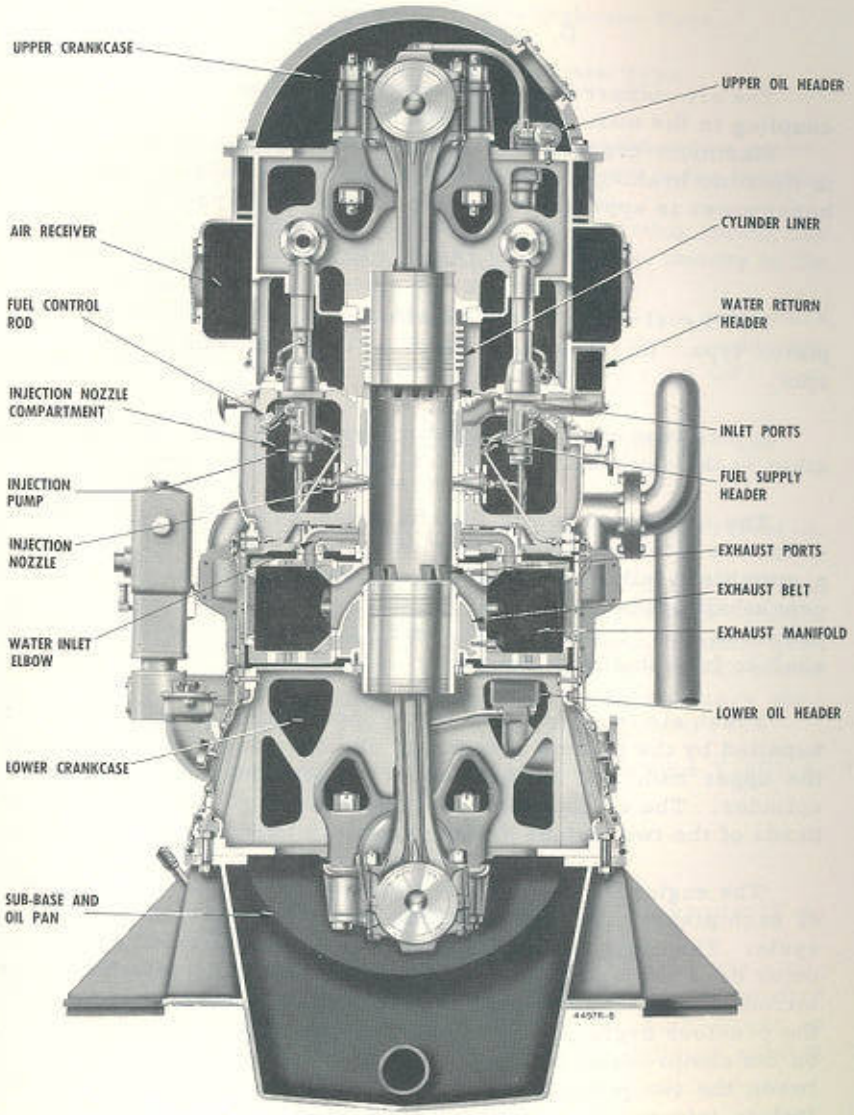
The diesel engine is the Fairbanks-Morse 8-1/8x10 opposed-piston type. Engine idling speed is 300 rpm; full speed is 850 rpm.

In this type engine, two pistons work vertically towards each other in the same cylinder. No valves or cylinder heads are used.

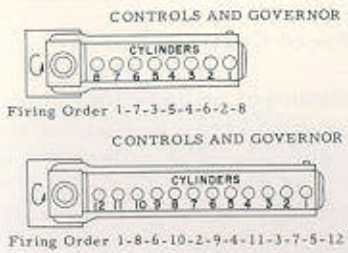
The upper and lower pistons drive separate crankshafts which are interconnected by a vertical drive shaft and gears with a suitable flexible coupling of coil spring design. The lower crankshaft leads the upper in timing by 15 degrees, which is known as the "Lower Crank Lead" and which causes the lower shaft to furnish 80% of the power developed.

Fresh air is admitted to the cylinders and exhaust gases are expelled by the pistons uncovering and covering the inlet ports at the upper end, and the exhaust ports near the lower end of the cylinder. The combustion space is formed between the recessed heads of the two pistons as they approach inner dead center.

The engine operates on the two-cycle principle. Two strokes of each piston thru one revolution of the crankshafts complete a cycle. The cycle begins with movement of the pistons from their outer dead center. After the air from the rotary type blower is introduces into the cylinder, sweeping out the burned gases from the previous cycle, the pistons cover the exhaust and inlet ports on the compression part of the cycle and compress the charge between the two pistons. Near the end of the compression stroke, fuel is injected into the combustion space in a fine spray. The high temperature resulting from the compression of the air ignites the fuel. Combustion and the resulting expansion of the gases forces the pistons outward, thereby delivering work to the crankshafts and forming the power or second stroke of the cycle.



Illus. 1. Cross-section of Engine



Illus. 2. Cylinder Arrangement and Engine Rotation
(Arrow indicates lower crankshaft rotation as viewed from the drive end.)

The expanding and burning of the gases continues until nearly the end of the power stroke when the lower piston begins to uncover the exhaust ports allowing the burned gases to escape to the atmosphere thru the exhaust system. As the rotation continues the upper piston starts uncovering the inlet ports.

Scavenging air, due to the design of the tangentially directed inlet ports, sweeps the cylinder clear of the remaining exhaust gases, and refills the cylinder with clean air for the next compression stroke.

The exhaust ports are covered ahead of the inlet, permitting scavenging air to continue to enter and fill the cylinder with air at almost the scavenging air pressure. The whirling motion or turbulence persists during the injection period and is very beneficial in mixing the air and fuel. Thus during the one revolution of the crankshaft and two strokes of the pistons, compression, injection, combustion, expansion, exhaust and scavenging occur in the cylinder.

F. ENGINE GOVERNOR

The engine governor is the Woodward Type PG with

1. Electro-hydraulic speed control.

2. Built-in engine low oil pressure shutdown protection.

3. Built-in load regulator, controlling resistance in exciter battery (4-pole) field.

4. Speed and fuel indicator scales on governor housing.

5. Overriding solenoid used to send load regulator to minimum field during wheel slip.

Electro-hydraulic Speed Control

Governor speed control utilizes four solenoids in the governor energized thru four control trainline wires running from the lead unit throttle thru each unit. The solenoids are designated "A," "B," "C," and "D" and the trainline wires "AV," "BV," "CV," and "DV." The following table shows solenoids energized at each throttle position:

Throttle Position	Solenoids Energized A	B	C	D	RPM Engine Speed
Stop				*	0
Idle					300 ± 4
1					300 ± 4
2	*				376 ± 15
3			*		454 ± 15
4	*		*		536 ± 4
5		*	*	*	613 ± 15
6	*	*	*	*	692 ± 4
7		*	*		766 ± 4
8	*	*	*		850 ± 4

Engine Low Lubricating Oil Shutdown

If engine lube oil pressure falls below a preset amount for each engine speed the governor will stop the engine. The alarm bells will sound in each unit of the locomotive and the yellow "Low Oil" and blue "A.C. Failure" alarm lights will show on the engineer's panel of the unit affected.

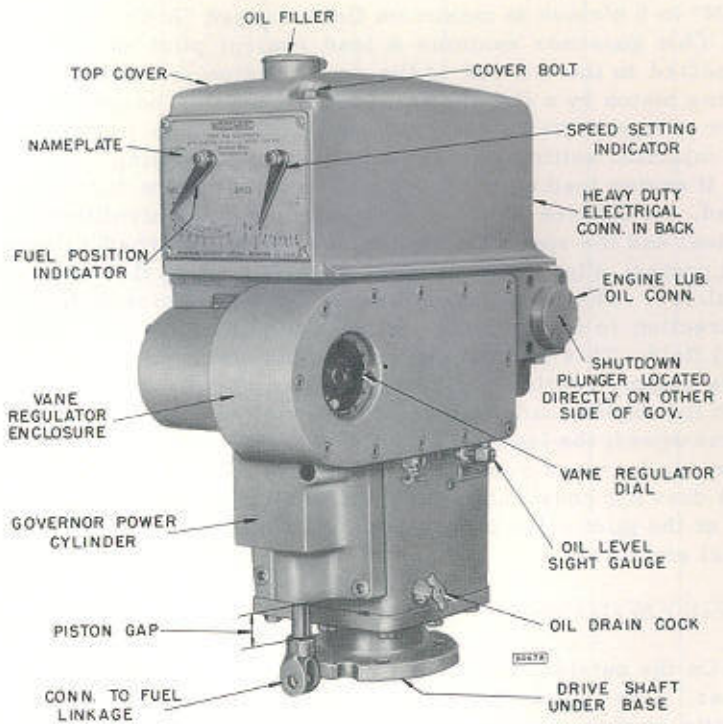
A pushbutton on the engine side of the governor housing will move out approximately 3/8" exposing a red band around the button. To stop the alarm:

1. Push in button on governor. This will put out yellow "Low Oil" alarm light.

2. Isolate engine. This will stop alarm bells and put out blue "A.C. Failure" alarm light.

THE GOVERNOR PUSHBUTTON WILL TRIP ONLY FROM AN ACTUAL LOW OIL ALARM AND NOT IF THE ENGINE STOPS FOR ANY OTHER REASON, EXCEPT POSSIBLY ON OVERSPEED TRIP.

A time delay is provided so that after a low oil alarm the engine may be started and idled for approximately forty seconds so



Illus. 3. Governor

that the cause of low oil pressure may be determined. Attempting to put the engine on the line during the 40 second period will cause an immediate shutdown if the low oil pressure condition, which caused the engine to stop, is still present.

Lube oil pressure of less than 5 psi at idle will shut the engine down after the 40-second time delay. Pressure less than 18 psi at full engine speed will shut the engine down without a time delay.

Load Regulator

The load regulator, included in the governor housing, consists of a commutator-type rheostat in the exciter battery (4-pole) field, with the rheostat brush arm operated by a hydraulic vane motor. The vane motor is operated by governor oil controlled by the pilot valve in the governor. The vane motor brush arm is visible thru a window.

Brush arm travel is from 7 o'clock at minimum field (marked

"MIN" to 5 o'clock at maximum field marked "MAX").

The governor contains a load control pilot valve which is connected to the tail rod of the power piston and also the speed setting piston by a floating lever and linkage. The governor pilot valve plunger will be centered or at its balance point when the fuel injection setting is correct for the speed setting.

If engine load tends to exceed the rated figure for any engine speed, the balance between the power piston (controlling fuel injection) and the speed setting piston will be disturbed causing the load control pilot valve to allow governor oil to flow to the load regulator. The regulator will move toward minimum field or in a direction to insert more resistance in the exciter battery (4-pole) field. This reduces the load on the main generator and prevents engine overloading at any engine speed. In like manner, when the engine load tends to fall below the rated figure for any engine speed, the load control pilot valve will cause the load regulator to decrease resistance or move toward maximum field. This does not constitute a torque control since the centered position of the pilot valve is dependent on speed setting and not on the actual engine speed.

Indicator Scales on the Governor

On the outside of the governor housing are two pointers with scales. One is marked "Speed" and markings correspond to throttle position. The other is marked "Fuel" and indicates power piston position in sixteenths of an inch. The lower the fuel scale reading, the more fuel is being injected into the engine.

Overriding Solenoid in Governor

The overriding solenoid in the governor is energized when any of the three wheel slip relays pick up, or when the throttle is in "Idle" position. It operates to send the load regulator to minimum field by control of oil flow.

SECTION 107A

ALARM AND TROUBLE SHOOTING SUMMARY

Colors may vary from those below according to the code of the railroad; however, each light has a name plate and can be identified.

TROUBLE CAUSE	ALARM	ALARM LIGHT	ENGINE STOPS	ENGINE TO IDLE	POWER OFF	UNIT NOT FULLY LOADING
Alternator Field Breaker Tripped	A.C. Failure	Blue	(5th-6th throttle)	Yes	Yes	-
Engine Overspeed Tripped	A.C. Failure	Blue	Yes	-	Yes	-
Engine Protector Relay Tripped	Engine Protector, A.C. Failure	Red and Blue in Cab, Red on EPR	Yes	-	-	-
Emergency Fuel Cutoff Tripped	A.C. Failure	Blue	Yes	-	Yes	-
Emergency Fuel Cutoff Partially Tripped	-	-	-	-	-	Yes

TROUBLE CAUSE	ALARM	ALARM LIGHT	ENGINE STOPS	ENGINE TO IDLE	POWER OFF	UNIT NOT FULLY LOADING
Fuel Pump Breaker Tripped, in Electrical Cabinet	A.C. Failure	Blue	Yes	-	Yes	-
Throttle in "Stop" with Engine "On the Line"	A.C. Failure	Blue	Yes	-	Yes	-
Control Cutout Breaker Tripped	-	-	Yes	-	Yes	-
Auxiliary Generator Fuse Blown	Discharge On Battery Ammeter	-	(Causes low battery)	-	Possible	-
(Will give A.C. Failure alarm also if reverse current relay is set to drop out at 30 amps. or less reverse current.)						
Engineer's Fuel Pump Breaker Tripped, Lead Unit	-	-	Yes	-	Yes	-
Ground or Impulse Relay Tripped	Ground or Impulse	White	-	Yes	Yes	-
Ground or Impulse Relay Tripped 5th or 6th Throttle	Ground or Impulse, A.C. Failure	White and Blue	Yes	-	Yes	-

Isolation Switch in "5," "6" or "7" Position	-	-	-	-	-	Yes
Isolation Switch in "IDLE" Position	-	-	-	Yes	Yes	-
Hot Engine	Hot Engine	Red	-	-	-	-
Wheel Slip	Wheel Slip	White	-	-	-	Yes
Locomotive Run Switch in "OFF" Position on Lead Unit	-	-	-	-	Yes	-
Engineer's Control Breaker Tripped	-	-	-	Yes	Yes	-
Starting Contactor Stuck (G+ or G-, GF1)	-	-	-	-	Yes	-
Low Control Air Pressure	-	-	-	-	Yes	-
Engine Governor Plug Not Secure	-	-	Possible	Possible	Possible	Possible
Jumper Cable Loose Between Units	-	-	Possible	Possible	Possible	Possible

TROUBLE CAUSE	ALARM	ALARM LIGHT	ENGINE STOPS	ENGINE TO IDLE	POWER OFF	UNIT NOT FULLY LOADING
Low Lubricating Oil Pressure	Low Oil; A.C. Failure	Yellow and Blue	Yes	-	Yes	-
Pair of Traction Motors Cutout	-	-	-	-	-	Yes
One or More Fuel Injection Pumps Cut Out	-	-	-	-	-	Yes
Low Fuel Pressure	-	-	-	-	-	Yes
Transition Switch in "SERIES" Position or Plug Out of Relay Box	-	-	-	-	-	Yes
The following causes usually result in road trouble that crews can learn to detect, but which should be corrected only by qualified maintenance men.						
V-Belts Slipping on Exciter or Auxiliary Generator	Fluctuating Battery Ammeter	-	-	-	-	Yes
Transition Relays Out of Adjustment	-	-	-	-	-	Yes

Governor or Load Regulator Out of Adjustment	-	-	-	-	-	Yes
Engine Speeds Low	-	-	-	-	-	Yes
Faulty Interlocks or Contactors	-	-	Possible	Possible	Possible	Possible
Engine Air Intake Filters Clogged	-	-	-	-		Yes

ALARMS AND CORRECTIVE PROCEDURE

Listed below is each alarm, how it affects the unit, and steps necessary for correction. Alarm bells will ring on all units, but lights will burn only on the unit affected unless the railroad has specified otherwise.

Colors of alarm lights may vary from those given below to meet a railroad's standard code. In any case there is a name tag below each light.

LIGHT	ALARM	ACTION	TO CORRECT CONDITION
None	None	Engine stops.	1. Check control cutout breaker (Illus. 4, Sec. 101A) in the electrical cabinet. Reset if necessary. 2. Check engineer's fuel pump breaker (Illus. 2, Sec. 101A). Reset if necessary.
None	None	Discharge on battery ammeter.	1. Check auxiliary generator fuse (Illus. 4, Sec. 101A). Replace if necessary. 2. Have maintenance check BC contactor. 3. Have maintenance adjust RC relay to 30 or less amps reverse current so it will trip when the auxiliary generator fuse blows.
Blue	A.C. Failure	Isolates engine. Stops engine in 5th or 6th throttle.	1. Turn isolation switch to "ISOLATE" position. This will put out light and stop bells (Sec. 101A, Illus. 2). 2. Check engine overspeed trip reset lever. Reset if necessary. (Sec. 101A, Illus. 7.) 3. Check battery ammeter (Sec. 101A, Illus. 8). If a discharge current shows with engine running, auxiliary generator fuse (Sec. 101A, Illus. 4) is probably blown. 4. Check alternator field circuit breaker (Sec. 101A, Illus. 4). 5. Check fuel pressure (Sec. 101A, Illus. 8). If below 20 lbs., see Sec. 116A.
		Alarm comes on also if engine stops from overspeed trip, lack of fuel, etc. while on the line.	
Red, Blue	Engine Protector, A.C. Failure	Stops engine.	1. Check engine protector for correct position of 2-way valve (Sec. 101A1, Page 1). If the EPR is tripped, the red light will burn on the switch housing and on the engineer's control panel. Reset if necessary. 2. Start engine. If EPR repeatedly trips after engine has been started and running, inspect engine for internal defects. DO NOT REMOVE CRANKCASE COVERS UNTIL TWENTY (20) MINUTES HAVE ELAPSED AFTER SHUTDOWN.
White	Ground or impulse relay tripped	Isolates engine. Stops engine in 5th or 6th throttle, in which case blue "A.C. FAILURE" light will also come on.	1. Return the isolation switch to "ISOLATE" position. 2. Reset relay by pressing reset button (Sec. 101A, Illus. 4). 3. Put the engine back on the line. 4. If relay repeatedly trips, try running with the isolation switch (or throttle if running single unit) in a reduced engine speed position. 5. If the relay still continues to trip repeatedly, leave the unit isolated. ALWAYS ISOLATE THE ENGINE BEFORE PRESSING THE RESET BUTTON.

LIGHT	ALARM	ACTION	TO CORRECT CONDITION
Yellow and Blue	Low lubricating oil pressure and A.C. Failure	Stops engine.	1. Isolate unit. 2. Check engine overspeed trip (Sec. 101A, Illus. 7). Reset if necessary. 3. Push in reset button on governor (Sec. 101A, Illus. 9). This will put out yellow alarm light and stop bells. 4. Start engine. If alarm comes on again, check for cause of low oil pressure. Common causes are an open drain valve on the filter (Illus. 3, Sec. 117A), low lube oil supply or dirty in-line strainers. (Refer to Sec. 117A.)
Red	Hot engine (Water out of engine between 195-205° F.	Alarm only. Loading not affected.	Refer to Sec. 118A.

SECTION 110A. DYNAMIC BRAKING

Operation of Controls

1. Before operating locomotive, check that:

   a) The Dynamic Brake Unit Switch, Illus. 2, Sec. 101A, on the engineer's control panel is set for the number of units in the locomotive. This is to obtain proper maximum field loop current for excitation of each unit's exciter.
   b) The Dynamic Brake Circuit Breaker, Illus. 4, Sec. 101A, in the electrical cabinet is in "ON" position. This breaker controls the field loop excitation circuit.

2. Upon entering dynamic braking, always wait a few seconds in each control step before proceeding. This protects against excessive current surges.

3. The dynamic brake retards the train in the same way as a strong independent brake, therefore, the same care must be used in controlling slack.

4. Place throttle in "Idle." Wait five to ten seconds to allow engine speed to decrease and generator residual voltage to decay.

5. Move selector lever to "OFF." (Reverse lever must be in forward or reverse.) This will throw the cam switch from "motoring" to "braking" position.

6. After a few seconds, move selector until it latches in the FIRST braking position. Here the diesel engine speed is automatically increased from 300 to 700 rpm (sixth notch). Braking contactor B1, Illus. 5, Sec. 101A, closes to connect the traction motor fields to the main generator, but excitation is not applied.

7. If train speed is high, residual magnetism in the generator and exciter fields may cause sufficient braking effort to bunch slack. This will be approximately 200-250 amps on the load ammeter at maximum locomotive speed. The load ammeter reading is a measure of the braking effort being produced.

8. AFTER SLACK IS BUNCHED, move the selector lever to the right to give the desired amount of braking. Do not allow the load ammeter pointer to go into the red area of the braking band on the scale, Illus. 3, Sec. 101A. Excitation is applied just beyond the first braking position, when a controller contact closes the field loop contactor, FL.

9. On these units, the ground relay will trip to give an alarm indication only if the braking grids are grounded (this can happen from excessive dirt, moisture, or both in the grids). IF THE GRIDS ARE WET, AMPERAGE SHOULD BE HELD AT A MINIMUM FOR A FEW SECONDS TO ALLOW THE GRIDS TO DRY OUT BEFORE PROCEEDING TO HEAVIER BRAKING.

10. DO NOT APPLY THE DYNAMIC BRAKE BEYOND 700 AMPS AT 50 MPH OR OVER. This avoids exceeding the commutation limit of the traction motors.

11. The brake warning light is set to come on when the pointer enters the red area (840 amps). Slight differences in characteristics between units may cause the warning light to come on while the pointer is still in the white zone. The light governs, and braking must always be reduced until the light goes out.

Exception: Intermittent momentary burning of the warning light while limiting control (Par. 12) is functioning is permissible.

12. Automatic Dynamic Brake Limiting Control

a) Train Master units which are equipped with dynamic braking are fitted with a dynamic brake limiting control which uses a voltage relay connected across the grids to pick up a signal which is relayed to the engine governor overriding solenoid (ORS). The ORS actuates the vane regulator, which in dynamic braking is connected as a potentiometer in parallel with the 1.5 ohm dynamic braking field loop excitation circuit resistor. Over voltage on the grids will pick up voltage relay BKR, Illus. 4, Sec. 101A, which energizes the ORS to send the vane regulator to minimum field, reducing excitation.

b) When the controller selector handle is advanced far enough so the grid current as shown on the load ammeter slightly exceeds approximately 820 amperes (full rated current is 840 amperes), the load ammeter pointer will begin a slight cycling motion. This indicates that the point of maximum braking, as set by the regulating relay BKR, has been reached.

c) Further movement of the handle toward maximum braking at constant or increasing train speed will increase the amplitude of cycling (although keeping the same approximate current limit), therefore it must be avoided as it will not give any additional braking power. In such cases the braking handle must be retarded until the cycling is reduced to 70 amps or less.

At decreasing train speeds the selector handle may be advanced at will to obtain the desired amount of braking at 820 amps or less.

d) Actuation of the brake warning relay BWR, Illus. 2, Sec. 101A, which gives a warning light and buzzer, is perfectly permissible providing the action is only momentary and not continuous.

The BWR is set for approximately 840 amperes on the load ammeter, which is at the point of maximum continuous grid amperage and must of necessity be close to that of the regulating relay BKR.

Therefore, when working at or near maximum braking, a momentary current overswing due to controller handle movement may actuate the BWR. Also, the cycling of BKR may also intermittently actuate the BWR. This is permissible providing BWR doesn't stay on more than just momentarily.

e) To protect the traction motors, grids, and grid blower fan from excessive overload, there is a third voltage relay BKL, Illus. 4, Sec. 101A, which picks up at approximately 1000 grid amperes (160 amps past the brake warning into the red zone) and will "dump" the dynamic brake entirely by energizing control relay DBNR, Illus. 4, Sec. 101A.

To recapture the dynamic brake, the selector handle must first be returned to the "OFF" position.

f) Braking relays are set at specified voltages, hence relay pickup amperages will vary slightly in operation since grid resistances vary about 5% with temperature.

BKR - Braking Regulating Relay	
Pickup volts	780-790
Approximate load amps	820
BWR - Brake Warning Relay	
Pickup volts	370-380
Approximate load amps	840
BKL - Braking Limit Relay	
Pickup volts	950-960
Approximate load amps	1000

13. An interlock on the D-24 Control Valve of each unit keeps the automatic brake from applying on the locomotive when the dynamic brake is in use. The independent brake is always available, but avoid using it except in emergency as the wheels may slide. The automatic air may be used on the train at any time along with the dynamic brake, since the interlock on the D-24 control valve will keep the air brakes from applying on the locomotive.

Note that if a unit is isolated, so that its dynamic brake is inoperative, air brakes on the unit will apply while the rest of the locomotive is in dynamic braking.

14. A brake-valve initiated emergency air brake application will automatically nullify the dynamic brake and allow locomotive brakes to apply. The selector handle must be returned to the No. 1 position and then to "OFF" to recapture the dynamic brake.

15. As the speed decreases, braking effort builds up to a maximum near the locomotive continuous speed and then decreases at a sharp rate. However, there is still considerable braking left at 10 mph and often this is more effective than the independent brake.

The brake must not be expected to stop heavy trains in short distances or to slow trains down on heavy grades.

16. At low speeds, dynamic braking effort decreases sharply. Around 5 mph, the dynamic brake may be released by moving the selector lever to No. 1 position and applying the independent brake to keep slack from running out.

17. If the dynamic braking circuit on any one unit is defective, the dynamic brake on that unit may be isolated by using the "DBCO" position of the motor cutout switch, Illus. 4, Sec. 101A. This does not affect motoring on that unit or dynamic braking on coupled units. Do not change position of Unit Selector Switch.

When maximum braking slows the train, the ammeter pointer will fall back as train speed drops. To maintain maximum braking, move the selector handle to the right to keep the pointer at the upper end of the white zone (840 amps). If a steady speed is desired rather than a slowdown, ease off by moving the handle to the left until the required speed is reached. To hold this speed, move the handle forward to retard or back to accelerate.

The dynamic brake is not intended for use in bringing a train to a stop. Braking force diminishes rapidly as speed drops below continuous. However, if the distance available for the stop is sufficient and it is desired to avoid an automatic air application for some particular reason, the train may be slowed down gradually with the dynamic brake.

19. Manipulating Dynamic Brake on Grades

On heavier grades the dynamic brake may be insufficient to hold the train. The train speed will increase, causing the ammeter pointer to cycle with operation of the limiting control. Keep moving the handle back to hold the pointer in the white area. When the train speed reaches the maximum authorized, make an air brake application to check the train. Do not change the position of the handle. After reducing speed, release the air and allow the dynamic brake to hold the train while the brake pipe is being recharged. When the air brakes apply, the ammeter pointer will drop back. After release of the air, the train will again gain speed, assuming the grade conditions are the same. This will bring the ammeter pointer up again. When the pointer nears the limit of the white zone, the speed will again be at the desired limit and another air brake application should be made.

This method of handling will maintain a nearly constant speed if light air applications are made which will reduce the speed very slightly. Actually, the effect of a light air application will show as a movement of the ammeter pointer before it is noticeable on the speedometer as a drop in speed. Thus, if the air is released as soon as the ammeter begins to fall back, the speedometer will remain practically steady. After some practice in judging the frequency and amount of air applications, an engineer will materially lower the running time.

A similar procedure should be used when the grade includes stretches where the speed is restricted because of curves, yards, track conditions, etc. By the use of heavier air applications, the speed can be reduced to meet the restriction. After passing a restricted area, release the air and allow the train to come up to the normal speed for the grade where the pointer will again reach the top of the white area. This method will accomplish smooth train handling and, in some respects, act as a graduated release after slowdowns.

Severe conditions of grade and tonnage may make continuous full use of dynamic braking desirable. Advance the selector during air applications to keep the pointer at the limit of the white zone. After air release, ease off the selector handle to keep the ammeter pointer from excessive cycling. This handling requires more manipulation by the engineer and is seldom necessary.

SECTION 115B. 24-RL AIR BRAKE EQUIPMENT

AUTOMATIC BRAKE VALVE

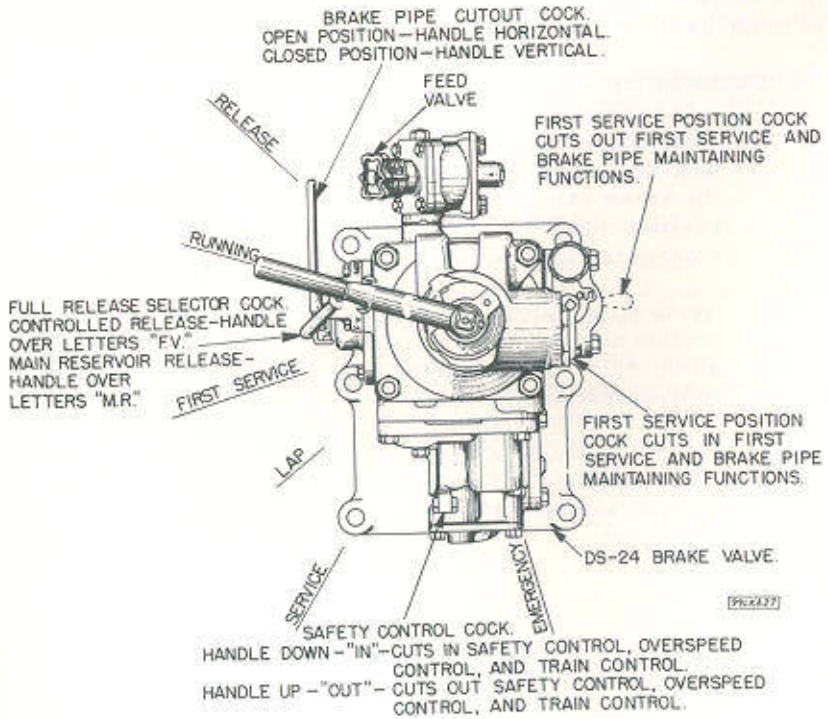
The six handle positions are: (left to right on the quadrant- refer to Illus. 1)

Release	Lap
Running	Service
First Service	Emergency

Release Position gives controlled full release according to the position of the full release selector cock. Refer to paragraph 3 under "Cocks on the brake stand." A warning port operates to inform the engineman of the handle position.

Running Position gives air flow to the brake pipe as regulated by the feed valve. This position is used to release the brakes; when the brakes are charged and ready for use; and when the brakes are not being operated.

First Service Position is for use on long trains with maxi-



Illus. 1. DS-24 Brake Valve

mum permissible leakage. This position provides an initial normal service rate of brake pipe reduction sufficient to initiate quick service on the train brakes, after which a slower rate is imposed, allowing the brake pipe pressure to readjust itself throughout the train and avoiding a heavy reduction at the front end. A maintaining type of equalizing piston is utilized to assure that this imposed rate is not exceeded.

Lap Position is used while holding the brakes applied after a service application until it is desired either to make a further brake pipe reduction or to release brakes. All ports are closed.

Service Position applies locomotive and train brakes uniformly on both a time and pressure basis. This is accomplished by the displacement reservoir, which delays the beginning of effective brake cylinder pressure development on the locomotive to coincide with that on the train.

Emergency Position provides a rapid increase in locomotive brake cylinder pressure for passenger and short freight trains; or a controlled build-up for long freight trains. This adjustment is made by the rotair valve.

Cocks on the brake stand are:

1. Brake Pipe Cutout cock, located on the filling piece portion at the bottom. Forward position of the handle cuts the brake valve in. Move slowly when moving to "LIVE" position to cut in brake valve, to avoid an undesired emergency application.

2. Application Valve Cutout cock on the service application portion normally sealed in the "IN" position. "OUT" position cuts out the safety control, overspeed, and train control features.

   NOTE: On units equipped with safety control, if the foot pedal diaphragm ruptures, the sealed cock in the pedal air line can be closed so that the application valve need not be cut out.

3. Full Release Selector cock on the left side of the rotary valve seat portion. (On some railroads this cock is blanked out so the "MR" position cannot be used.)

   MR position (pointing away from engineer) allows air at main reservoir pressure (as in No. 6 ET or No. 8 ET equipment) to flow to the brake pipe unregulated by the feed valve, when the brake handle is in release position. Overcharging is possible.

   FV position (pointing toward engineer) connects the brake pipe to the control pipe and maintains feed valve pressure in the brake pipe, with the brake handle in release or running.

   The "FV" position prevents overcharging of the brake pipe during full release, and is normally used.

4. First Service cock, on the right side filling piece portion, which cuts out the first service position of the brake valve when handle is pointing away from engineer.

INDEPENDENT BRAKE VALVE

The S-40-F independent brake valve incorporates the "Release" position at the extreme left and the "Full Application" position at the extreme right with the "Application Zone" between. The brake valve is self-lapping which means that the air is automatically lapped off when the applied pressure increases to that set by the position of the brake handle.

Locomotive brakes can be held off during an automatic application by depressing the independent brake handle in "Release" position.

The handle is removable in release position.

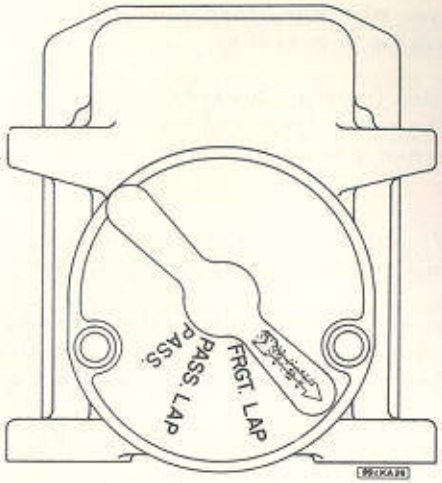
LOCOMOTIVE OVERSPEED

(Installed only when specified by the railroad.
On some railroads locomotive overspeed warning is a function of train control equipment.)

Exceeding maximum permissible locomotive speed will open a precision switch in the speed recorder, de-energizing the overspeed magnet valve causing a full service brake application, tripping of the PC switch and the "Power Off" light to come on.

A warning whistle is provided to sound just before reaching maximum speed, and an unwanted brake application may be forestalled by reducing speed within 4 seconds, or making a full service application.

Accidental control power failure (resulting from low battery voltage or tripping of a control breaker) can cause an overspeed brake application at any locomotive speed because of loss of voltage on the normally energized overspeed magnet valve. If this occurs consistently for any reason, the overspeed control can be cut out by turning the sealed overspeed cutout cock located just beneath the center trap door of the cab floor.



Illus. 2. K-2-A Rotair Valve

K-2-A ROTAIR VALVE

Positions are as follows:
(Refer to Illus. 2)

"FRGT" - Cuts in: Independent brake valve
Controlled emergency
Split-reduction (if used)
Suppression timing (if used)

"PASS" - Cuts in: Independent brake valve
Cuts out: Controlled emergency
Split-reduction (if used)
Suppression timing (if used)

"FRGT LAP" - Used in Trailing units only
Cuts out: Independent brake valve
Automatic service split-reductions

"PASS LAP" - Used in Trailing units only
Cuts out: Independent brake valve

SAFETY CONTROL
(For units so equipped)

Releasing pressure on the foot pedal and the hinged brake valve handle at the same time (one or the other must be kept de-

pressed while running) will cause a warning whistle to blow. Within four seconds, the pedal must be again depressed and the brake valve lapped, or an automatic full service application will occur, tripping the PC switch and causing the "Power Off" light to come on.

To release a safety control application, depress either the brake valve handle or the foot pedal and move the automatic brake valve handle to "Lap" position until the application portion releases when the application pipe nears main reservoir pressure. Then move brake valve handle to "Release" position.

The safety control feature can be cut out by closing the sealed 3/8" cutout cock in the line to the foot pedal.

BRAKE CYLINDER CUTOUT COCKS

The brakes on any truck can be cut out by closing the brake cylinder cutout cock located under the underframe above each truck on the governor side of the unit.

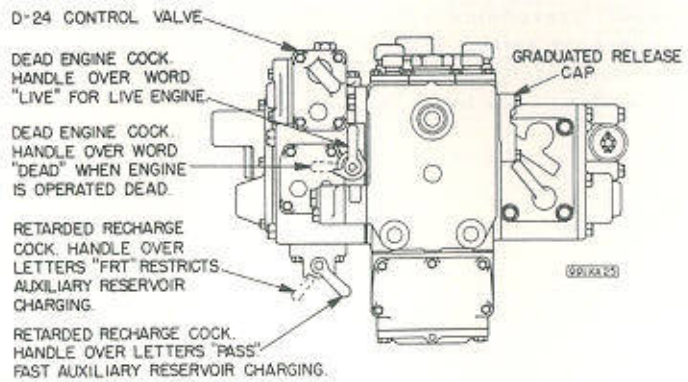
D-24 CONTROL VALVE

This valve has two cocks and one cap:
(Refer to Illus. 3)

1. Dead Engine Cock

"LIVE" position provides main reservoir charging from the air compressor, and is the normal position.

"DEAD" position provides main reservoir charging from the brake pipe. Use only when locomotive is hauled dead in a train. Refer to the section entitled "TOWING."



Illus. 3. D-24 Control Valve

2. Retarded Recharge Cock

Position should correspond to that of the leading unit.

"FRT" position restricts auxiliary reservoir charging.
"PASS" position gives quick auxiliary reservoir charging.

3. Graduated Release Cap

"GRADUATED" setting gives graduated release of the automatic brake for passenger service.
"DIRECT" setting gives direct release of the automatic brake for freight service.

TOWING

When it is necessary to prepare a locomotive for dead heading, first stop the engine in the usual manner. (See Pars. P and Q, Sec. 104A.)

Set up the brake equipment as follows:

1. Place the handle of both brake valves in "Running."
2. Remove both brake valve handles.
3. Move the brake pipe cutout cock to the "Closed" position.
4. Move the dead engine cock on the control valve to "Dead" position.
5. Set the rotair valve in "Pass" position.
6. If for any reason, it is desired to keep the maximum braking power lower than standard on 24-RL equipment, insert a 28 lb. safety valve in the No. 16 control pipe in the tee applied for this purpose. The usual practice is to remove one of the two compressor intercooler safety valves for this purpose lowering the air pressure setting from 60 to 28 lbs. After towing, be sure to return the safety valve to the intercooler and raise the air pressure setting back to 60 lbs.

1 - Bell Pipe
2 - Forward Sanding Pipe
3 - Reverse Sanding Pipe
4 - Application & Release Pipe
5 - Actuating Pipe
6 - Main Reservoir Equalizing Pipe
7 - Controlled Emergency Pipe
8 - Compressor Governor Pipe
9 - Compressor Discharge Pipe
10 - Main Reservoir Pipe
11 - Brake Cylinder Pipe
12 - Brake Pipe

A1 - Wiper Operating Valve
A2 - Main Wiper Valve
A3 - Horn Valve
A4 - NS-1 Reducing Valve with vented cutout cock (set at 80 P.S.I.)
A5 - King #14 Bell Ringer Valve
A6 - D-24 Brake Valve
A7 - K-2-A Rotair Valve
A8 - S-40-F Independent Brake Valve
A9 - Duplex Solenoid Valve
A10 - Sand Control Valve
A11 - D-3 Magnet Valve
A12 - E-7-C Safety Valve (set at 170#)
A13 - D-24 Control Valve
A14 - B-3-A Relay Valve
A15 - C-1 Main Reservoir Cutoff Valve
A16 - Main Reservoir Safety Valve (set at 150#)
A17 - 1-1/4 Check Valve
A18 - Wright's Little Watchman Valve

B - 1/2 O.B. Strainer

D - Type "H" Filter

E - Horn

F1 - 3/8 Cutout Cock
F2 - 1/2 Vented C.O. Cock
F3 - 1" Combined Dirt Collector & C.O. Cock
F4 - 1/2 Drain Cock
F5 - 1-1/4 Vented C.O. Cock
F6 - 3/4x3/4x3/8 Three Way Cutout Cock
F7 - 1/2 Cutout Cock
F8 - 1-1/4 D.L. Angle Cock (R.H.)

G - 3-CD Air Compressor

H - Bell

J - Sand Trap

K1 - 2150 C.I. Control Air Reservoir
K2 - Equalizing & Reduction Limiting Reservoir
K3 - No. 1 Main Reservoir 30, 317 Cu. In.
K4 - No. 2 Main Reservoir 30, 317 Cu. In.
K5 - Auxiliary Emergency & Displacement Volume Reservoir

M1 - 3/4 C.O. Cock - Locking Handle
M2 - 3/8 C.O. Cock - Locking Handle
M3 - 1" C.O. Cock Locking Handle

N1 - 1/2x1/2x60° Angle Bracket Coupling
N2 - 1x1x60° Angle Bracket Coupling
N3 - E & L1" Dummy Coupling
N4 - F-1" Dummy Coupling
N5 - H-1" Dummy Coupling

O - S-16 Compressor Governor

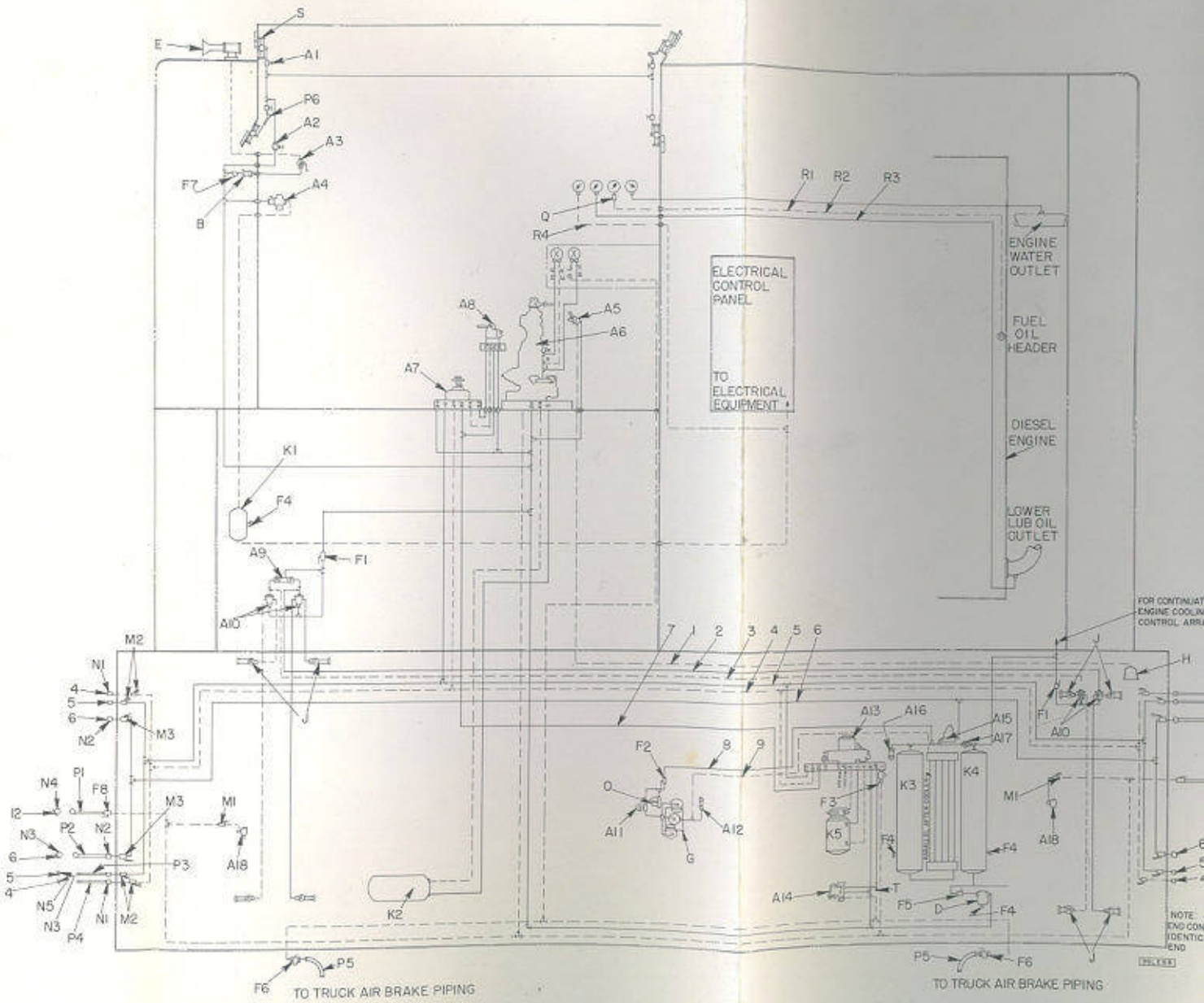
P1 - 1-3/8x22 Hose - FP-5 Coupling
P2 - 1-1/8x23 Hose - LS-4 Coupling
P3 - 5/8x24 Hose - ES-2 Coupling
P4 - 5/8x24 Hose - HS-2 Coupling
P5 - 1-1/8x30 Hose
P6 - Flexible Hose - 2 Req'd.

Q - Choke Fitting

R1 - Water Temperature Tube
R2 - Fuel Oil Pressure 3/8 O.D. Tube
R3 - Lub. Oil Pressure 3/8 O.D. Tube
R4 - Control Air Tube 3/8 O.D.

S - Windshield Wiper - 4 Req'd.

T - 1/2 Plugged Tee



Illus. 4. Typical Control and Air Brake Schematic Piping Diagram (M.U. Any Combination)

SECTION 116A. FUEL OIL SYSTEM

DESCRIPTION

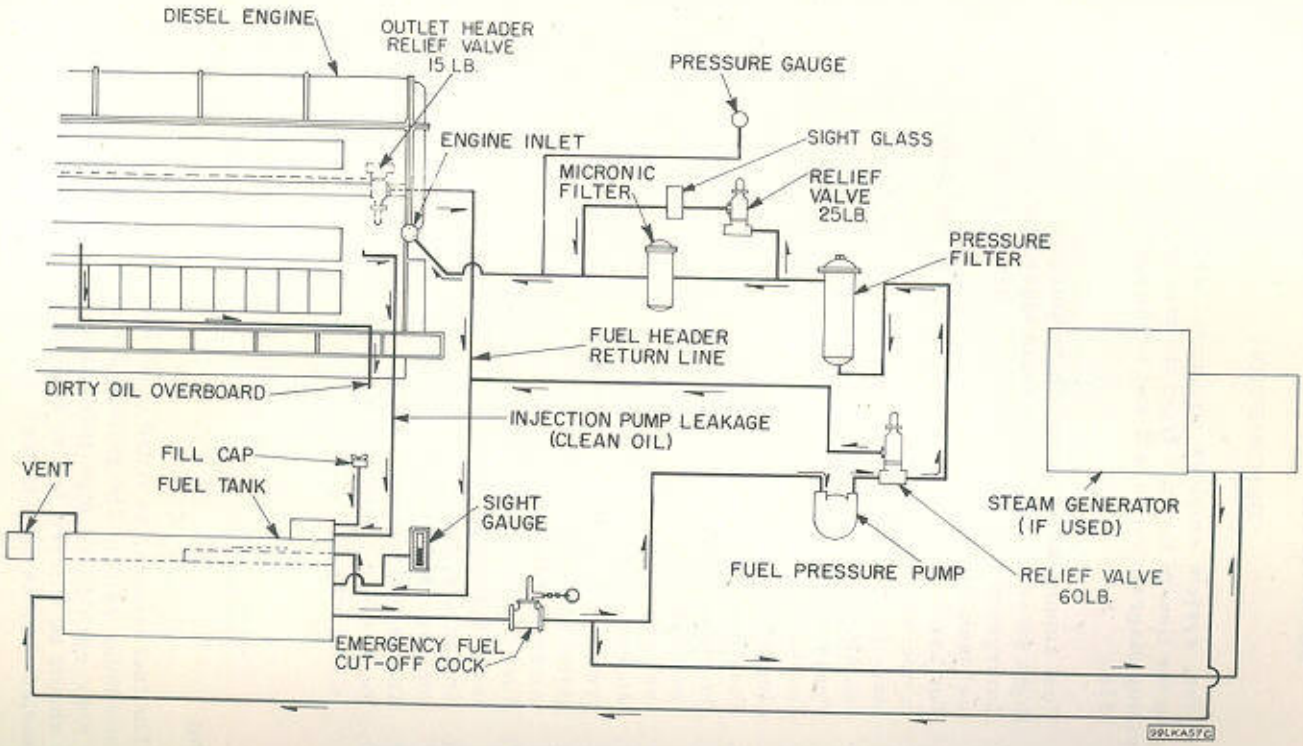
The fuel system employs equipment as follows, listed according to the flow of the fuel from the tank to the engine. Refer to the piping diagram on page 2 and to the drain and fill diagram in Sec. 131A.

1. Fuel supply tank underneath locomotive.
   Sight glasses and gage on main tank (Illus. 3 and 4).
2. Emergency fuel cutoff valve, located on governor side of fuel tank (Illus. 2, 3 and 4).
   For use in case of fire, pull rings at fuel filler pipes or in operating cab.
3. Main fuel transfer pump, motor driven thru a flexible coupling and located below the engine governor.
4. Pressure relief valve (60 lbs.) in transfer pump discharge line, to by-pass fuel back to tank in the event of a clogged line ahead of the pump.
5. Fuel pressure filters, located on the pressure side of fuel transfer pump. Fuel oil pressure at idle engine speed below 20 pounds indicates the filter cartridges may need changing.
6. Micronic fuel pressure filter, in series with main fuel pressure filter but equipped with by-pass line with sight glass and 25 lb. relief valve. If sight glass shows fuel micronic filter should be changed.
7. Fuel pressure gage, mounted on cab panel, indicates pressure supplied to engine fuel header (Illus. 7, Sec. 101A).
8. Engine fuel headers, supplying engine fuel pumps and nozzles. Relief valve (15 lb.) at header outlet (Illus. 6).
9. Engine fuel pumps and nozzles.
10. Fuel return headers, which carry excess clean fuel back to fuel tank.

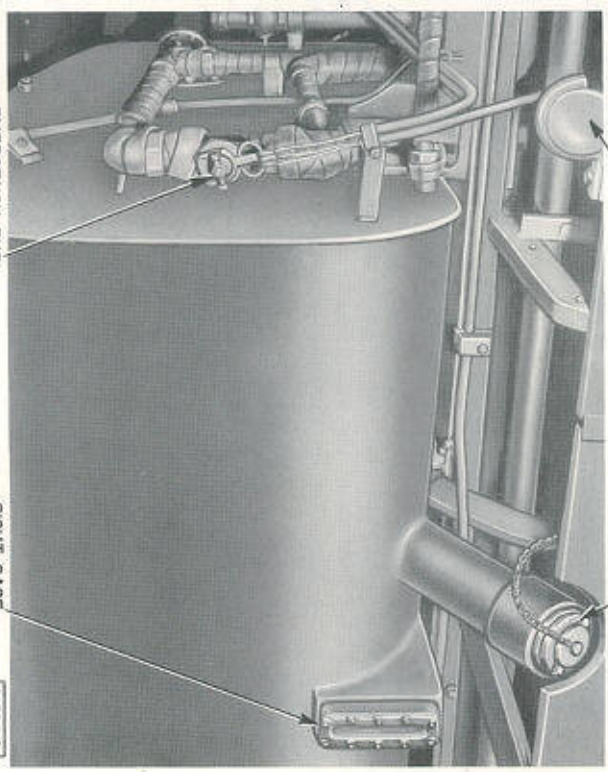
FUEL TANK

Filling

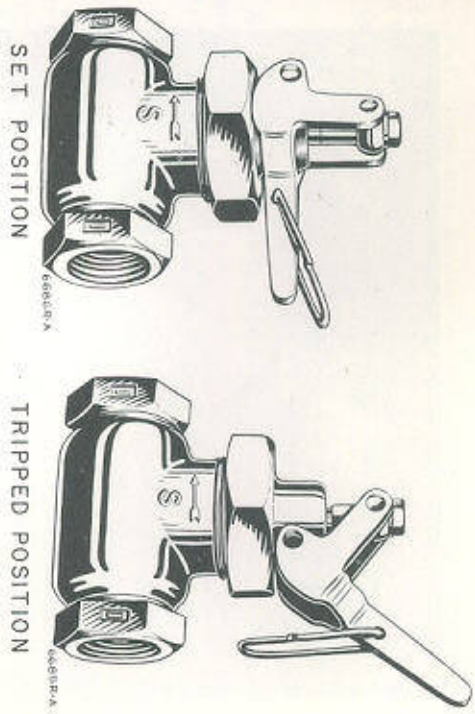
The fuel tank can be filled from either side of the locomotive at a maximum rate of 250 gallons per minute. Sight glasses and gage near each filler pipe indicate tank level (Illus. 3 and 4). Fuel should be filtered before it enters the tank, and should not be handled near an open flame.



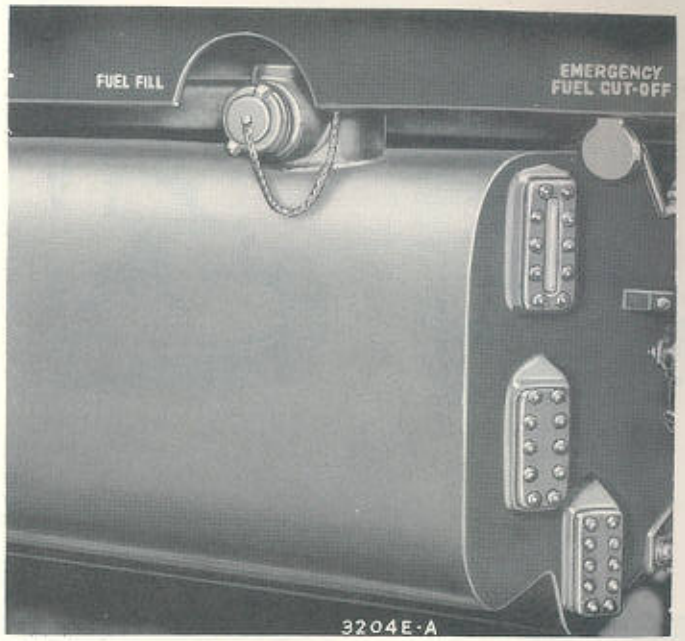
Illus. 1. Fuel Oil System Schematic Piping Diagram



Illus. 2. Fuel Tank - Governor Side



Illus. 2. Emergency Fuel Cutoff Valve



Illus. 4. Fuel Tank - Opposite Governor Side

Draining

There are two drain plugs at either end for draining the tank and a plug at the bottom of the sump for draining any water. Both tanks and sump should be drained periodically for water and sediment.

During freezing weather, it is advisable to put about five gallons of alcohol in the fuel tank, to settle in the sump and prevent the water from freezing. Under severe conditions more alcohol may be added for the tank itself.

Vents

There are two vents, one on each side terminating above the tank equipped with 4 inch flame arrestors.

EMERGENCY FUEL CUTOFF VALVE

This valve (Illus. 2) is employed to cut off all fuel in case of fire. Pull rings are located on each side of the fuel tank by the filler pipes and in the operating cab. Once pulled shut, the valve must be reset by hand. The valve on passenger units shuts off fuel to the steam generator as well as to the engine.

STEAM GENERATOR FUEL SUPPLY
(For passenger units so equipped)

An auxiliary line is tapped into the main suction line between the emergency cutoff valve and the fuel pump, to supply the steam generator on passenger units.

ENGINE FUEL HEADERS

The fuel supply headers on each side of the engine are connected to each injection pump. More fuel is pumped thru the injection system than is needed by the pumps, and a pressure of about 15 lbs. is maintained by the relief valve at the header outlet.

FUEL RETURN HEADERS

Excess lubricating oil from the injection pump push rod lubrication and any leakage of fuel oil from the injection tube connections collecting in the injection nozzle compartments is piped to a drain to the ground.

FUEL PRESSURE

Fuel should be clean to avoid trouble in the system. The fuel pressure should be approximately 20 to 25 lbs. If the fuel pump runs and this pressure does not show, the following may be the cause:

1. No fuel in tank.
2. Emergency cutoff valve tripped.
3. Leaks in fuel pump suction line.
4. Clogged suction strainer.
5. Worn pump packing rings.
6. Relief valves sticking, pitted or worn.
7. Clogged pressure filter or filters.

If the pump does not run, check the fuel pump control circuits.

INJECTION TUBE FAILURE

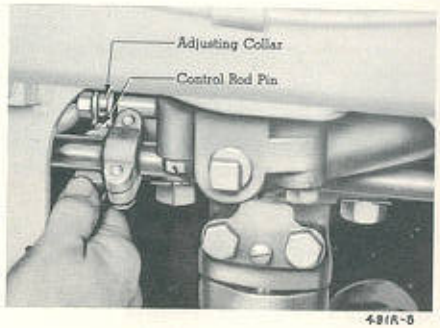
If a tube between the injection pump and nozzle should break or loosen, the escaping fuel will be carried away in the waste fuel drain. The pump having the defective tube should be cut out as

shown in Illus. 5. This can be done by pulling out the control rod plunger and at the same time pushing the control rack assembly as far as possible to the right so that the plunger end no longer engages in the slotted end of the rack. The pin can be released and the pump will no longer deliver fuel.

No more than two pumps should be cut out at one time and then only long enough to get to a maintenance point. Never cut out a complete cylinder, i.e., the two pumps opposite each other on the same cylinder.

IRREGULAR OPERATION

A cylinder not receiving fuel or not firing can be detected by the irregular sound of the engine. Likewise, any cylinder getting excessive fuel due to a defective nozzle can be detected. Cut out any one pump not functioning properly, but not a complete cylinder.



Illus. 5. Fuel Injection Pump Cutout

SECTION 117A. LUBRICATING OIL SYSTEM

GENERAL

The lubricating oil system serves a dual purpose by furnishing oil to the engine for cooling the pistons and lubricating the various bearings and wearing parts under pump pressure. Refer to the piping diagram on the following page and to the drain and fill diagram in Sec. 131A.

FLOW OF LUBE OIL

The engine driven lubricating oil pump draws oil from the engine crankcase thru a coarse strainer, and pumps it thru the multi-element filter to the oil cooler. Here, the oil is circulated around water cooled tubes and then piped thru a fine strainer to the engine oil headers. Flow continues thru the engine parts and back to the crankcase.

RELIEF VALVES AND BY-PASSES

At idling speed all oil is designed to flow thru the multi-element filter. At higher engine speeds a relief valve will open at 15-20 lbs. to allow part of the oil to flow thru an external by-pass around the multi-element filter. At full engine speed about 20% of the oil goes thru the filter.

Plugging of the oil cooler or strainer will open an internal by-pass in the pump and cause the engine to shut down from low oil pressure if sufficient drop occurs. The pump relief valve is set at 70 lbs.

LOW OIL PRESSURE PROTECTION

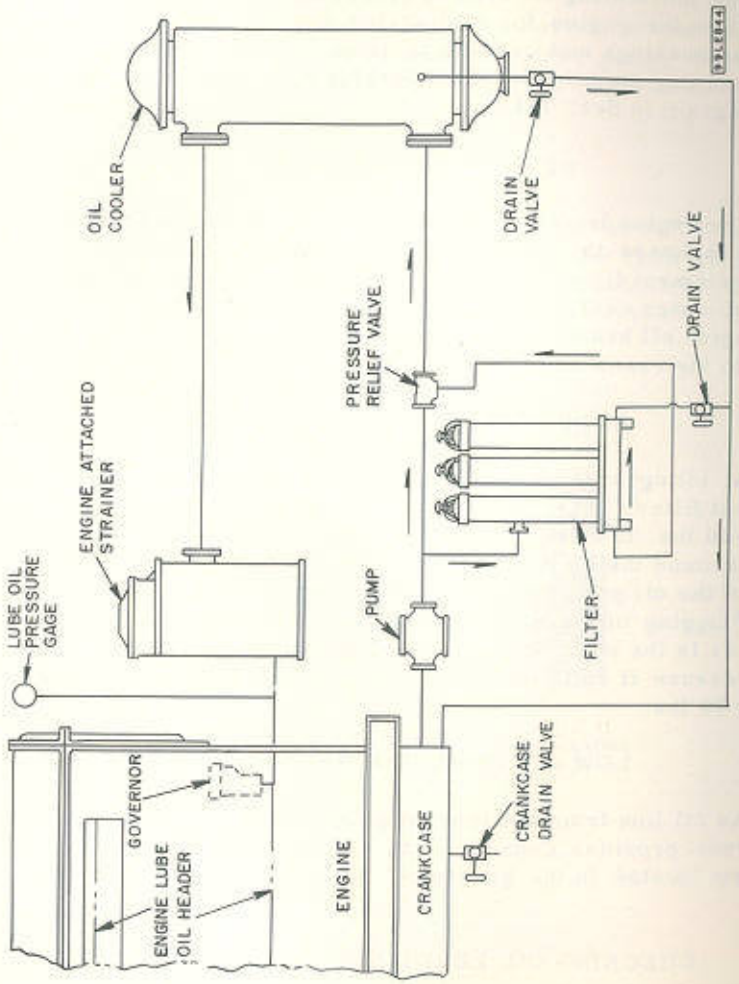
An oil line from the lower engine lubricating oil header to the governor provides connection to the low oil pressure shutdown feature located in the governor. Refer to Sec. 105A for operation.

CHECKING OIL LEVEL AND FILLING SYSTEM

Measuring Oil Level

Oil level is measured at the dip stick located in the engine subbase on the governor side of the engine. Refer to Illus. 2. The lubricating oil level should be checked at the start of every run, and should be between the "FULL ENGINE" and "ADD OIL" marks.

If the engine is running when the level is checked, read the



Illus. 1. Lubricating Oil Schematic Piping Diagram

side of the gage marked "ENGINE RUNNING." Read side marked "ENGINE STOPPED" when engine is not running. Use the following procedure:

1. Unscrew bayonet gage, and remove and wipe clean of oil.
2. Insert to full thrust but do not screw onto pipe.
3. Withdraw and read proper side.
4. Replace in pipe and screw down snug.

Filling System

The engine is supplied with lubricating oil by filling the crankcase thru the filler pipe on the governor side rear crankcase door on the engine.

1. Initial Fill

When the system is being filled for the first time, oil should be added until the level reaches the "FULL ENGINE" mark on the "ENGINE STOPPED" side of the dip stick. After the engine has been run and the oil distributed thru the system, the level should be at "FULL ENGINE" mark.

2. Adding Oil

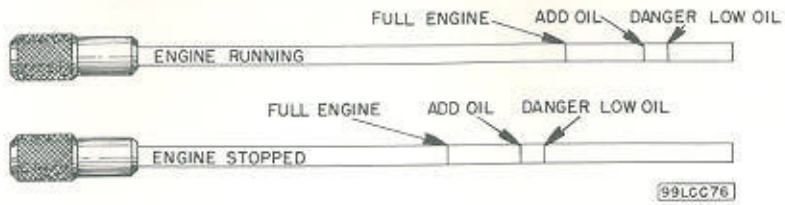
Lubricating oil need not be added until the oil level has reached the "ADD OIL" mark. Oil should then be added until the level reaches the "FULL ENGINE" mark on the dip stick, depending on whether the engine is stopped or running.

DRAINING SYSTEM AND CHANGING OIL

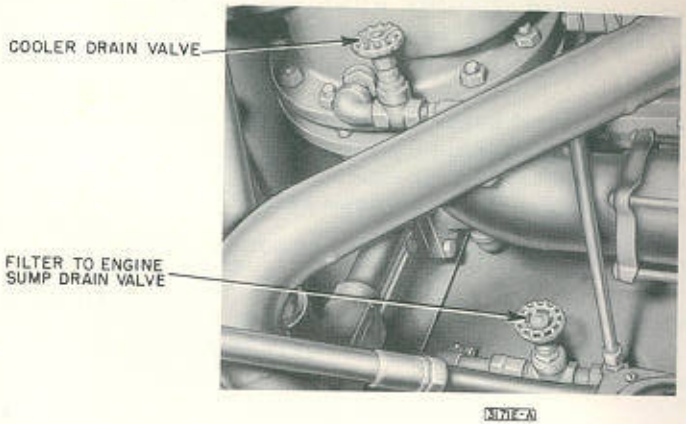
The system is drained from the bottom of the engine crankcase thru the drain pipe at the pump end of the engine. The drain is equipped with a valve and pipe cap at the end.

To change lubricating oil, proceed as follows:

1. Open drain valves at oil filter and cooler. Filter and cooler will drain into the crankcase.
2. Remove pipe cap on end of system drain pipe on outside of locomotive.



Illus. 2. Lubricating Oil Dip Stick



Illus. 3. Filter and Cooler Drain Valves

3. Open crankcase drain valve on outside of locomotive.
4. When oil flow stops, close crankcase and filter and cooler drain valves and replace the pipe cap on the end of the drain pipe.
5. Renew filter elements and clean strainer.
6. Refill system to "FULL ENGINE" mark on the "ENGINE STOPPED" side of the dip stick.
7. Start engine, allowing oil to circulate and fill system.
8. Stop engine. Allow oil to settle in crankcase and take level reading on bayonet gage.
9. If necessary, add enough lubricating oil to bring the oil level back up to "FULL ENGINE" mark.

DRAINING OIL FILTER AND STRAINER

To service the multi-element oil filter, a drain valve is provided to drain the filter into the crankcase (Illus. 3).

The strainer is equipped with drain valve and capped drain line leading to the outside of the unit.

CAUSES OF LOW LUBRICATING OIL PRESSURE

1. Filter or cooler drain valve open, by-passing oil back to the crankcase.
2. Insufficient oil.
3. Dirty strainer or cooler.
4. Oil diluted by fuel oil or water.
5. Line broken.
6. Pump defective.
7. Cooling water above 195° F.

SECTION 118A. COOLING SYSTEM - LOW PRESSURE

GENERAL DESCRIPTION

A single cooling water system is utilized with one engine-driven centrifugal pump circulating water thru the engine, radiators, and lubricating oil cooler.

The single engine driven water pump forces the water into the engine and then to the radiators. After being cooled by the air circulated thru the radiators by the radiator cooling fans, the water flows thru the lubricating oil cooler and returns to the pump suction. A constant head is maintained on the system by the line to the overhead expansion tank.

Air for cooling the radiators enters thru shutters on both sides of the radiator end of the locomotive. The air is drawn thru the radiators and expelled thru the roof by alternating current motor driven fans mounted in the top of the radiator compartment. Three fans are used on 1600 hp units and four fans on 2400 hp units.

Below each fan is a small set of shutters operated by air flow, designed to close when the fan is not operating to prevent reverse fan operation.

TEMPERATURE CONTROL SYSTEM

The temperature control equipment is shown in Illus. 1 and 3.

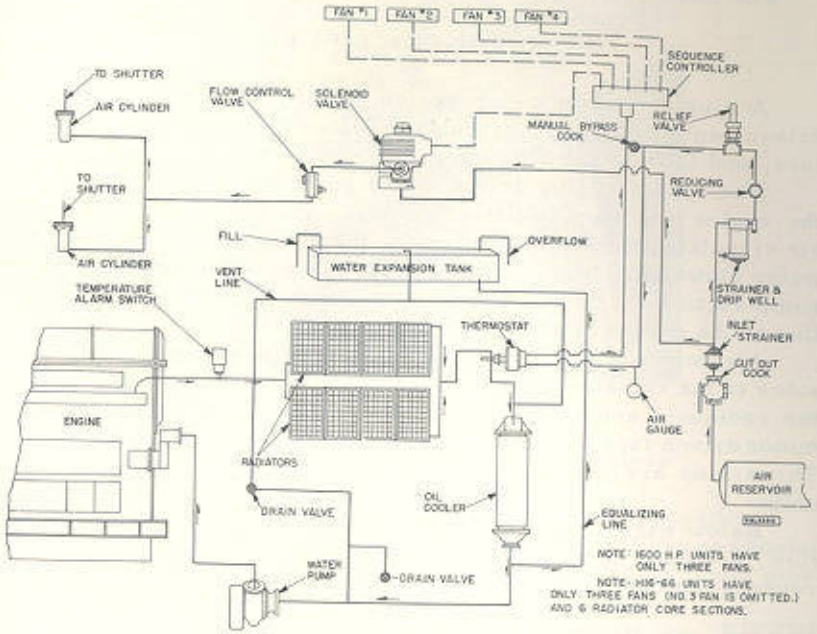
Main reservoir air at a pressure of 140 lbs. is fed thru a shutoff cock and filter to a reducing valve where the pressure is reduced to 17 lbs. From the reducing valve, the air continues thru a relief valve, set at 19 lbs., to the thermostat. (See Illus. 3, Page 4.)

The temperature sensitive element of the thermostat is mounted in the cooling water piping. The pressure of the air fed to the thermostat is 17 lbs.; however, the pressure of the air leaving the thermostat is dependent upon the temperature of the water at the point where the thermostat temperature sensitive element is immersed. The pressure of the air leaving the thermostat will vary from 0 to 17 lbs. With a cold engine, the air pressure leaving the thermostat is 0 lbs.

This air pressure is fed to the step controller where it rotates a camshaft to make the electric contacts close in sequence.

The manual control cutout cock (Illus. 1 and 3) when opened will by-pass the thermostat and is for use in event of thermostat failure. Normally this cock is closed.

The cooling fan motors are electrically connected to the alternator by contactors (Illus. 2) located in the cooling hatch. Refer to the arrangement diagram. The fan contactors are energized by electric contacts in the step controller (Illus. 4) located on the



Illus. 1. Cooling Water System Schematic Piping and Control Diagram

bulkhead at the pump end of the engine. An additional contact operates the shutter magnet valve, controlling air at main reservoir pressure to the two shutter operating cylinders. There is a shutoff cock in the air line to the magnet valve.

The thermostat, which is mounted with its temperature sensitive element in the cooling water line, is set to increase the air pressure to the step controller as the temperature of the cooling water increases. As the water temperature rises above the temperature at which the thermostat is set, the air pressure to the pneumatic step controller gradually increases from 0 lbs. to 17 lbs. At 4 lbs., switch No. 1 of the step controller closes an electrical circuit to energize a solenoid valve which opens the shutters. As the branch line air pressure increases to 17 lbs., the contacts of the four other cam-closed switches close in order of their air pressure settings and operate fan contactors to start the cooling fans in sequence, according to the following table:

Step Controller Switch No.	* Approx. Temp. °F.	Close R-W Circuit Pressure Lbs.	Action With R-W Circuit
1	153-158	4	Opens Shutters
2	156-161	6	Starts No. 1 fan
3	159-164	8	Starts No. 2 fan
4	162-167	11	Starts No. 3 fan
5	165-170	13	Starts No. 4 fan

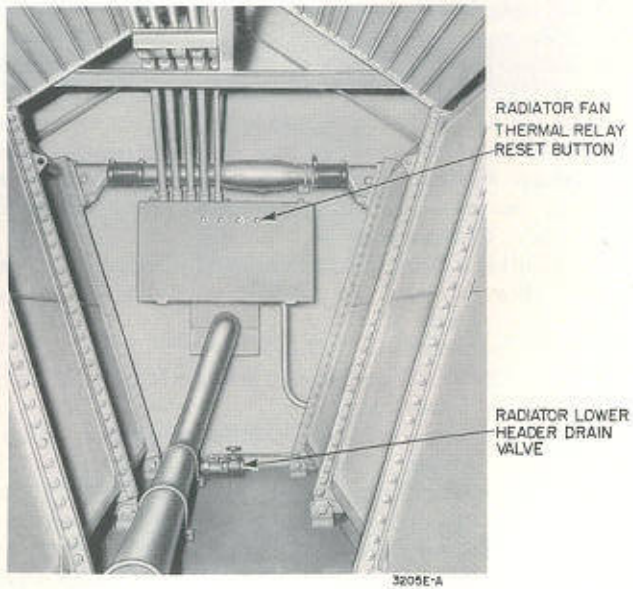
* Water out of engine.

NOTE: 1) 1600 hp units use only three fans, three contactors and four controller contacts. Number 4 switch is omitted.

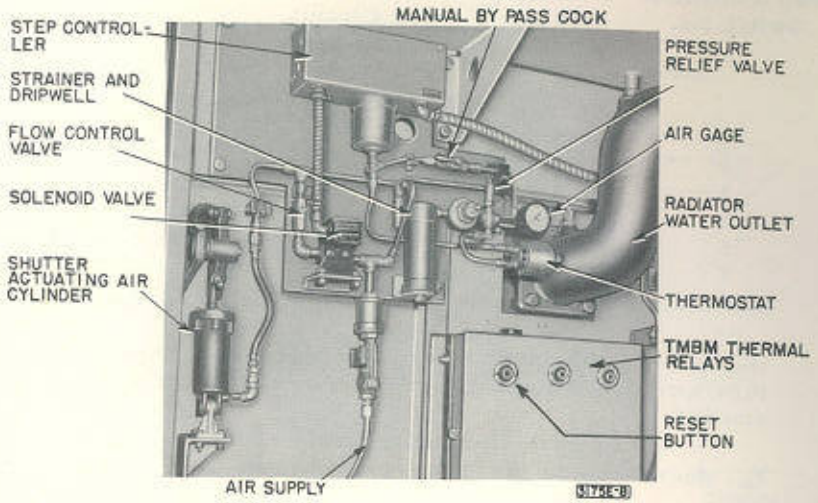
2) Normal idling water temperature is 150° to 155° F., decreasing to 140° in cold weather.

Normal full load water temperature is 160° to 170° F. up to 80° F. outside, increasing to 185° F. at 110° outside.

The hot engine alarm is set to operate in the 195° to 205° F. range.



Illus. 2. Fan Motor A.C. Contactor



Illus. 3. Cooling Control Equipment

HOT ENGINE ALARM SWITCH

This switch is located on the engine water outlet manifold and is directly connected to a water thermal switch. If the water outlet temperature exceeds the 195° - 205° F. range, the switch closes to light the hot engine alarm light (only on unit affected) and ring the alarm bells on all units. If alarm comes on, check for cause and, if necessary, cool engine down by reducing throttle or isolation switch. Do not shut engine down as this will momentarily increase the temperature due to lack of cooling water circulation. Causes may be:

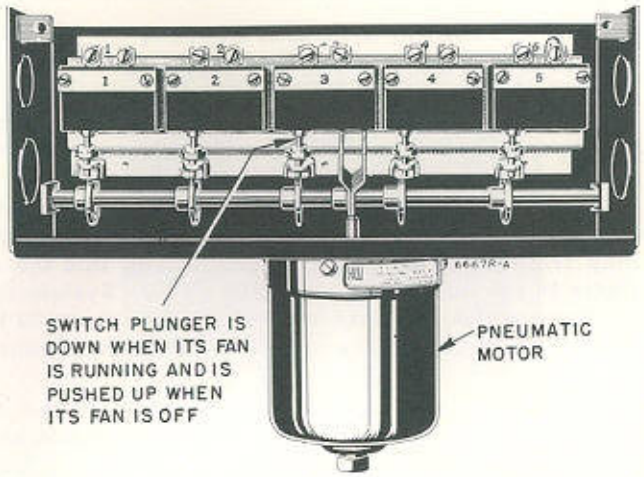
1. Shutters stuck or closed. Reducing valve inoperative magnet valve sticking or shutoff cock in main reservoir line closed, Illus. 1 and 3.
2. Fan not running. Check for:

a. Thermal overload relays tripped, Illus. 2. Push in reset button to reset relay.

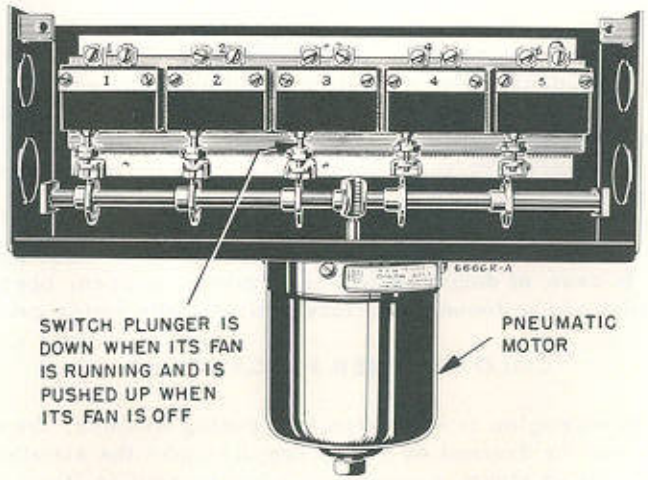
b. Leakage in 17 lb. control air lines. Be sure reducing valve is adjusted for 17 lbs. at the air gage.

c. Defective thermostat. Open manual control cutout cock in the 17 lb. line which is designed to cause the shutters to open and all fans to operate.

d. Defective step controller. If necessary, pull pin connecting the air piston to the camshaft, Illus. 4, and rotate the camshaft by hand to the limit of its travel so that all plungers



Step Controller with Switches Closed
(Shutters open and all fans running)



Step Controller with Switches 1, 2, and 3 Closed
(Shutters open and fans 1 and 2 running)

Illus. 4. Step Controller

are down. This will energize all fan contactors and all fans will run.

3. Engine water level low (Illus. 3, Sec. 104A).
4. Defective water pump.
5. Restricted water circulation.
6. Scale deposits in water system causing poor heat transfer.

FILLING COOLING SYSTEM

1. A sight glass on the water expansion tank indicates water level. A low-level red line indicates minimum level on the sight glass. An engine should never be operated with no water showing in the glass.

2. Filling is thru a filler pipe located one on each side of the locomotive, or thru the roof water treatment fill in an emergency. When filling from the side, water should be run into the system until it starts to run out the opposite filler pipe. System capacity is 210 gal. for the 1600 hp unit, and 250 gal. for the 2400 hp unit. Be sure the drain valve for the engine water tank is closed before filling.

3. After filling an empty system, run engine for several minutes to eliminate air pockets; then shut down engine and after five minutes add more water if needed.

4. CAUTION: If a hot engine is drained, never refill with cold water. Doing so may cause cylinder liners to crack.

DRAINING COOLING SYSTEM

1. Open drain valves located at pump end of engine. These valves will drain engine, oil cooler, engine water tank and cab heater return line.

2. Open drain valve in the line from engine to heater and the valve between the return and feed lines.

3. Open water treatment tank drain valves (Illus. 5).

4. Remove drain plug from bottom of engine water pump.

5. In case of doubt as to which valves to open, open every valve which can be found on the locomotive. Only water can drain.

COLD WEATHER PRECAUTIONS

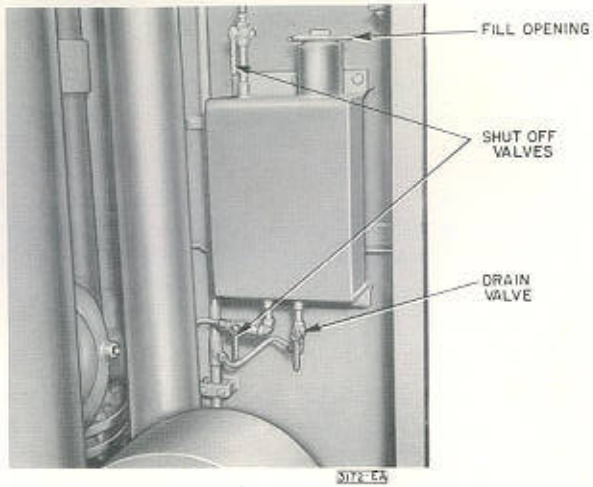
When an engine is shut down in freezing weather, the cooling system must be drained or steam supplied thru the standby lines. The locomotive steam connection is designated in Illus. 1, Sec. 131A. To admit steam to the cooling system:

1. Open valve in steamline to engine water jacket and pump. Valve is located at the pump end of the engine.

2. Open valves in water line to the cab heaters. Always have water on at the same time as live steam alone will melt the heater elements.

CAUTION: Do not admit steam to the cooling system when the engine is running. Otherwise engine will overheat.

Avoid boiling the water in the system. Any water treatment compound lost should be replaced.



Illus. 5. Water Treatment Tank

SECTION 120A. VAPOR HEATING CORP. STEAM GENERATORS

The instructions contained in this book are for the guidance of personnel engaged in the operation of OK series steam generators with standby operation provided.

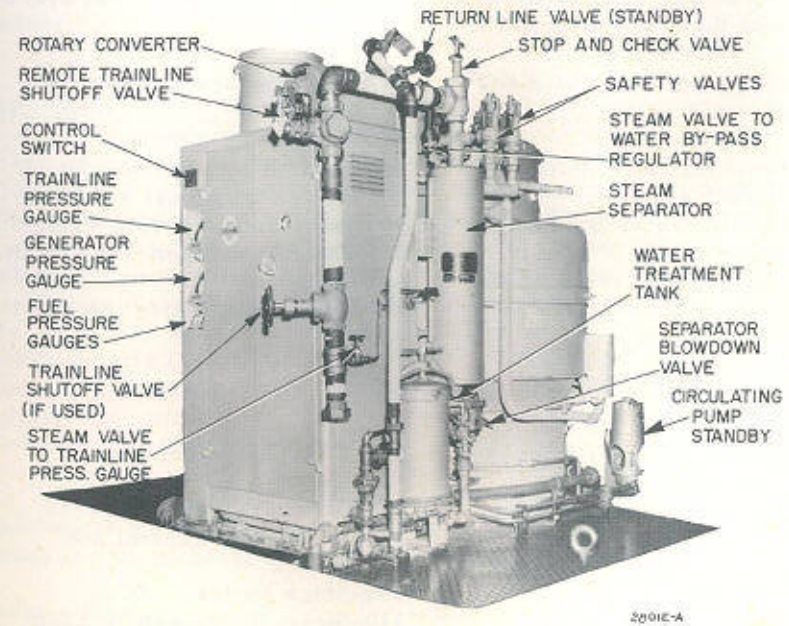
The symbol number after each device mentioned in the test refers to the piping schematic chart.

The chart shows the various controls and devices on the OK series of steam generators and outlines the flow of fuel, water, and steam.

Description

Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

The steam generating part of the unit consists of five sets of coiled water tubing, nested and connected in series to form a single tube several hundred feet long. Water is pumped into the coil inlet and converted to steam as it progresses thru the coils. Heat is furnished by the combustion of diesel fuel oil, which is sprayed



Illus. 1. Steam Generator (Type OK-4740 shown)

KEY TO IDENTIFICATION SYMBOL VALVES

Valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle. These designations apply only to the OK series steam generators.

The following valves must be OPEN during normal operation of the steam generator:

1-Atomizing Air Shut-off Valve
3-Coil Shutoff Valve
7-Remote Control Trainline Shutoff Valve
7a-Reset Lever
9-Return Water Outlet Valve
11-Steam Admission Valve to Trainline Pressure Gage
13-Steam Admission Valve to Water By-Pass Regulator
15-Stop and Check Valve (Closed during start or shut down procedure)
17-Three-way Washout Valve
19-Water By-Pass Regulator Shutoff Valve
21-Water Supply Stop Valve

The following valves must be CLOSED during normal operation of the steam generator.

2-Coil Blowdown Valve and Switch
4-Fill-Test Valve
6-Layover Connection Shutoff Valve
8-Manual Water By-Pass Valve
10-Steam Admission Valve to Radiation (Open in cold weather)
12-Steam Separator Blowdown Valve
14-Washout Inlet Valve
16-Washout Inlet Valve
19-Water Pump Test Valve
20-Water Suction Drain Valve
22-Water Treatment Tank Drain Valve
56-Return Line Valve (Standby)

CONTROLS

100-Atomizing Air Pressure Regulator
101-Atomizing Air Switch
102-Control Switch
103-Fuel Pressure Regulator 150#
104-Fuel Solenoid Valve
105-Fuel Spray Head
106-Overload Reset Button (Motor)
107-Safety Valves
108-Servo-fuel Control and Switch
109-Stack Switch
110-Steam Temperature Limit Control

The text will point out the differences in operation where they exist.

Description

Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

The steam generating part of the unit consists of three sets of coiled water tubing, nested and connected in series to form a single tube several hundred feet long. Water is pumped into the coil inlet and converted to steam as it progresses through the coils. Heat is furnished by the combustion of diesel fuel oil, which is sprayed by compressed air through the atomizing nozzle in the fuel spray head-105 into the firepot above the coils. Here the fine oil spray mixes with air supplied by the blower-202, and is ignited by a continuous electric spark-220. The fire and hot gases flow, first downward, then outward through the nest of coils.

The supply of fuel is regulated to evaporate 90% to 95% of the water pumped through the coils. The excess water flushes scale and sludge from the coils and is carried over with the steam into the steam separator-221, where the water and sludge are removed before the steam flows into the trainline.

The excess water collects in the bottom of the steam separator. Water above the level of the return outlet flows out through a steam trap-223 and through the heat exchanger-213, where it gives up its heat to the incoming feed water. From the heat exchanger the return water flows back to the water supply tank-232. The motor converter-215 drives the blower-202, water pump-230, and fuel pump-209 at a constant speed. The water by-pass regulator-111 automatically controls the steam generator output by regulating the amount of water fed to the coils. Before entering the coils, the water passes through the servo-fuel control-108, which admits fuel to the spray nozzle in direct proportion to the amount of water entering the coils. The servo-fuel control also adjusts the damper-203 to admit the proper amount of air for efficient combustion of the fuel.

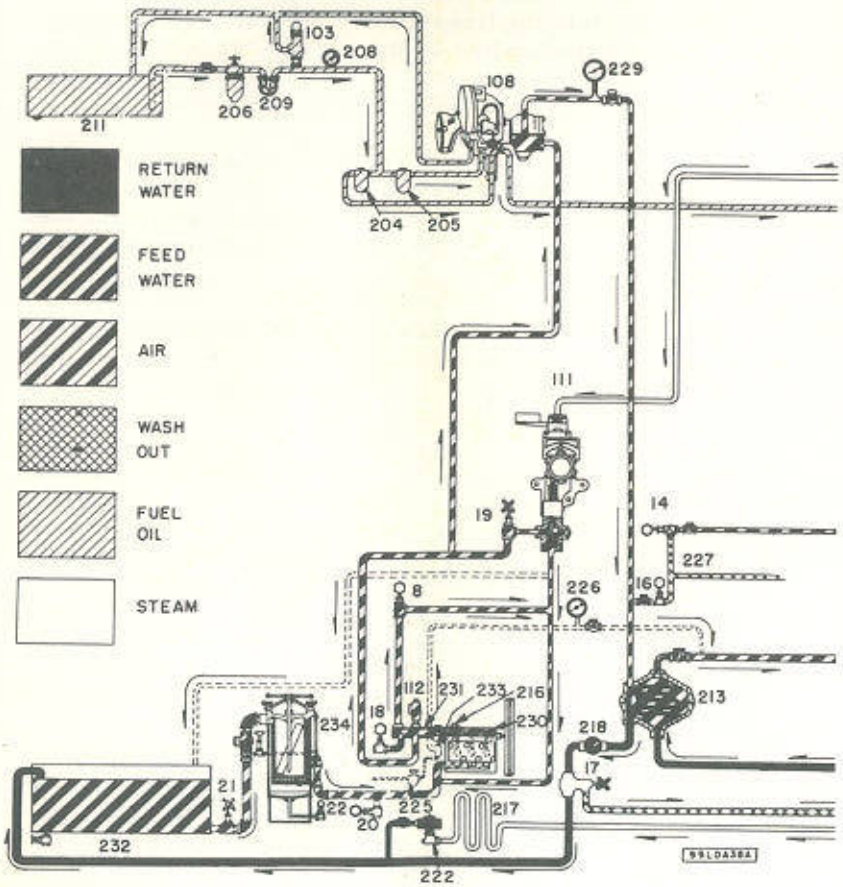
The trainline steam pressure is regulated by adjusting the handwheel on the water by-pass regulator-111. The length of train and the weather conditions determine the setting.

Before Starting

On OK models, the valves designated by odd numbers must

KEY TO IDENTIFICATION SYMBOL VALVES

Valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle. These designations apply only to the OK series steam generators.



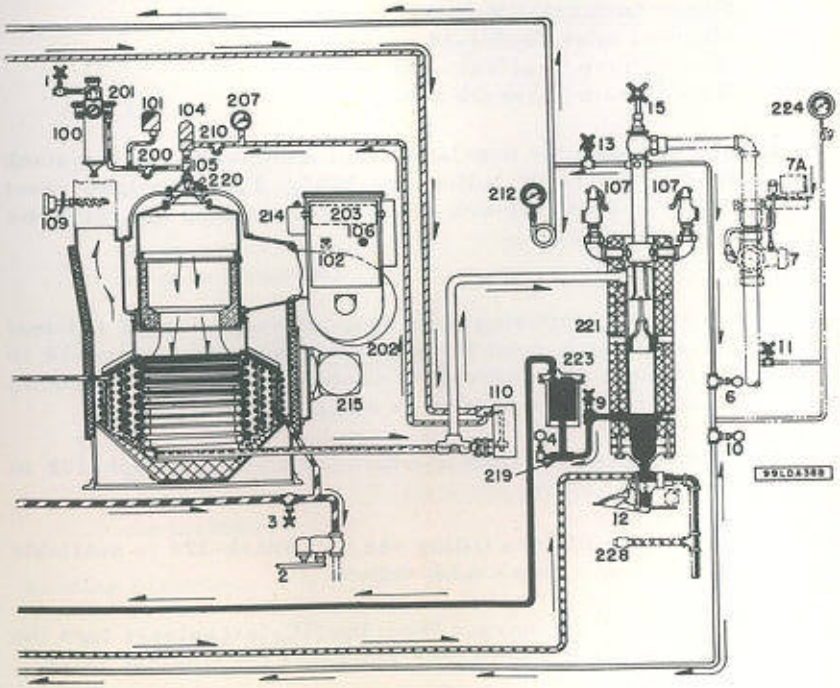
Illus. A2. Steam Generator Schematic Diagram

The following valves must be OPEN during normal operation of the steam generator:

1-Atomizing Air Shut-off Valve
3-Coil Shut-off Valve
7-Remote Control Trainline Shut-off Valve
7a-Reset Lever
9-Return Water Outlet Valve
11-Steam Admission Valve to Trainline Pressure Gage
13-Steam Admission Valve to Water By-Pass Regulator
15-Stop and Check Valve (Closed during start or shut down procedure)
17-Three-way Washout Valve
19-Water By-Pass Regulator Shut-off Valve
21-Water Supply Stop Valve

The following valves must be CLOSED during normal operation of the steam generator:

2-Coil Blowdown Valve and Switch
4-Fill-Test Valve
12-Steam Separator Blowdown Valve
14-Washout Inlet Valve



- Vapor-Clarkson Steam Generator

6-Layover Connection Shut-off Valve
8-Manual Water By-Pass Valve
10-Steam Admission Valve to Radiation (Open in cold weather)
16-Washout Inlet Valve
18-Water Pump Test Valve
20-Water Suction Drain Valve
22-Water Treatment Tank Drain Valve

CONTROLS

100-Atomizing Air Pressure Regulator
101-Atomizing Air Switch
102-Control Switch
103-Fuel Pressure Regulator
104-Fuel Solenoid Valve
105-Fuel Spray Head
106-Overload Reset Button Motor
107-Safety Valves
108-Servo-Fuel Control and Switch
109-Stack Switch
110-Steam Temperature Limit Control
111-Water By-Pass Regulator and Switch
112-Water Pressure Relief Valve

AUXILIARY CONTROLS

200-Atomizing Air Strainer
201-Atomizing Air Pressure Gage
202-Blower
203-Damper
204-Fuel Filter (Fuel pressure line)
205-Fuel Filter (Servo actuating line)
206-Fuel Filter (Suction line)
207-Fuel Nozzle Pressure Gage
208-Fuel Pressure Gage (At fuel pressure regulator)
209-Fuel Pump
210-Fuel Strainer
211-Fuel Tank
212-Generator Steam Pressure Gage
213-Heat Exchanger
214-Ignition Transformer
215-Motor Converter
216-Oil Filter Cap
217-Radiation
218-Return Water Flow Indicator
219-Return Water Strainer
220-Spark Plugs
221-Steam Separator
222-Steam Trap (Radiation)
223-Steam Trap (Return water line)
224-Trainline Steam Pressure Gage
225-Treatment Injector Filter
226-Treatment Injector Gage
227-Washout Solution Inlet
228-Washout Solution Outlet
229-Water Pressure Gage
230-Water Pump
231-Water Strainer Manifold
232-Water Tank
233-Water Treatment Injector Pump
234-Water Treatment Tank (Strainer tank only if injector system is used.)

be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle. These designations apply only to the OK series steam generators.

1. Make certain that the following valves are OPEN:
   Atomizing Air Shut-off Valve-1
   Coil Shut-off Valve-3
   Return Water Outlet Valve-9
   Steam Admission Valve-11 to Trainline Pressure Gage-224
   Steam Admission Valve-13 to Water By-Pass Regulator-111
   Three-Way Washout Valve-17
   Water By-Pass Regulator Shut-off Valve-19
   Water Supply Stop Valve-21

2. Be sure that the following valves are CLOSED:
   Coil Blowdown Valve-2
   Layover Connection Shut-off Valve-6
   Manual Water By-Pass Valve-8
   Steam Admission Valve-10 to Radiation-217
   Washout Inlet Valves-14 and 16
   Water Pump Test Valve-18
   Water Drain Valve-20 and 22

3. See that both the overload reset button-106 and the stack switch-109 reset button are "in". The overload reset button is located inside the control panel on the magnetic overload relay.

To Fill

1. Open the atomizing air shut-off valve-1 and fill-test valve-4; latch open the separator blowdown valve-12 to drain the steam separator. Close the separator blowdown valve when the separator is completely drained.

2. Close the main switch and turn the control switch-102 to FILL.

3. While the coils are filling see that spark-220 is available for ignition. Check ALL valves.

4. When water discharges from the fill-test valve-4 turn the control switch-102 to OFF and close the fill-test valve.

NOTE: If the coils are empty it will take about five minutes to fill the steam generator with water.

To Start

CAUTION: DO NOT START THE STEAM GENERATOR UNLESS THE COILS ARE FILLED.

1. Latch open the separator blowdown valve-12 and turn the control switch-102 to RUN. (For easy starting, be sure the control switch has been OFF long enough for the motor to come to a full stop.)

2. Close the separator blowdown valve when the generator steam pressure gage-212 registers 50 lbs.

3. Open the separator blowdown valve several times for three to five second intervals during the first few minutes of operation.

4. Set the water by-pass regulator-111 to the required train line pressure.

5. After the trainline is coupled, open the remote control trainline shut-off valve-7 by depressing the reset lever-7a. Then open the stop and check valve-15.

NOTES:

1. Check the return water flow after the steam generator has settled down to a steady output. On 3000 lb. units the return water flow indicator-218 should cycle from 4 to 12 times a minute; on 1600 lb. units it should cycle from 4 to 8 times a minute.

2. If the steam generator does not start or function properly, check all valves to see that they are open or closed as indicated on page 4.

3. The steam generator should come up to full operating pressure in one or two minutes; it may take 10 to 15 minutes to build up the required operating steam pressure in the trainline.

Running Attention

1. Open the separator blowdown valve-12 for five seconds at least once every hour.

2. Turn the handle on the fuel filter-206 during stops. At the

same time, turn the handle on the treatment injector filter-225, where this method of water treatment is used.

To Shut Down the Steam Generator

For short stops it is only necessary to close the stop and check valve-15. The fire will cycle and maintain operating pressure in the steam generator. For terminal stops, proceed as follows:

1. Close the stop and check valve-15 and the remote control trainline shut-off valve-7.

2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gage-212 registers 200 lbs. turn the control switch-102 to OFF.

3. Open the coil blowdown valve-2. When the generator pressure drops to 75 lbs. close the valve.

4. Open the separator blowdown valve-12 and blow down the steam separator-221 with the remaining pressure. Close the separator blowdown valve.

5. Fill the coils with water.

6. Close the atomizing air shut-off valve-1 and open the main switch.

NOTE: When starting, do not omit draining the steam separator, opening the fill-test valve, and again filling the steam generator with water. If the coils are already full, it will only take a moment for water to discharge from the fill-test valve.

Freezing Weather Precautions

The inlet valve-10 to the radiation-217 should be opened when operating during severe weather.

If a locomotive with a multiple installation does not have all of its steam generators in operation, open the coil blowdown valve-2, the layover connection shut-off valve-6 and the inlet valve-10 to the radiation on idle steam generators.

CAUTION: LAYOVER CONNECTION SHUT-OFF VALVE-6 MUST BE CLOSED WHEN TRAINLINE SHUT-OFF VALVE-7 IS CLOSED TO CUT A CAR OUT OF A TRAIN.

If a locomotive is left standing out of service, operate one of the steam generators or make a connection to the yard steam line. In extremely cold weather the water pump-230 and steam generator controls should be given additional protection against freezing.

If no steam at all is available, thoroughly drain the steam generator. Open the drain valves-20 and 22, the water pump test valve-18, the coil blowdown valve-2, the separator blowdown valve-12 and the coil shut-off valve-3. Break the pipe connections where necessary to completely drain the piping. Turn the water pump by hand to clear it of water, or blow it out with compressed air. Remove the cover of the water treatment or water strainer tank-234 and make sure it is drained.

Trouble Shooting

If one of the protective switches (magnetic overload relay, coil blowdown valve switch, stack switch high temperature contacts or low temperature contacts) operates to shut down the steam generator, the alarm will ring and the "boiler off" signal will flash on the remote control panel.

Turn the control switch-102 to OFF and use the following instructions as a guide in locating the trouble.

Motor and Burner Shut Down During Operation

1. Blown fuses: The alarm will not ring and the instrument lights will go out. The main fuse (or circuit breaker) is generally located in the low voltage cabinet of the locomotive. Check this fuse, and check the control fuses in the steam generator control cabinet. The OK series of steam generators has a test lamp and fuse clips wired inside the control cabinet. Use this fuse test clip and test lamp to check the fuses.

2. Overload reset button 106 "out": The alarm will ring; the instrument lights will remain on. Turn the control switch-102 OFF; check for hot blower-202 or water pump-230 bearings. Push the overload reset button "in".

3. Stack switch-109 reset button "out": The high temperature contacts in the stack switch are open; the alarm will ring and the instrument lights will remain on. Turn the control switch-102 to OFF; open the separator blowdown valve-12 and drain the steam separator-221. Close the

separator blowdown valve, push in the stack switch reset button, refill the coils with water, and then start the steam generator.

4. Coil blowdown valve-2 partially open: The alarm will ring, the instrument lights will remain on. Be sure the locking pin on the coil blowdown valve handle is properly seated in the closed position.

Motor Starts but Burner Does Not

If the fire fails to light, the low temperature contacts on the stack switch-109 will not close, and after a 45 second time delay the out-fire relay will open the circuit to shut down the steam generator. The alarm will ring and the instrument lights will remain on. Turn the control switch-102 OFF and check the following list for possible causes for the burner failure.

1. Ignition failure: Turn control switch to RUN - no spark visible through the peep hole glass, or spark is of low intensity. If an ignition fuse is blown or if the current flow is broken for any other reason, the ammeter in the ignition circuit on OK units registers zero when the ammeter test button is pressed in. If the ammeter registers below normal, the spark plug electrodes are dirty or too far apart. If the ammeter registers above normal the electrodes are too close together, or the ignition circuit is grounded.

   Check the ignition fuses - on OK units use the test lamp and clips installed in the control cabinet for that purpose. Tighten loose cable connections and replace chafed or broken wire which may be breaking or grounding the circuit.

2. Low atomizing air pressure-201: The air switch-101 on OK units opens and breaks the circuit to the fuel solenoid valve 104, which then stops the flow of fuel to the sprayhead-105. On DSK units, low air pressure will fail to lift the diaphragm in the fuel sprayhead-105; the needle valve remains closed and prevents the admission of fuel to the firepot.

   Be sure the air admission valve is fully open. Clean the strainer screen in the atomizing air line and drain the atomizing air pressure regulator-100. If the low atomizing air pressure persists, tighten the adjusting screw at the top of the air pressure regulator to increase the

atomizing pressure.

3. Low fuel manifold pressure-208: Turn the handle on the suction line fuel filter-206 several times. A slight suction leak may cause the manifold pressure to build up slowly; put the control switch-102 on FILL to bleed the fuel line and bring the manifold pressure up to normal.

4. Low fuel nozzle pressure-207: Lack of water causes the servo-fuel control-108 to limit the supply of fuel entering the nozzle. (If the water supply is almost completely stopped, the cam plate may come down far enough to actuate the cut-out switch on the servo and close the fuel solenoid valve-104.)

Be sure that the water pump test valve-18 is closed, the cover on the water treatment or strainer tank-234 is tight, the three-way washout valve-17 is fully open, and that the drain valves-20 and 22 are tightly closed.

Open and close the water by-pass regulator-111 adjusting handle several times to free the regulator from possible sediment. If the water pressure gage-229 still registers low, close the water by-pass regulator shut-off valve-19. This closes the water by-pass line and permits all of the feed water to flow to the servo-fuel control-108; the steam generator will start at once if the by-pass regulator is causing the trouble. Set and manually regulate the trainline steam pressure by adjusting the manual water by-pass valve-8.

High feed water temperature or leaky water line connections may cause the water pump-230 to become air or vapor bound. Violent fluctuation of the water pressure gage needle indicates this condition. Tighten leaky water line connections and bleed the line by opening the water pump test valve-18. Allow water to flow from this valve until no air or vapor bubbles are evident in the water.

Irregular Trainline Pressure

1. Burner cycles off and on: Insufficient water delivery causes the steam generator to run in superheat; the steam temperature limit control-110 operates to protect the coils against overheating. Check the water pump output as instructed in the preceding paragraphs.

2. Safety valves blow: Shut down the steam generator. Lower the trainline pressure setting on the adjusting handle

of the water by-pass regulator-111 and start the steam generator again. If the safety valves-107 continue to pop, close the water by-pass regulator shut-off valve-19, and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

Items to Report

1. Water pressure greater than 450 pounds at any time.
2. Excessive stack temperature.
3. Fluctuation of the fuel manifold pressure.
4. Frequent cycling of the burner.
5. Water flow indicator not cycling.
6. Water by-pass regulator inoperative.
7. Faulty operation of the steam generator for any reason.

2400 H. P. TRAIN MASTER UNITS

TRAIN HEATING SYSTEM SUPPLEMENT

Steam Generator

Detailed information covering the steam generator is given beginning on page 1.

Water Storage

Water capacity is provided in a 1000 gal. tank under the steam generator and in a 1400 gal. tank under the radiator compartment.

A 4-inch equalizing line is provided between tanks. Total water capacity is 2400 gallons.

A system drain and valve is provided on the 4-inch equalizing line draining outside the rail.

Plugs are provided in each tank for flushing and cleaning. Steam generator suction is taken off the 4-inch equalizing line ahead of the cab, and bypass water is piped to the 1400 gal. tank.

Filling System

Filler pipes, one on each side of the locomotive, are equipped with 2-1/2" male coupling connections which provide a rapid means of filling the system. Fill from either side until water runs out the overflow pipes. Each water tank has an overflow.

Treatment Tank and Water Treatment

The treatment tank for this system is the one between the steam generator and the separator. Treatment compound is added by removing the top cover. The type and amount of water treatment required is determined by the water conditions encountered in service.

Standby Heating

During freezing weather, steam from the steam generator or an outside source, connected to the steam trainline can be admitted. (DO NOT ADMIT STEAM UNLESS UNIT IS SHUT DOWN, except for the sanitary water tank.) With the engine running, steam entering the steam generator water tanks will cause the water to get too hot for the generator water pump to pick it up,

and steam into the cooling system and cab heaters can cause an over-heated engine. Steam can be admitted as follows:

1. For the engine cooling system and cab heaters by opening the steam valves as described under that section.

2. For the steam generator water supply by opening the steam valves on the floor to the left of the steam generator for the rear tank, and ahead of the left sponson tank for both sponson tanks.

3. For the sanitary water tank by opening the steam valve at the rear right of the unit.

If outside steam is used, be sure the trainline or standby steam valves are open and the steam generator stop-and-check valve is open. A 1" standby steam inlet and valve to the steam line is located at the left rear of the unit.

* SECTION 125A. QUESTIONS AND ANSWERS

Group 1a - Transition - General

Q. Is transition automatic or manual?
A. Transition if fully automatic. There is no provision for manual transition, except selector positions 1-2-3-4 for controlling any trailing units of other manufacture requiring manual transition.

Q. What is the "Automatic - Series" transition toggle switch for?
A. When in "Series" position, operation is limited to the first three transition steps for heavy drag operation.

Group 1b - Transition Sequence - 1600 hp General Service Units

Q. What power contactors are closed in the four steps of transition?
A.

Step	Connection	Power Contactors Closed
1	3 Series 2 Parallel; No Shunting	S1, S2
2	3 Series, 2 Parallel; First Shunt	S1, S2; M1, M2, M3, M4
3	2 Series, 3 Parallel; No Shunting	P1, P2, P3
4	2 Series, 3 Parallel; First Shunt	P1, P2, P3; M1, M2, M3, M4
5	2 Series 3 Parallel; Second Shunt	P1, P2, P3; M1, M2, M3, M4, M5, M6, M7, M8

Q. Must the throttle be in the 7th or 8th notch to make transition?
A. No. Transition is a function of locomotive speed and will take place at a particular MPH regardless of throttle position.

* All illustrations referred to in this section are located in Sec. 101A unless otherwise indicated.

Q. At what approximate MPH do the various steps of transition take place?

A. Gear Ratio 15:68

Minimum Continuous MPH	6
Transition 1 to 2	14
Transition 2 to 3	22
Transition 3 to 4	26
Transition 4 to 5	40
Maximum Locomotive MPH	65

Q. What sequence occurs in each step of transition?

A.

Step	Forward Sequence
1 to 2	Contact FS1 in Speed Shunter (upon a signal from the axle generator) closes to energize shunting contactors M1, M2, M3, and M4.
2 to 3	1. Similarly, shunter contact TR closes, starting rotation of Cam Controller. 2. Cam Controller contact RV opens to de-energize contactor RVT reducing power for this step of transition. 3. Continued rotation of Cam Controller closes contact S1B, energizing relay TCR which re-calibrates shunting circuits for use again in parallel (2S3P). 4. Continued rotation of Cam Controller opens cam contact MS which in turn opens circuit to Speed Shunter contacts FS1, FS2, and FS3. This de-energizes shunting contactors M1 to M4. 5. Continued rotation of Cam Controller closes cam contact PL, picking up power contactors P1 and P2. This temporarily isolates traction Motors 3 and 4. Traction motors 1-2 and 5-6 are now across the generator in series-parallel. 6. Continued rotation of Cam Controller opens cam contact SER, dropping power contactors S1 and S2. 7. Continued rotation of Cam Controller closes cam contact PL3, picking up power contactor P3. Traction motors 1-2, 3-4, and 5-6 are now across the generator in series-parallel. 8. Continued rotation of Cam Controller closes contact RV which energizes contactor RVT restoring full power to main generator. 9. Continued rotation of Cam Controller closes cam contact MS, so shunting circuits can operate again.
3 to 4	Contact FS1 in Speed Shunter closes to energize motor shunting contactors M1, M2, M3, and M4 again.
4 to 5	Contact FS2 in Speed Shunter closes to energize motor shunting contactors M5, M6, M7, and M8.

Step	Backward Sequence
5 to 4	Contact FS2 opens dropping M5, M6, M7, and M8.
4 to 3	Contact FS1 opens dropping M1, M2, M3, and M4.
3 to 2	1. Speed Shunter contact TR opens to start reverse rotation of Cam Controller. 2. Cam Controller contact MS opens to disconnect shunting circuits. 3. Cam Controller contact RV opens to de-energize contactor RVT, reducing main generator voltage. 4. Cam Controller contact S1B opens to de-energize relay TCR, recalibrating shunting circuits for use again in series operation (3S2P). 5. Continued rotation of Cam Controller opens cam contact PL3, dropping power contactor P3. 6. Continued rotation of Cam Controller closes cam contact SER, picking up power contactors S1 and S2. 7. Continued rotation of Cam Controller opens cam contact PL, dropping power contactors P1 and P2. 8. Continued rotation of Cam Controller closes cam contact RV, closing contactor RVT and restoring full generator power. 9. Continued rotation of Cam Controller closes cam contact MS so shunting circuits can again operate. 10. Speed Shunter contact FS1 closes again to pick up motor shunting contactors M1 thru M4.
2 to 1	FS1 opens to drop M1, M2, M3, and M4.

Group 1c - Transition Sequence
2400 hp Train Master Units

Q. What power contactors are closed in the seven steps of transition?

Step	Connection	Power Contactors Closed
1	3 Series, 2 Parallel; No Shunting	S1, S2
2	3 Series, 2 Parallel; First Shunt	S1, S2; M1, M2, M3, M4
3	3 Series, 2 Parallel; Second Shunt	S1, S2; M1, M2, M3, M4, M5, M6, M7, M8
4	2 Series, 3 Parallel; No Shunting	P1, P2, P3
5	2 Series, 3 Parallel; First Shunt	P1, P2, P3; M1, M2, M3, M4
6	2 Series, 3 Parallel; Second Shunt	P1, P2, P3; M1, M2, M3, M4, M5, M6, M7, M8
7	2 Series, 3 Parallel; Third Shunt	P1, P2, P3; M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12

Q. Must the throttle be in the 7th or 8th notch to make transition?
A. No. Transition is a function of locomotive speed and will take place at a particular MPH regardless of throttle position.

Q. At what approximate MPH do the various steps of transition take place?

A. Gear Ratio	15:68	15:63	17:62
Minimum Continuous MPH	9	10	11.4
Transition 1 to 2	13	14	18
Transition 2 to 3	16	19	23
Transition 3 to 4	20	23	28
Transition 4 to 5	25	28	35
Transition 5 to 6	33	37	45
Transition 6 to 7	43	47	56
Maximum Locomotive MPH	65	70	80

Q. What sequence occurs in each step of transition?

A. Step	Forward Sequence
1 to 2	Contact FS1 in Speed Shunter, Illus. 4, (upon a signal from the axle generator) closes to energize shunting contactor M3. Interlock on M3 contactor energizes shunting contactors M1, M2 and M4.
2 to 3	Similarly shunter contact FS2 closes to energize M7. Interlock on M7 contactor energizes contactors M5, M6 and M8.
3 to 4	1. Similarly, shunter contact TR closes, starting rotation of Cam Controller, Illus. 4. 2. Cam Controller contact RV opens to de-energize contactor RVT, Illus. 4, reducing power for this step of transition. 3. Continued rotation of Cam Controller closes contact S1B, energizing relay TCR which recalibrates shunting circuits for use again in parallel. 4. Continued rotation of Cam Controller opens contact MS which in turn opens circuit to speed shunter contacts FS1, FS2, and FS3. This de-energizes shunting contactors M1 to M8. 5. Continued rotation of Cam Controller closes cam contact PL picking up power contactors P1 and P2. This temporarily isolates traction motors 3 and 4. Traction motors 1-2 and 5-6 are now across the generator in series-parallel. 6. Continued rotation of Cam Controller opens cam contact SER, dropping power contactors S1 and S2. 7. Continued rotation of Cam Controller closes cam contact PL3, picking up power contactor P3. Traction motors 1-2, 3-4, and 5-6 are now across the generator in series-parallel. 8. Continued rotation of Cam Controller closes contact RV which energizes contactor RVT, restoring full power to main generator. 9. Continued rotation of Cam Controller closes cam contact MS so shunting circuits can again operate.
4 to 5	Contact FS1 in Speed Shunter closes to ener-

gize motor shunting contactor M3 again. Interlock on M3 contactor energizes contactors M1, M2, and M4.

5 to 6 — Contact FS2 in Speed Shunter closes to energize motor shunting contactor M7. Interlock on M7 contactor energizes contactors M5, M6, and M8.

6 to 7 — Contact FS3 in Speed Shunter closes to energize motor shunting contactor M11. Interlock on M11 contactor energizes contactors M9, M10, and M12.

Step	Backward Sequence
7 to 6	Contact FS3 opens dropping M9, M10, M11, and M12.
6 to 5	Contact FS2 opens dropping M5, M6, M7, and M8.
5 to 4	Contact FS1 opens dropping M1, M2, M3, and M4.
4 to 3	1. Speed Shunter contact TR opens to start reverse rotation of Cam Controller. 2. Cam Controller contact MS opens to disconnect shunting circuits. 3. Cam Controller contact RV opens to de-energize contactor RVT, reducing main generator voltage. 4. Cam Controller contact S1B opens to de-energize relay TCR, recalibrating shunting circuits for use again in series operation. 5. Continued rotation of Cam Controller opens cam contact PL3, dropping power contactor P3. 6. Continued rotation of Cam Controller closes cam contact SER, picking up power contactors S1 and S2. 7. Continued rotation of Cam Controller opens cam contact PL, dropping power contactors P1 and P2. 8. Continued rotation of Cam Controller closes cam contact RV, closing contactor RVT and restoring full generator power. 9. Continued rotation of Cam Controller closes cam contact MS so shunting circuits can again operate. 10. Speed Shunter contacts FS1 and FS2 close again to pick up motor shunting contactors M1 thru M8.
3 to 2	FS2 opens to drop M5, M6, M7, and M8.
2 to 1	FS1 opens to drop M1, M2, M3, and M4.

Group 2 - Isolator

Q. What is the function of each position of the isolator?
A. The isolator, Illus. 1, has five positions as follows:

Position	Function
Isolate	Engine is said to be "isolated" or "off the line" and will remain at idling speed regardless of the throttle position. Power cannot be delivered on the unit either in motoring or dynamic braking. Other units are not affected. The isolator must be in this position before the engine can be started. With the isolator in this position, the "A.C. Failure" alarm will not operate. Also, the engineer's throttle in stop position will not shut down an engine which has been isolated. The engine stop button on the engineer's control panel will function only when the engine is isolated. The mechanical stop button on the engine above the governor is available at any time.
Run 5	Engine speed is restricted to 5th notch regardless of throttle position. (AV and CV circuits to the governor are opened.) Other units are not affected. When throttle is in notch 1 2 3 4 5 6 7 8 Engine speed is in notch 1 1 1 1 3 3 5 5
Run 6	Engine speed is restricted to 6th notch regardless of throttle position. (CV circuit to the governor is opened.) Other units are not affected.

When throttle is in notch 1 2 3 4 5 6 7 8
Engine speed is in notch 1 2 1 2 3 4 5 6

Run 7 — Engine speed is restricted to 7th notch regardless of throttle position. (AV circuit to the governor is opened.) Other units are not affected.

When throttle is in notch 1 2 3 4 5 6 7 8
Engine speed is in notch 1 1 3 3 5 5 7 7

Run 8 — Engine is fully under the engineer's controls, or "on the line."

Q. What are the principal uses of the intermediate speed positions on the isolator?
A. 1. To put the engine "on the line" in gradual steps.
2. To reduce engine speed to prevent ground relay action in event of moisture grounds.
3. To reduce peak voltage without reducing maximum tractive effort in event of motor or generator trouble.
4. To reduce engine load temporarily in event of a hot engine alarm.

Group 3 - Traction Motor Cutout Switch

Q. What is the function of each position of the Traction Motor Cutout Switch, Illus. 4?
A. This switch has five positions as follows:

Position	Function
Normal	All motoring and dynamic braking functions normal.
TMCO 1-2	Traction motors 1 and 2 (first two at boiler hood end) cut out. Dynamic brake will not function on unit. Transition will not function. Motors 3 and 4 connected in parallel with motors 5 and 6.
TMCO 3-4	Traction motors 3 and 4 (third motor on No. 1 truck and first motor on No. 2 truck) cut out. Dynamic brake will not function on unit. Transition will not function. Motors 1 and 2 are connected in parallel with 5 and 6.
TMCO 5-6	Traction motors 5 and 6 (last two on No. 2 truck) cut out. Dynamic brake will not function on unit. Transition will not function. Motors 1 and 2 are connected in parallel with 3 and 4. Load ammeter will not function.
DBCO	Dynamic brake cut out without affecting braking on other units. Operation in motoring not affected.

Q. When is the Traction Motor Cutout Switch useful?
A. 1. To isolate dynamic brake on unit in event of repeated ground relay action in braking, due to grounded grids. (The grids are always completely isolated in motoring.)
2. To isolate a traction motor in event of a traction motor blower failure.
3. To isolate a traction motor in event of flashover or motor lead trouble.
4. To isolate a pair of motors in event of wheel slip relay circuit trouble. CAUTION: Always check for sliding wheels first, in event of continuous wheel slip alarm. Cutting out motors isolates the alarm, but not a locked wheel.

Q. Will the Traction Motor Cutout Switch isolate a traction motor ground?
A. Generally not, due to the center tap type of ground relay circuit used. In such a case using an intermediate speed position on the isolator is most useful to forestall ground relay action.

Group 4 - PC Switch

Q. If the PC switch, Illus. 2, trips, will the fuel pumps stop?
A. No.

Q. If the PC switch trips with the throttle in the 5th or 6th notch, will the engines shut down?
A. No, unless the railroad chooses not to use the F-M standard circuit.

Group 5 - Dynamic Braking

Q. Can the dynamic brake be cut out without isolating the unit or affecting braking on other units in the locomotive?
A. Yes, using the DBCO position of the Traction Motor Cutout Switch, Illus. 3. Operation in motoring is not affected.

Q. Can the ground relay operate in dynamic braking?
A. Yes, it will light alarm light and ring alarm bell. Does not nullify dynamic brake action.

Q. How can ground relay action in dynamic braking be minimized?
A. By holding initial braking current low for a few seconds to dry out grids if they are wet or filled with snow. If ground relay action persists in braking, cut out the brake on the unit using the DBCO position of the Traction Motor Cutout Switch.

Q. What is the first thing to check if the dynamic brake is weak?
A. The Dynamic Brake circuit breaker in the electric cabinet, Illus. 4. This breaker controls the field loop control circuit.

If the breaker is "OFF," or if the loop circuit is broken between units, initial or residual braking current will be available; but no increase above initial as the braking handle is advanced.

Q. Why must dynamic braking current be held to 700 amps or below at speeds above 50 MPH?
A. To keep voltage on the traction motors within specified limits.

Q. Should the Unit Selector Switch, Illus. 1, be changed if a unit is isolated or has its dynamic brake cut out?
A. No; only when a unit is taken from or added to the locomotive.

Group 6 - Load Current Limits

Q. What are the load current limits?
A. In motoring

Continuous -	1020 motor amperes; 2040 generator amperes
40 Minutes -	1050 motor amperes; 2100 generator amperes
20 Minutes -	1100 motor amperes; 2200 generator amperes
10 Minutes -	1150 motor amperes; 2300 generator amperes

These ratings are not cumulative.

Do not go above 1020 motor amps or 2040 generator amps for thirty (30) minutes before using any one short time rating.

B. In Dynamic Braking

840 amps continuous. Small oscillations in overload zone permitted with brake regulated at 820 amps.

Group 7 - Cooling System

Q. How is the cooling system drained?
A. 1. Open main drain valve located at pump end of engine. This valve will drain engine, oil cooler, engine water tank, and cab heaters.
2. Open radiator drain valves located at platform end of each bank of radiators.
3. Remove plug at bottom of engine water pump.
4. To drain boiler water, open valve in the 4-inch equalizing line.
5. In case of doubt as to which valves to open to prevent a dead unit from freezing, open every valve which can be found on the locomotive.

This can cause loss of nothing but water as no lubricating oil can be drained except by removing the pipe cap at the end of the lube oil drain. Fuel can be drained only by removing a plug at the bottom of the fuel tank sump.

Q. What should be done if a hot engine alarm occurs?
A. See instructions in Sec. 107A, Page 8.

Q. What are correct operating engine water temperature?
A. 1. Shutters should open at 153-170° F. water out of engine.
2. Full load water temperature out of engine should run 165-170° F. up to 90° F. ambient increasing to 185° F. at 110° F. ambient.

Group 8 - Engine Lubricating Oil System

Q. What is normal operating engine lube oil pressure as shown on the cab gage?
A. 28 to 35 lbs. at full engine speed, and 9 to 12 lbs. at idle speed. Pressure will vary with oil temperature but should not fall below these limits.

Q. At what engine lube oil pressure is the governor built to shut

the engine down?

A. 18 to 20 lbs. at full engine speed and 3 to 5 lbs. at idle speed.

Q. If the cab gage shows below normal pressure, what are the first things to check?

A. 1. The drain valve for the six element oil filter and drain valve for the oil cooler, both located in the engine room. They should be closed tight. If either valve is left open, oil will be by-passed back to the engine. Refer to Illus. 3, Sec. 117A.

2. Engine lube oil level in the crankcase as shown by the dip stick. Be sure to read the correct side of the stick; one side is marked "Engine Running" and the other "Engine Stopped."

3. If (1) or (2) do not reveal the trouble, maintenance should check the in-line strainer for being dirty or plugged. All the oil must go thru this strainer before entering the engine.

Q. How much of the oil goes thru the six-element filter?

A. All oil at idle speed, decreasing in percentage to about 20% at full engine speed with the oil at normal operating temperature.

The filter by-pass valve is built to operate at 20-25 psi.

Group 9 - Engine Fuel Oil System

Q. What is the normal fuel oil pressure as shown by the cab gage, Illus. 7?

A. 18-25 psi.

Q. If fuel oil pressure is below normal, what should be checked first?

A. The emergency fuel cutoff valve, underneath the locomotive by the side of the fuel tank. Tripping of this valve ordinarily cuts off fuel pressure completely; but cases have been reported where this valve has been found just partially tripped, causing a drop but not a complete failure of fuel oil pressure. (See Sec. 116A, Illus. 1.)

Q. If fuel oil pressure gets too low with the engine working, what happens?

A. The engine will start surging, and the governor will open the fuel racks to the limit causing the load regulator to go to minimum field.

Group 10 - Engine Governor

Q. What can be done if an engine is found hunting?

A. Correction of hunting is a maintenance job, except possibly in case of low fuel pressure (see Group 7). Some of the more common causes are:

1. Low fuel pressure. (See Group 7.)
2. Dirty or thin oil in the governor, or detergent oil in the governor without a non-foaming additive.
3. Air in governor oil, bleed if necessary.
4. Loose linkages - engine to governor or in engine fuel racks.
5. Fuel injection pumps stuck.
6. Fuel racks binding.
7. Engine fuel rack limiting (torque limit) screw set below or too close to full load rack setting. Full load should be 16 rack total (8 for each pump or a cylinder) and the torque limit screw at 17 rack total.
8. Governor compensating screw improperly set. Should be 1/4 to 1/2 turn open.

Group 11 - Air Compressor Operation

Q. How is air compressor operation controlled?

A. Each compressor is equipped with a governor which is an air-operated pressure switch closing at 130 lbs. and opening at 140 lbs. main reservoir pressure.

The governor closes to energize the unloader magnet valve, which shuts off air to, and exhausts air from the compressor unloader. Shutting off the air to the unloader makes the compressor pump. By trainlining magnet valve control, compressors on all units operate together.

Q. If a compressor fails to pump, what can be done?

A. Shut the cock in the air line to the compressor governor and unloader. This will make the compressor pump if the unloader magnet valve is defective. Compressor control must then be operated manually or the safety valves will pop.

Q. How can a bad order air compressor be kept from pumping?

A. By throwing the toggle switch at the compressor, which will isolate the compressor governor and magnet valve control.

SEQUENCE CHART

2400 hp Units With Dynamic Braking

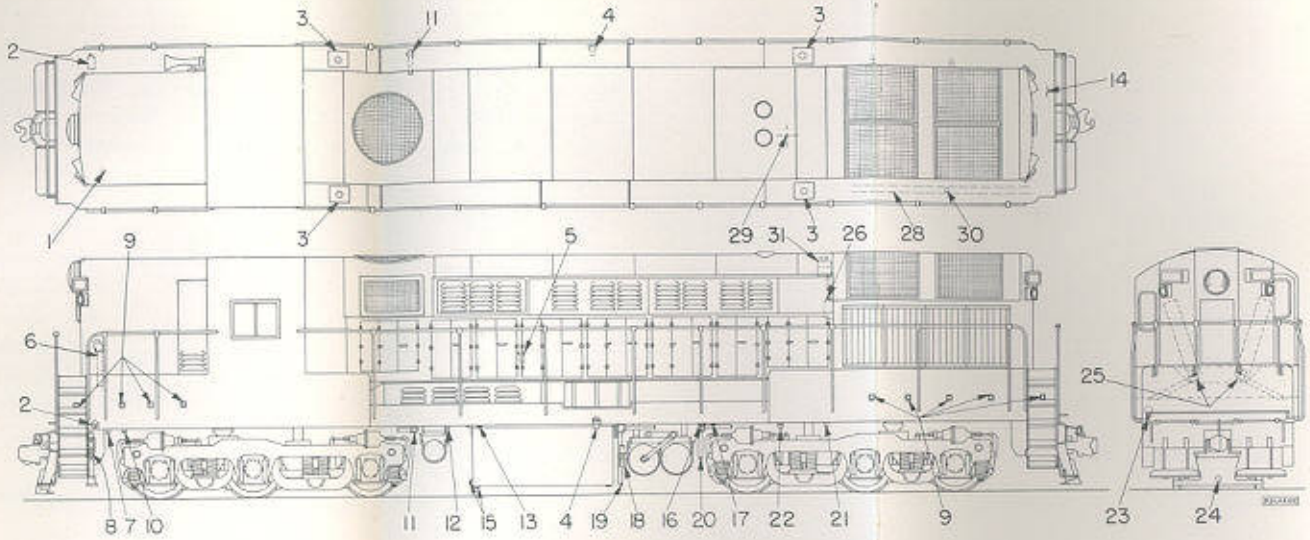
For Engine Governor Sequence See Sec. 105A, Page 8

Operation		Motor Connection	Selector	Throttle	Isolator	Cam Switch	Contactors: FPC	CF1	G+ G-	TV	GF	EF	S1	S2	P1 -	P2	P3	M1,M2	M3,M4	M5,M6	M7,M8	M9,M10	M11,M12	FL	B1	Relays: DBM	TR	PCR	FR	TDR	BR
Shut Down		Fuel Pump Sw. Open	Off	Idle	Isol.	B																									
Engine Start		Fuel Pump Sw. Closed	Off	Idle	Start	B	*	*	*																						
Idling		Fuel Pump Sw. Closed	Off	Idle	Isol.	B	*																								
Idling		Fuel Pump & Con. Sw. Closed	Off	Idle	Isol.	B	*																					*			*
Idling		Fuel Pump, Con., & Gen. Fld. Sw. Closed	Off	Idle	Isol.	B	*																					*			*
Idling		Fuel Pump, Con., & Gen. Fld. Sw. Closed	Off	Idle	Run	B	*			*																		*			*
Idling		Fuel Pump, Con., & Gen. Fld. Sw. Closed	1 to 4	Idle	Run	M	*			*	*																	*			
Motoring Forward Transition	1	3S, 2P	1 to 4	1 to 8	Run	M	*			*	*																		*	*	*
							*			*	*		*	*															*	*	*
							*			*	*	*	*	*															*	*	*
							*			*	*	*	*	*															*	*	*
	2	3S, 2P 1st Shunt	1 to 4	8	Run	M	*			*	*	*	*	*				*	*										*	*	*
	3	3S, 2P 2nd Shunt	1 to 4	8	Run	M	*			*	*	*	*	*				*	*	*	*								*	*	*
	4	2S, 3P	1 to 4	8	Run	M	*			*	*	*			*	*												*	*	*	*
							*			*	*	*			*	*	*											*	*	*	*
							*			*	*	*			*	*	*											*	*	*	*
	5	2S, 3P 1st Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*	*	*									*	*	*	*
	6	2S, 3P 2nd Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*	*	*	*	*							*	*	*	*
	7	2S, 3P 3rd Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*	*	*	*	*	*	*					*	*	*	*
Motoring Backward Transition	6	2S, 3P 2nd Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*	*	*	*	*							*	*	*	*
	5	2S, 3P 1st Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*	*	*									*	*	*	*
	4	2S, 3P	1 to 4	8	Run	M	*			*	*	*			*	*	*											*	*	*	*
	3	3S, 2P 2nd Shunt	1 to 4	8	Run	M	*			*	*	*			*	*	*												*	*	*
							*			*	*	*			*	*	*												*	*	*
							*			*	*	*	*	*	*	*	*												*	*	*
							*			*	*	*	*	*	*	*	*												*	*	*
	2	3S, 2P 1st Shunt	1 to 4	8	Run	M	*			*	*	*	*	*				*	*										*	*	*
	1	3S, 2P	1 to 4	8	Run	M	*			*	*	*	*	*															*	*	*
Idling			1 to 4	Idle	Run	M							*	*																*	
							*						*	*															*		
Dynamic Braking			Off	Idle	Run	B	*																						*	*	*
							*																						*	*	*
			Brk.	Idle	Run	B	*					*					*							*	*	*			*	*	*	*

SECTION 131A. LOCATION OF DRAINS AND FILLER PIPES

LEGEND

1 - Hopper Tank Overflow
2 - Boiler Water Tank Fill
3 - Sand Fill
4 - Fuel Oil Tank Fill
5 - Crankcase Oil Fill
6 - Boiler Water Tank Air Vent
7 - Boiler Washout Inlet
8 - Boiler Washout Outlet
9 - Boiler Water Tank Washout Plugs (Gov. Side)
10 - Hopper Tank Fill
11 - Compressor Oil Drain (Far Side)
12 - Drain for Boiler Water Line
13 - Fuel Oil Tank Air Vent
14 - Boiler Water Tank
15 - Fuel Oil Tank Flush Out Plugs
16 - Engine Water Drain
17 - Lube Oil Strainer Drain
18 - Subbase Lube Oil Drain
19 - Crankcase Drain
20 - Snubber Drain
21 - Water Expansion Tank Fill
22 - Standby Steam Connection (On units without boiler, only)
23 - Steam Take-off for Standby Heating
24 - Steam End Connector (Both Ends)
25 - Radiator Drain Cocks
26 - Water Treatment Fill
27 - Dirty Fuel Oil to Waste
28 - Steam Line
29 - Engine Water Drain Valve
30 - Steam Take-off for Standby Heating (On units with boiler, only)
31 - Engine Water Expansion Tank



Illus. 1. Drain and Fill Diagram

SECTION 132A. ELECTRICAL CONTROL SYSTEM DESCRIPTION OF PARTS

General

Wiring diagrams differ for each locomotive order because of variations in specifications and details of construction. Therefore, reference should be made to the wiring diagrams which cover specifically the locomotives being operated or maintained. These diagrams are furnished to the railroad when the locomotives are delivered. In addition, typical schematic wiring diagrams are included in this section.

To assist in the understanding of the diagrams, a list of electrical control equipment is given below, identifying the items by the symbols used and giving the function of each. However, any individual set of wiring diagrams may not contain all the items listed because the differences in locomotive construction will result in the elimination or addition of electrical equipment. For instance, on locomotives which are not equipped with dynamic braking, a number of the items listed will be omitted.

* Indicates used only on units equipped for dynamic braking.

Symbol	Device	Function
AV, BV CV, DV	Solenoids in Electro-Hydraulic Governor (See also ORS & TV)	Control engine governor action. Energized from lead unit throttle thru trainline wires AV, BV, CV, and DV.
BC	Battery Charging Contactor	Electro-magnetic contactor connecting the auxiliary generator to the battery and the low-voltage control circuits. (Except the alternator field which is taken directly off the aux. gen. after the aux. gen. fuse.)
* B1	Braking Contactor	Electro-pneumatic contactor connecting the traction motor fields in series with the main generator in dynamic braking.
* BKL	Braking Limit Relay	Voltage relay connected across brake grids. Nullifies dynamic brake when grid current limit is exceeded (about 150 amps. above brake warning). Se-

Symbol	Device	Function
		lector handle must be returned to "Off" position to reset.
* BKR	Brake Regulating Relay	Voltage relay connected across brake grids. Limits dynamic braking grid current permissible, with selector handle in a steady position.
* BR	Braking Pilot Relay	To throw cam switch to "Motoring" when throttle selector is moved from "Off" to "1" with locomotive run switch off.
* BW	Brake Warning Light	Informs engineer when BWR is energized on any unit. Trainlined thru BW wire.
* BWR	Brake Warning Relay	Voltage relay connected across brake grid blower motor to indicate when grid current is above maximum continuous. (Beginning of red zone on load ammeter.)
* CSB, CSM	Magnet valves, contacts & interlocks on the Cam switch. "CSB" indicates those normally closed in braking. CSM indicates closed in motoring. The Cam Switch is electro-pneumatically operated thru magnet valves CSB and CSM.	Changes main power and control circuits from motoring to dynamic braking and vice versa. CSB is energized in "OFF" and "BRAKE" on throttle selector, thru "B" wire.
CC	Air Compressor Synchronizing Magnet Valve.	When energized by CG thru CS trainline wire, shuts off air to unloader, to load air compressor.

Symbol	Device	Function
CG	Air Compressor Governor Switch	Energizes CS trainline wire. Closed by main reservoir air pressure at 130 lbs.; opened at 140 lbs.
* DBM	Dynamic Brake Interlock	Releases or prevents an automatic service (not emergency) or electro-pneumatic straight air brake application on the locomotive while the dynamic brake is in operation.
* DBNR	Dynamic Brake Nullifying Relay	Nullifies dynamic brake when energized by PCR. Selector handle must be returned to "OFF" to reset.
EF	Exciter Field Contactor	Energizes exciter battery (4-pole) field controlling exciter and hence main generator output. MOTORING: Closes when throttle is in Notch 1 or above, with unit "on the line" and Locomotive Run Switch closed. DYNAMIC BRAKING: Closes with throttle selector in "BRAKE" and reverse handle in "FORWARD" or "REVERSE."
EFR	Exciter Field Reduced Contactor	Closes to by-pass a set amount of current around exciter 4-pole field and load regulator when energized by any of the three wheel slip relays. Also energizes governor ORS to send load regulator to minimum field.
EPR	Engine Protector Relay	Pressure switch connected to engine crankcase. If as much as 1 oz. pressure above atmospheric builds up in crankcase, EPR will close to actuate engine shutdown circuit. A red light will burn on the EPR and in cab, and if the engine is on the line an "A.C. FAILURE" alarm will also result.
ESR	Engine Stop Relay	Relay added on customer request to provide stopping engine on all units from any unit.

Symbol	Device	Function
ETS	Engine Temperature Switch	Connected to thermo-bulb in engine water outlet manifold. Set to close at 195-205° F. Sounds alarm bells in all units and lights red light on control panel of unit affected.
* FL	Field Loop Contactor	Controls dynamic brake field loop excitation circuit. Energized on leading unit only when selector is just beyond first braking position, and reverse handle is in "FORWARD" or "REVERSE."
For, Rev	Magnet valves, contacts and interlocks on the two Reversers. "For" indicates those normally closed in "forward." "Rev" indicates those normally closed in "reverse." The reversers are electro-pneumatically operated thru magnet valves "For" and "Rev."	Change direction of current thru traction motor fields.
FPC	Fuel Pump Contactor	Connects fuel pump to the Control Cut-out breaker. Utilized to energize each fuel pump from its own battery.
FR	Forward-Reverse Pilot Relay	Pilot relay operating TDR.

Symbol	Device	Function
FSM, RSM	Forward and Reverse Sanding Magnet Valves	Control forward and reverse sanding. Energized by SPS thru reverser interlocks.
FS1, FS2, FS3	Traction Motor Field Shunting Relays	Relays in Speed Shunter equipment box, energizing shunting contactors M1 to M12. (M1 to M8 on 1600 hp General Service units.)
G+, G-	Engine Starting Contactors	Connect main generator armature and starting field to battery for starting the engine. Energized from Isolator thru Engine Start Button and BC and EF interlocks.
GF1	Auxiliary Engine Starting Contactor	On 2400 hp units, connects generator shunt field to battery during first three seconds start button is pressed, in order to give additional "breakaway" torque for starting engine.
GR	Ground Relay	Energized in event of a ground in the main power circuits. Alarm bells ring on all units, and white light lights on control panel of unit affected. MOTORING: De-energizes TV to bring engine speed to idle and de-energizes EF and IR1 to remove power. If relay trips while throttle is in 5th or 6th position, "DV" governor solenoid shuts engine down. DYNAMIC BRAKING: Sounds alarm bell on all units and lights white light on affected unit. Does not nullify the dynamic brake.
IR	Impulse Relay	Designed to energize in event of flash-over. Set to operate at 3800 amperes "slow rise" and 1700 amperes "rapid rise" of main generator current. By mechanically opening the generator field contactor in the generator field circuit, it removes excitation quickly.

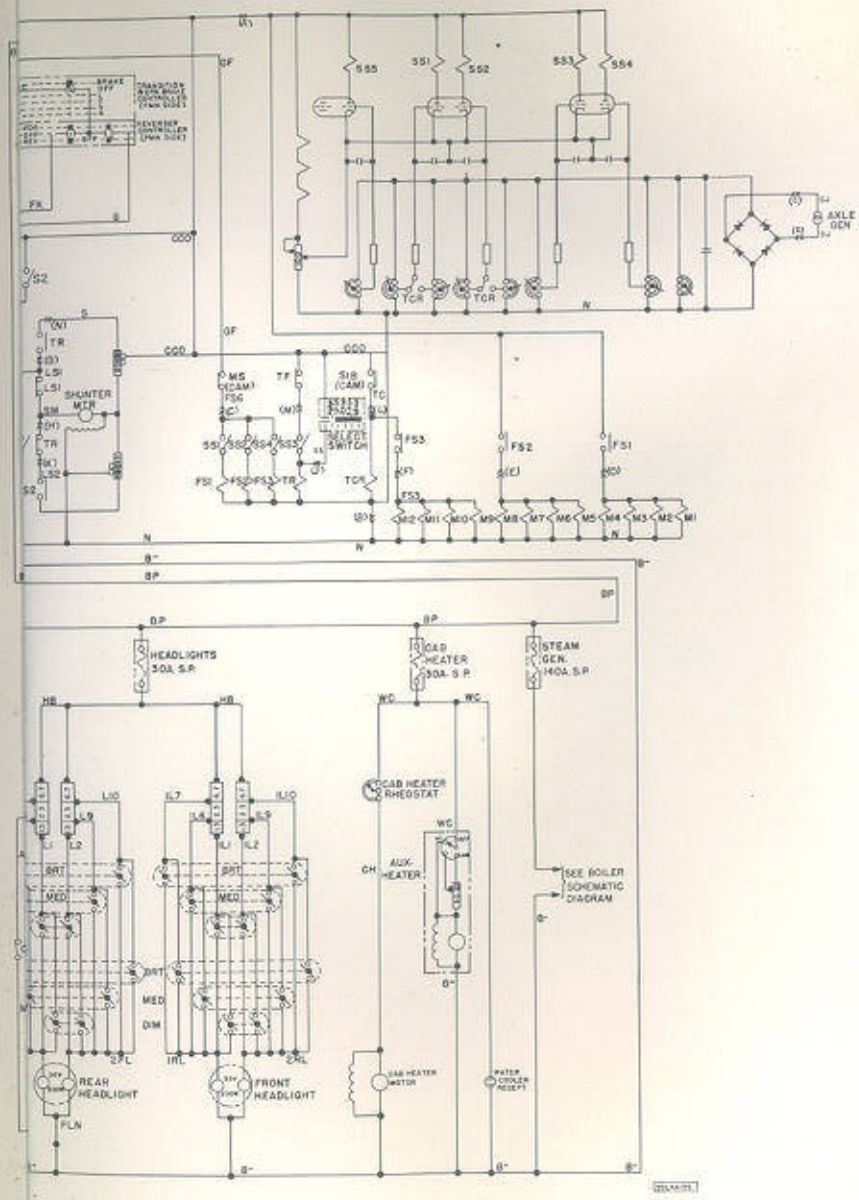
Symbol	Device	Function
		Functions are identical to the ground relay. The formerly-used generator field contactor "GF" is now built as part of this relay.
LOS	Low Oil Switch (in Governor)	Shuts engine down if engine lubricating oil pressure falls too low for engine speed being maintained.
LS1, LS2	Limit Switches (in Cam Controller)	Limit travel in each direction of 74-volt DC motor driving cam controller.
M1-M12	Traction Motor Field Shunting Contactors	Shunt traction motor fields to increase motor speed. Controlled by FS1, FS2, and FS3.
MS	Cam Controller Contact	"Motor Shunting" contact in Cam Controller, permitting FS1, FS2, and FS3 to energize only at proper time.
NVR	No AC Voltage Relay	De-energizes if alternator voltage falls below approximately 100 volts. Alarm bells ring on all units and blue light lights on control panel of unit affected. MOTORING: De-energizes TV to bring engine speed to idle. De-energizes EF and GF to remove power. If relay opens while throttle is in 5th or 6th position, "DV" governor solenoid shuts engine down. DYNAMIC BRAKING: De-energizes B1 to drop braking on unit affected. De-energizes TV to bring engine speed to idle.
ORS	Overriding Solenoid (in Governor)	Sends load regulator to minimum field when energized by either closing of EFR (wheel slip operation) or by opening of EF.
OSM	Overspeed Magnet Valve	Gives automatic service application on air brakes when de-energized. This may be caused by:

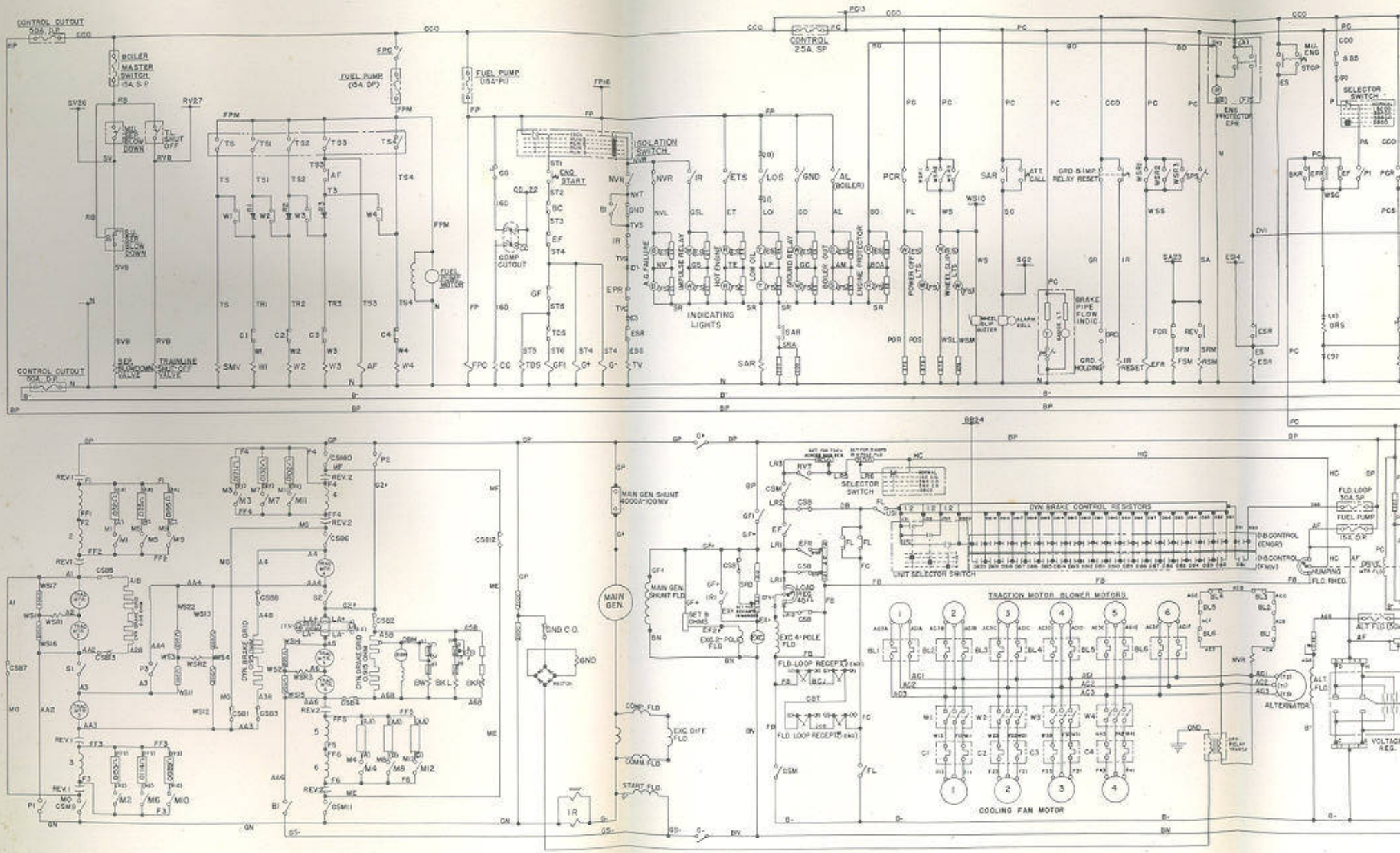
Symbol	Device	Function
		1. Overspeed Switch opening at maximum locomotive speed. 2. Low battery voltage or control cutout breaker tripping.
Over-speed Switch	Overspeed Switch (in Speed Recorder)	Opens to de-energize OSM if maximum locomotive speed is exceeded.
P1, P2, P3	Parallel Power Contactors	Electropneumatic contactors connecting traction motors to the main generator in 2S3P operation.
PCR	Pneumatic Control Relay	Opens throttle control circuits when de-energized by opening of PCS. This drops power on all units and brings all engines to idle speed.
PCS	Pneumatic Control Switch	Air pressure switch located in electrical cabinet. Opens in event of brake-valve initiated emergency, safety control, overspeed, or train control air brake application. When open de-energizes PCR.
RCR	Reverse Current Relay	Opens Battery Charging Contactor (BC) when battery voltage exceeds auxiliary generator voltage. This prevents current from the auxiliary generator to the battery from reversing.
RV	(See RVT)	
RVT	Reduced Voltage Transition Relay	De-energized during transition by opening of Cam Controller contact RV. Places added resistance in exciter 4-pole field circuit, reducing main generator excitation.
S1, S2	Series Power Contactors	Electropneumatic contactor connecting traction motors to the main generator in 3S2P operation.
SAR	Signal Alarm Relay	Energizes alarm bells.

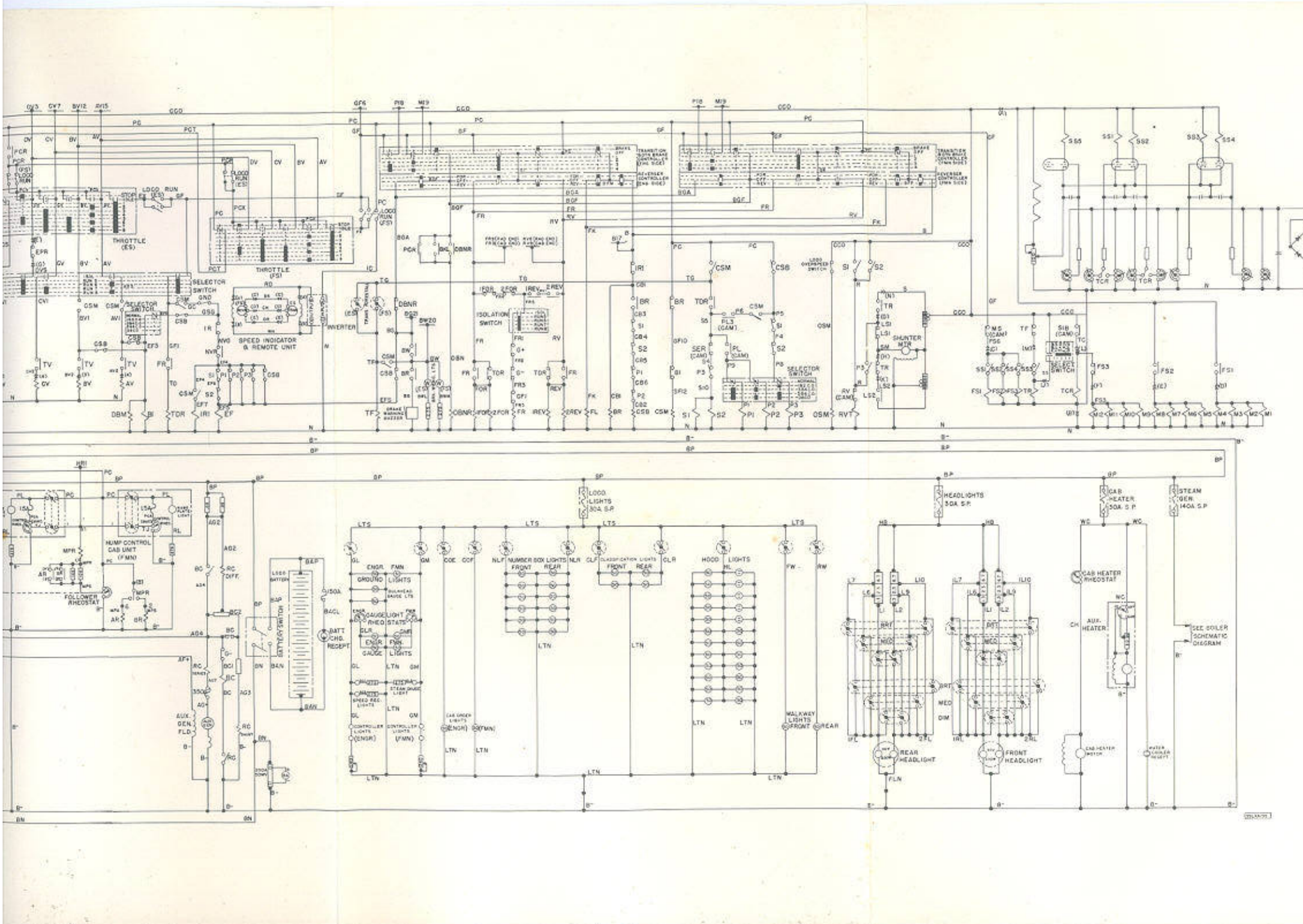
Symbol	Device	Function
SMV	Shutter Magnet Valve	Controls main reservoir air to the two shutter operating cylinders. Energized by switch TS, in Pneumatic Step Controller.
SPS	Sanding Pressure Switch	Energizes FSM or RSM and trainline wire SP (No. 12). Closed by engineer's sander switch or brake valve bail.
SS1, SS2, SS4	Speed Shunter Pilot Relays	Energize Speed Shunter relays FS1, FS2, and FS3 on a signal from the axle generator, when permitted by Cam Controller contact MS.
SS3	Speed Shunter Pilot Relay	Energizes Speed Shunter relay TR on a signal from the axle generator when relay TF is de-energized.
SS5	Speed Shunter Pilot Relay	Provides Fail Safe Provision in event cam controller does not perform backward transition sequence.
TDR	Time Delay Relay	Delays opening of power contactors S1, S2, or P1, P2, and P3 until after excitation is removed, reducing contact tip burning.
TDS	Time Delay Start Relay	On engine starting on 2400 hp units, drops contactor GF1 out three (3) seconds after engine start button is pressed.
T1, T2, T3	Triode Tubes	In Speed Shunter box. Regulate current to SS relays.
TF	Transition Forestalling	Prevents transition when Transition Forestalling Switch in cab is thrown to "Series Only" position. In this position of switch relay, TF is energized.
TR	Transition Relay	Relay in Speed Shunter box operating 74-volt DC Cam Controller motor. Energized by either SS3 or one of the motor cutout positions of the Traction Motor Cutout Switch.

Symbol	Device	Function
TMCO	Traction Motor Cutout Switch	Cuts out traction motors in pairs, putting other four motors in 2 Series, 2 Parallel by energizing relay TR. This will also make the dynamic brake inoperative on unit affected only. Also inserts resistance in exciter 4-pole field to limit main generator peak voltage. Dynamic Brake cutout position "DBCO" de-energizes B1 on unit affected. Operation in motoring is not affected.
TS, TS1, TS2, TS3, TS4	Temperature Control Switches (in Fan-Shutter Control Pneumatic Step Controller)	Energize Shutter Magnet Valve (SMV) and cooling fan contactors (W1-W4).
TV	Throttle Contactor	Brings engine speed to idle by de-energizing AV, BV, and CV solenoids in the governor. Engine stops if TV is energized with throttle in 5th or 6th position, since governor DV solenoid will shut down engine.
* Unit Selector Switch		Sets resistance in dynamic braking field loop control circuit according to number of units in locomotive. Settings are designed so loop control current remains approximately the same regardless of number of units in locomotive.
VR	Voltage Regulator	Regulates auxiliary generator voltage. Correct settings are 72 volts idling, 75 volts full speed.
W1-W4	Radiator Fan Motor Contactors	Connect radiator cooling fan motors to alternator. Energized by TS1-TS4.

Symbol	Device	Function
WS1, WS2, WS3	Wheel Slip Relays	Sounds buzzer and lights warning light at engineer's station when wheels slip on any unit; also automatically reduces power on unit affected by energizing contactor EFR.




CONTROL CUTOUT
50A D.P.
BOILER MASTER SWITCH 15A S.P.
FUEL PUMP (15A DP)
FUEL PUMP (10A P.)
CONTROL 25A SP
ISOLATION SWITCH
ENG. START
COMP. CUTOUT
INDICATING LIGHTS
SELECTOR SWITCH
ENG. PROTECTOR EPR
BRAKE PIPE FLOW INDIC.
MAIN GEN.
MAIN GEN. SHUNT FLD.
EXC 4-POLE FLD.
EXC 2-POLE FLD.
FLD. LOOP RECEPT.
DYN. BRAKE CONTROL RESISTORS
UNIT SELECTOR SWITCH
TRACTION MOTOR BLOWER MOTORS
COOLING FAN MOTOR
ALTERNATOR
FUEL PUMP
VOLTAGE REG.


THROTTLE (ES)
THROTTLE (FS)
SELECTOR SWITCH
SPEED INDICATOR & REMOTE UNIT
INVERTER
ISOLATION SWITCH
SHUNTER MTR
HUMP CONTROL CAB UNIT (FMN)
FOLLOWER RHEOSTAT
BATTERY SWITCH
BATT CHG. RECEPT
AUX. GEN. FLD.
LOCO LIGHTS 30A. S.P.
HEADLIGHTS 30A. S.P.
CAB HEATER 30A. S.P.
STEAM GEN. 140A. S.P.
CAB HEATER RHEOSTAT
AUX. HEATER
SEE BOILER SCHEMATIC DIAGRAM
REAR HEADLIGHT
FRONT HEADLIGHT
NUMBER BOX LIGHTS
CLASSIFICATION LIGHTS
HOOD LIGHTS
WALKWAY LIGHTS
GAUGE LIGHTS
CONTROLLER LIGHTS

READING COMPANY
Reading Division
Office - Road Foreman of Engines.

Reading, Pa.,
November 17, 1955.

NOTICE

TO ALL CONCERNED:

DIESEL ENGINE OVER-SPEED TRIP RE-SET LEVER
FAIRBANKS-MORSE 2400 horse-power Diesel
Locomotives Nos. 860 to 867, inclusive.

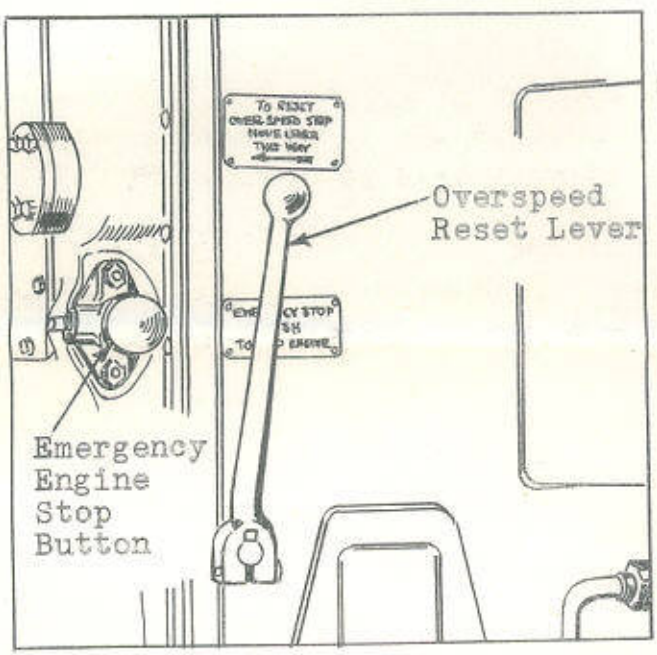
The Diesel engine over-speed re-set lever (illustrated below) is located on the Diesel engine above the governor.

If the over-speed operates THE LEVER DOES NOT CHANGE POSITION.

To re-set, pull lever as far as possible in the direction shown by the arrow, until it latches.

If an engine shuts down because of over-speed tripping, alarm bells will ring on all units and the "A.C. FAILURE" alarm light will burn on the unit affected.

IN EVENT OF AN ENGINE OVER-SPEED TRIP, ALWAYS CHECK THE LOW OIL PRESSURE RE-SET BUTTON ON DIESEL ENGINE GOVERNOR, LOCATED DIRECTLY BELOW OVER-SPEED RE-SET LEVER. IT IS POSSIBLE FOR BOTH DEVICES TO TRIP TOGETHER.



E. S. Watters,
Road Foreman of Engines.

READING COMPANY
Reading Division
Office - Road Foreman of Engines.

Reading, Pa.,
November 17, 1955.

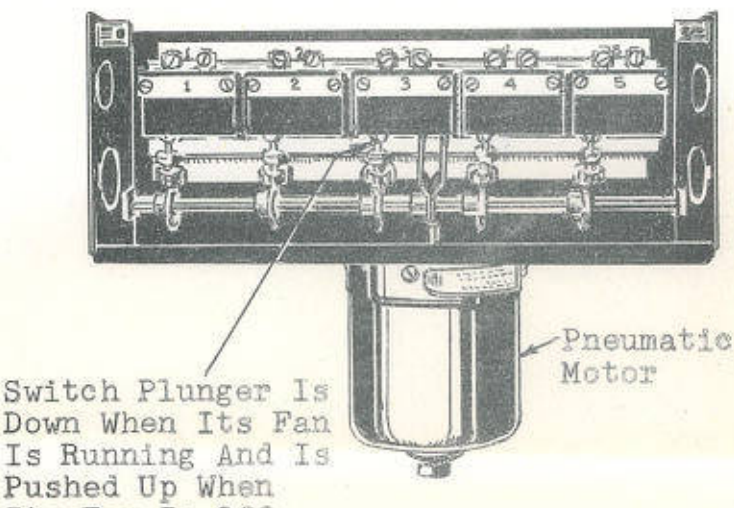
NOTICE

TO ALL CONCERNED:

FAN AND SHUTTER CONTROLS,
FAIRBANKS-MORSE DIESEL LOCOMOTIVES
NOS. 860 to 867 inclusive.

Fan and shutter control is entirely automatic.

In event of a hot engine alarm due to automatic control failure, disconnect the air piston (illustrated in sketch below) from the shaft controlling the cams, then rotate the cam shaft manually until each small switch plunger has dropped DOWN as far as it will go. This will energize the shutter magnet valve and fan contactors, allowing shutters to open and fan operation.



E. S. Watters,
Road Foreman of Engines.

READING COMPANY
Reading Division
Office - Road Foreman of Engines.

Reading, Pa.,
November 17, 1955.

NOTICE

TO ALL CONCERNED:

DIESEL ENGINE OVER-SPEED TRIP RE-SET LEVER
FAIRBANKS-MORSE 2400 horse-power Diesel
Locomotives Nos. 860 to 867, inclusive.

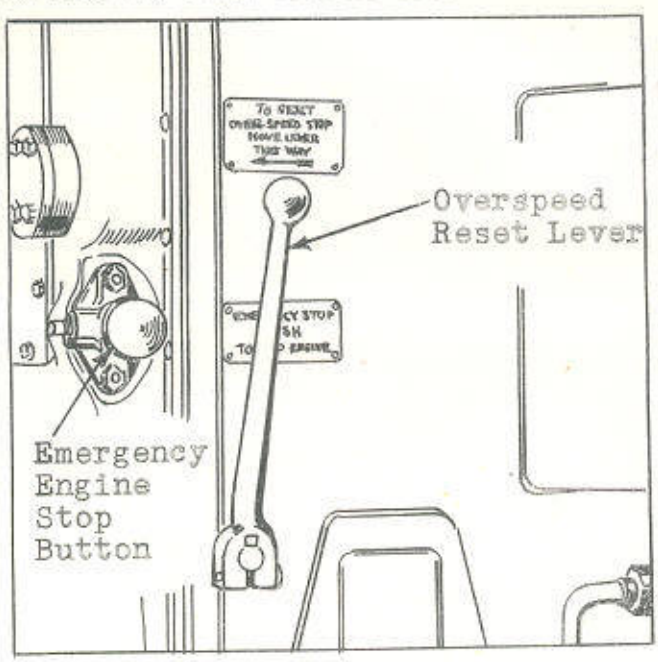
The Diesel engine over-speed re-set lever (illustrated below) is located on the Diesel engine above the governor.

If the over-speed operates THE LEVER DOES NOT CHANGE POSITION.

To re-set, pull lever as far as possible in the direction shown by the arrow, until it latches.

If an engine shuts down because of over-speed tripping, alarm bells will ring on all units and the "A.C. FAILURE" alarm light will burn on the unit affected.

IN EVENT OF AN ENGINE OVER-SPEED TRIP, ALWAYS CHECK THE LOW OIL PRESSURE RE-SET BUTTON ON DIESEL ENGINE GOVERNOR, LOCATED DIRECTLY BELOW OVER-SPEED RE-SET LEVER. IT IS POSSIBLE FOR BOTH DEVICES TO TRIP TOGETHER.



E. S. Watters,
Road Foreman of Engines.

READING COMPANY
Reading Division
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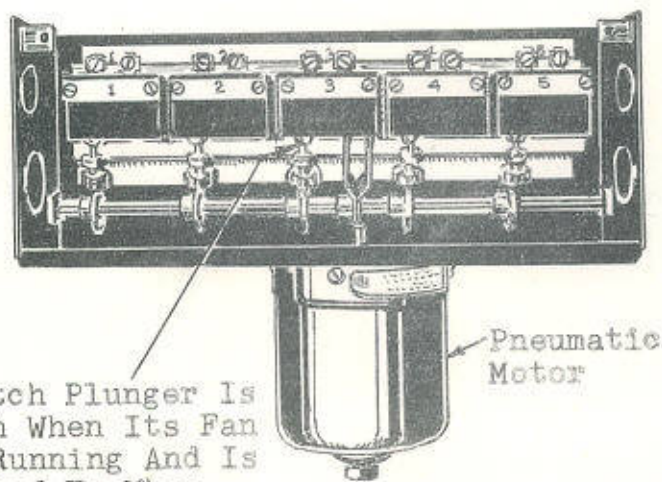
Reading, Pa.,
November 17, 1955.

NOTICE

TO ALL CONCERNED:

FAN AND SHUTTER CONTROLS,
FAIRBANKS-MORSE DIESEL LOCOMOTIVES
NOS. 860 to 867 inclusive.

Fan and shutter control is entirely automatic.
In event of a hot engine alarm due to automatic control failure, disconnect the air piston (illustrated in sketch below) from the shaft controlling the cams, then rotate the cam shaft manually until each small switch plunger has dropped DOWN as far as it will go. This will energize the shutter magnet valve and fan contactors, allowing shutters to open and fan operation.



E. S. Watters,
Road Foreman of Engines.

TROUBLE SHOOTING FAIRBANKS MORSE DIESEL LOCOMOTIVES

No's. 800 TO 867 INCL.

Trouble Cause:	Alternator Field Circuit Breaker Tripped.
Alarm:	Blue Light, Bell, Engine Will Go To Idle, Engine Will Stop In 5th And 6th Throttle. Power Off.
Correction:	Reset Alternator Circuit Breaker Located In High Voltage Cabinet.
Trouble Cause:	Diesel Engine Overspeed Tripped.
Alarm:	Blue Light, Bell, Power Off, Engine Stops.
Correction:	Reset Overspeed Lever By Pulling Lever As Far As Possible In The Direction Shown By Arrow Until It Latches. The Overspeed Lever Is Located On The Diesel Engine Above The Governor.
Trouble Cause:	Engine Protector Switch Tripped.
Alarm:	Blue Light In Cab, Red Light On Engine Protector Switch. Engine Stops.
Correction:	Reset By Depressing Button Located On Side Of Switch. The Engine Projector Switch Is Located On The Right Hand Engine Vertical Drive Cover Fireman's Side Of Locomotive.
Trouble Cause:	Emergency Fuel Cut Off Tripped.
Alarm:	Blue Light, Power Off, Engine Stops.
Correction:	Reset By Depressing Lever Down To The Fully Open Position. The Emergency Fuel Cut Off Valve Is Located At The Left Rear Corner Of The Fuel Tank Below The Filler Pipe.
Trouble Cause:	Emergency Fuel Cut Off Partially Tripped.
Alarm:	No Alarm, Engine Sluggish And Will Not Develop Full Power.
Correction:	Trip And Reset Emergency Fuel Cut Off Valve.

Trouble Cause: Fuel Pump Circuit Breaker Tripped.

Alarm: Blue Light, Engine Stops, Power Off.

Correction: Reset Fuel Pump Circuit Breaker Located In High Voltage Cabinet, Also Check Position Of Fuel Pump Switch Located On Face Of Engineer's Control Panel. In Resetting Circuits Breakers, First Snap Breaker Closed Then Reset Open.

Trouble Cause: Throttle In "Stop" Position.

Alarm: Blue Light, Power Off, Engine Stops.

Correction: Depress Stop Button Located At End Of Throttle And Open Throttle To Idle Position. Note - Diesel Engine Cannot Be Restarted With Throttle In Stop Position.

Trouble Cause: Control Cut Out Breaker Tripped.

Alarm: None. Power Off, Engine Will Shut Down.

Correction: Reset Control Circuit Breaker Located In High Voltage Cabinet, Also Check Position Of Control Button On Face Of Engineer's Control Stand.

Trouble Cause: Auxiliary Generator Fuse Blown.

Alarm: Blue Light If Reverse Current Relay Is Set Properly, Battery Ammeter Will Show Discharge, If Not Corrected Engine Will Stop Due To Low Battery, Loss Of Power May Occur. Check Battery Ammeter Frequently.

Correction: Change Out Auxiliary Generator Fuse, Located Lower Right Hand Corner Of High Voltage Cabinet.

Trouble Cause: Ground Or Surge Relay Tripped.

Alarm: White Light, Loss Of Power, Engine Will Go Idle And Shut Down If Throttle Is In The 5th Or 6th Notch.

Correction: Isolate Unit Affected And Depress Reset Button Located In High Voltage Cabinet, Start Engine In Usual Manner And Place On Line.

Trouble Cause: Isolator Not In Proper "Run" Position.

Alarm: None. Engine Will Not Develop Full Power.

Correction: The Isolator Has 5 Positions, Namely, Isolate, Run #5, Run #6, Run #7 and Run #8. To Obtain Full Power, Isolator Must Be In Run #8. The Isolator Is Located On Engineer's Control Stand And Can Be Reduced To Lower Run Positions To Overcome Various Unusual Operating Conditions.

Trouble Cause: Hot Engine.

Alarm: Red Light

Correction: The Cooling Fan And Shutter Arrangement Is Entirely Automatic Being Operated By A Step Controller which Consists Of Motor, Cam And Series Of Switches. Should This Device Fail, Manual Fan And Shutter Operation Can Be Obtained By Removing Cotter Pin From Switch Plunger, And Moving Plunger Manually. The Cam Will Rotate And Engage Switch Contacts To Open Shutters And Operate Fans. This Device Is Located In Left Hand Corner Of Front Wall Of Car Body Inside Engine Room.

Trouble Cause: P.C. Switch Tripped.

Alarm: Power Off, White Light, Loss Of Power, Engine Will Idle.

Correction: Place Throttle In Idle Position, Release Automatic Brakes, Lap The Automatic Brake Until Application Pipe Pressure Builds Up To Normal, Then Move The Handle To Running Position.

Trouble Cause: Wheel Slip.

Alarm: White Light, Buzzer, Loss Of Power, Sudden "Dipping" Of Load Meter.

Correction: Reduce Throttle If Slipping Persists And Apply Sand If Necessary.

Trouble Cause: Locomotive "Run" Switch in "Off" position.

Alarm: None. Engine will Not Develop Power.

Correction: Be sure throttle is in "Idle" position, then place Run Switch in "RUN" position.
This switch is located on face of Engineers' Control stand.
To Speed Up Air Compressor place "RUN" switch in Off and Open throttle to desired position.

Trouble Cause: Starting Contactor Stuck (G# G- or GF-1).

Alarm: None. Loss of Power, Engine Will go to Idle.

Correction: Shut engine down, open contacts. Start engine in usual manner and place On Line. Starting contacts are located in lower part of the High Voltage Cabinet.

Trouble Cause: Low Control Air Pressure.

Alarm: None. Loss of Power.

Corrections: Check Control Air Pressure Gage located on upper front panel of High Voltage Cabinet. It should read 80 pounds. If low, increase pressure by adjusting Control Air Regulating Valve located in lower part of High Voltage Cabinet, engine room side.

Trouble Cause: Low Lubricating Oil Pressure.

Alarm: Alarm Bell, Yellow and Blue light, Engine will shut down. Check position of Low Oil Button on governor. If tripped, re-set, and check oil level in crank case.

Corrections: Start engine. If engine continues to shut down due to Low Oil Pressure, trouble may be due to Blocked Filters, or other mechanical condition; in which case shut engine down and report condition.
The Low Oil Pressure is located on the side of governor, front end of Diesel engine, Fireman's side.

Trouble Cause:	Pairs of traction motors cut out.
Alarm:	None. Engine will not load fully.
Correction:	Check position of Traction Motor Cut-out Switch. All motors should be cut in, unless it becomes necessary to cut a motor out due to trouble. Traction motors can only be cut out in pairs, as indicated by number on dial of switch. Traction Motor Cut-out Switch is located in High Voltage Cabinet, cab end.
Trouble Cause:	Transition Switch in "Series" position.
Alarm:	White Light, and unit not fully loading.
Correction:	Transition Switch should be placed in automatic position for normal operation. Should it become necessary to place switch in "Series" position, a white light will burn, which is no cause for alarm. Transition Switch is located on front of Engineers' Control Panel.

THE FOREGOING INSTRUCTIONS ARE FOR
THE INFORMATION OF ENGINE CREWS,
TO ASSIST IN LOCATING AND
CORRECTING MINOR TROUBLE THAT
MAY OCCUR ON LINE OF ROAD.

E. S. Watters,

Road Foreman of Engines.

Form 722A

3-49 60M
8 x 10½

READING COMPANY

DIESEL LOCOMOTIVE INSPECTION REPORT

Diesel Locomotive Dispatched From.....

Diesel Locomotive { Number..... *Unit No..... Initial.....

INSTRUCTIONS: Each locomotive must be inspected after each trip or day's work and report made on this form, whether needing repairs or not. Proper explanation must be made hereon for failure to repair any defects reported, and the form approved by foreman, before the locomotive is returned to service.

Train No..... Inspected at..... Time..... M. Date..... 19___

Line	ITEM	SHIFTS 1st	2nd	3rd	Signature of Workman
" 1	Cooling water temperature—Lowest				
" 2	Cooling water temperature—Highest				
" 3	Fuel oil pump gage pressure				
" 4	Fuel oil return pressure				
" 5	Battery charge rate—Amp.—Idle Speed				
" 6	Battery charge rate—Amp.—Top Speed				
" 7	Lube oil pressure—Idle Speed				
" 8	Lube oil pressure—Top Speed				
" 9	Condition of Wheels				
	Treads and Flanges				
	REMARKS				
" 10					
" 11					
" 12					
" 13					
" 14					
" 15					
" 16					
" 17					
" 18					
" 19					
" 20					

Condition of Air Sanders.....
Condition of Bell Ringer.....
Condition of Brakes.....
Condition of Safety Appliances.....

Main Reservoir Pressure..... Pounds
Brake Pipe Pressure..... Pounds
Heated Bearings.....

Signature _____ Occupation _____

Condition of Bell Ringer.....
Condition of Air Compressor.....
Main Reservoir Pressure..... Pounds } As Found
Brake Pipe Pressure..... Pounds }

_____ Inspector.

Condition of Brakes.....
Condition of Safety Appliances.....
Main Reservoir Pressure..... Pounds } As Corrected
Brake Pipe Pressure..... Pounds }

_____ Final Inspector

The above work has been performed, except as noted, and the report is approved

_____ Foreman

*When locomotive consists of more than one unit, each unit number shall be given.

NOTE—Proper explanation should be made on back of this form for failure to repair any defects reported.