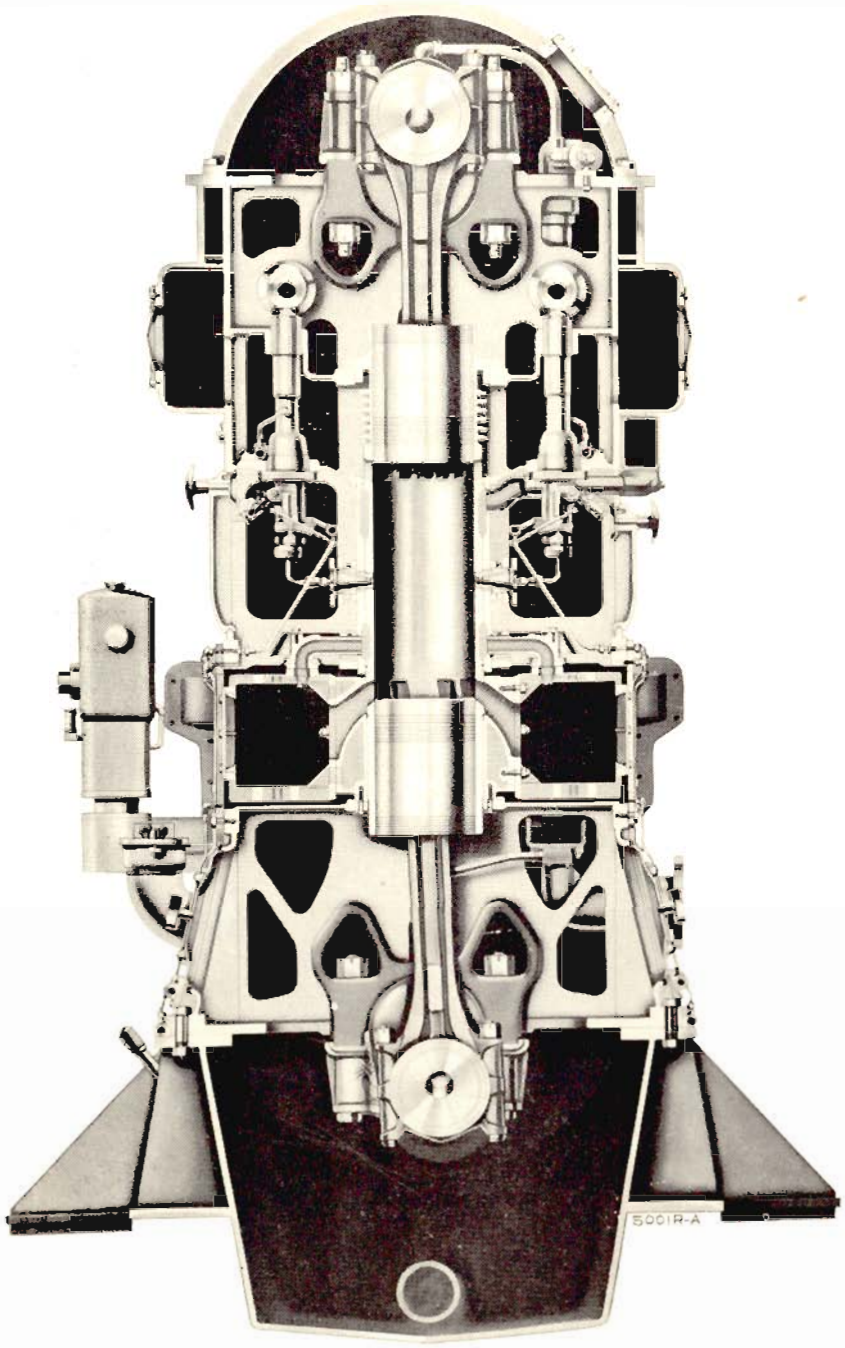
Bulletin 1204B

FOREWORD . . .

This enginemen's manual pertains to both the 1600 H.P. Diesel Freight, Passenger, and Transfer Units Type H16-44, H16-64 and H16-66 and the 2000 H.P. Freight and Transfer Units Type H20-44 and H20-66. These instructions, however, do not purport to cover all details or variations in equipment and they may not 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 Division, Chicago, Ill.

Feb., 1951

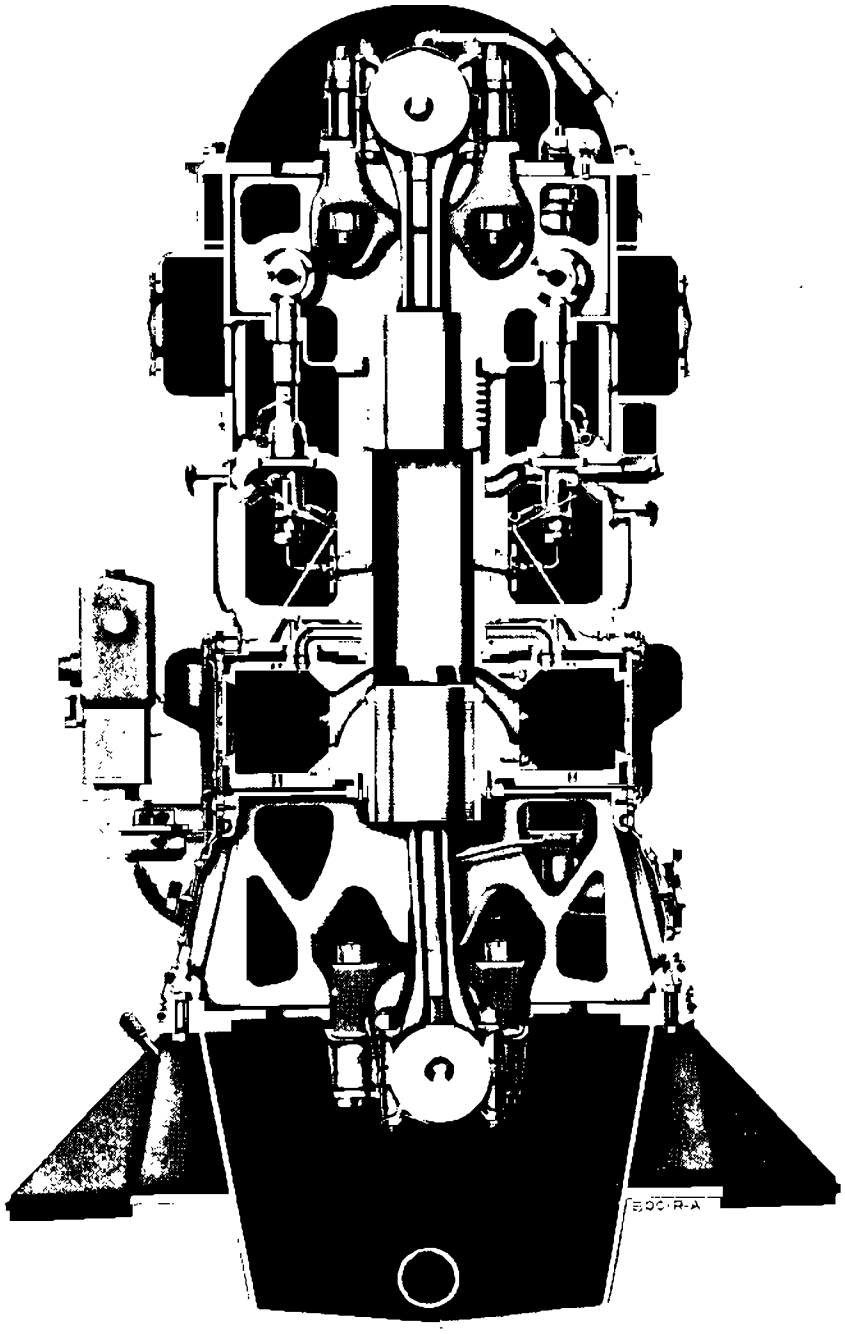
Printed in U.S.A.



Transverse Cross Section of the Engine

TABLE OF CONTENTS

Section



Transverse Cross Section of the Engine

TABLE OF CONTENTS

Section

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

ENGINEMEN'S MANUAL
SECTION 101A. GENERAL DESCRIPTION OF THE DIESEL ELECTRIC POWER EQUIPMENT
for
1600 H.P. Freight, Passenger, and Transfer Unit
and
2000 H.P. Freight and Transfer Unit

101A1. General Description of Equipment

Due to their similarity in design, both the 1600 H.P. units Type H16-44 and H16-66, and the 2000 H.P. Type H20-44 and H20-66 units are covered in this publication. Illus. A2 and A3 are the general arrangement of the 1600 H.P. units and Illus. A4 and A5 the 2000 H.P. units. More detailed description of these two models, with their design differences noted, are presented in the following sections.

The Diesel-electric motive power equipment, except for horsepower rating, is basically the same. It consists of a direct connected generator, an internal combustion engine unit, electrical apparatus to transmit the power, and traction motors geared to the driving axles of each truck. Suitable air brake equipment, frame, trucks, and accessories complete the locomotive.

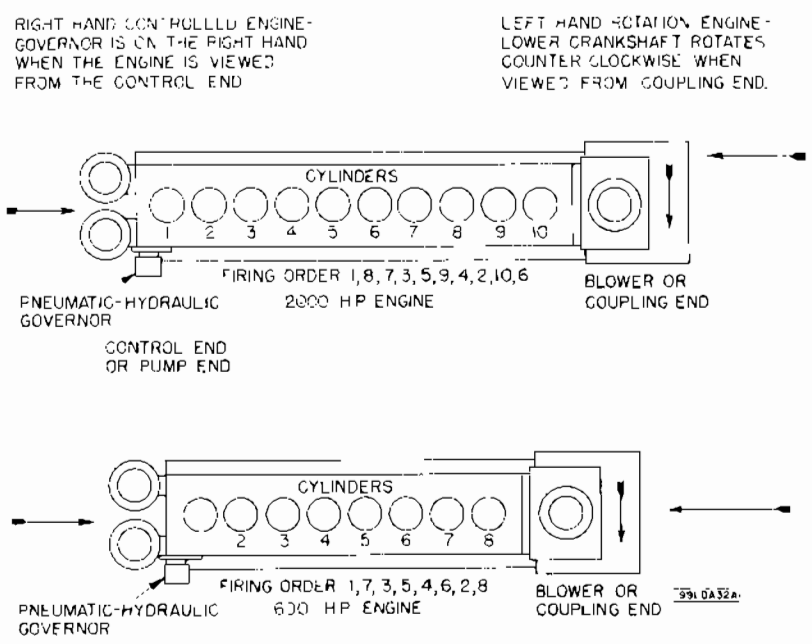
The electrical transmission affords smooth and gradual speed changes. Further smoothness of operation is guaranteed by an added development known as "Power Control." This feature makes these dual power locomotives. By this feature, the locomotive can be changed from "High Power" as used in regular service to "Low Power" for low speed operation when spotting cars or making couplings.

a. Diesel Engine

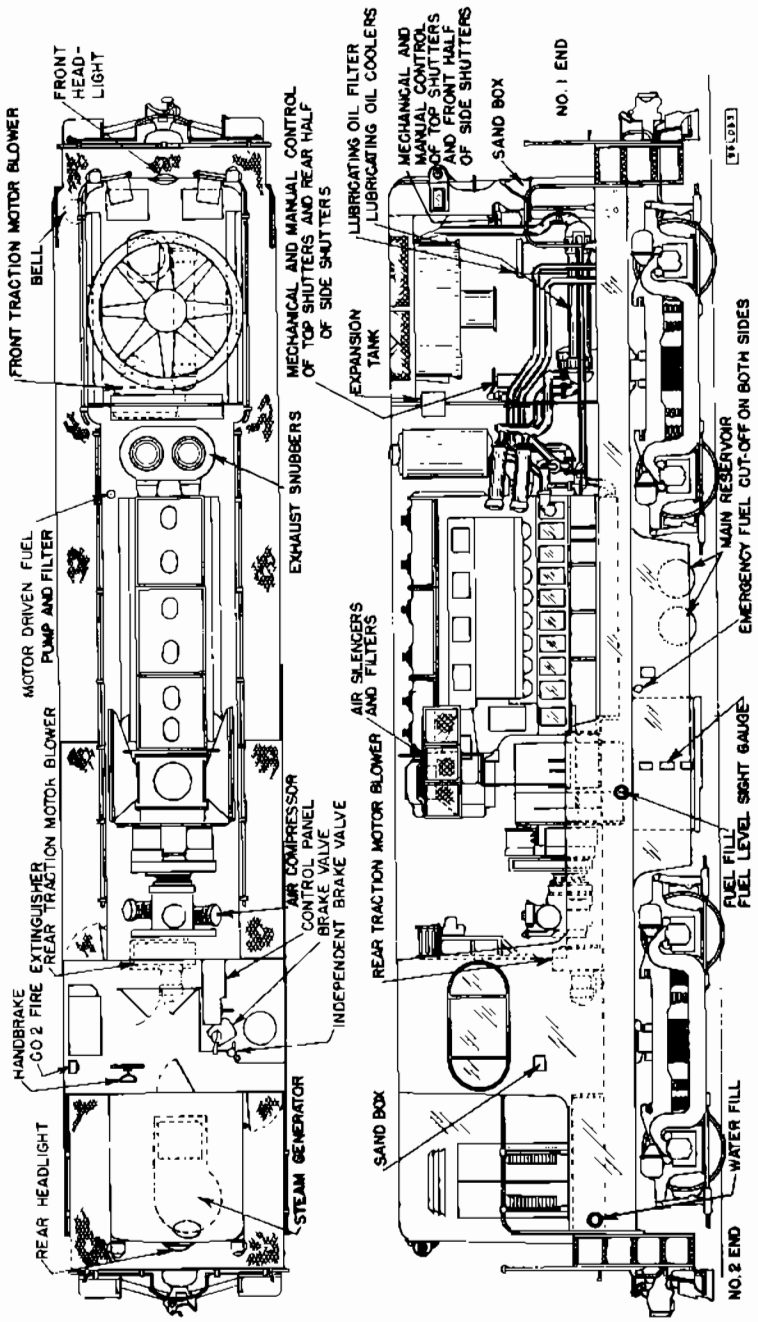
The engine used in these locomotives is of the opposed piston type in which two pistons work vertically towards each other in the same cylinder. The upper and lower pistons drive separate crankshafts which are interconnected by a vertical drive shaft and gears with a suitable flexible coupling of coil spring design. Fresh air is admitted to the cylinder and the 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 through one revolution of the crankshafts complete a cycle. The cycle begins with the movement of the pistons from their outer dead center. After the air from the rotary type blower is introduced 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.

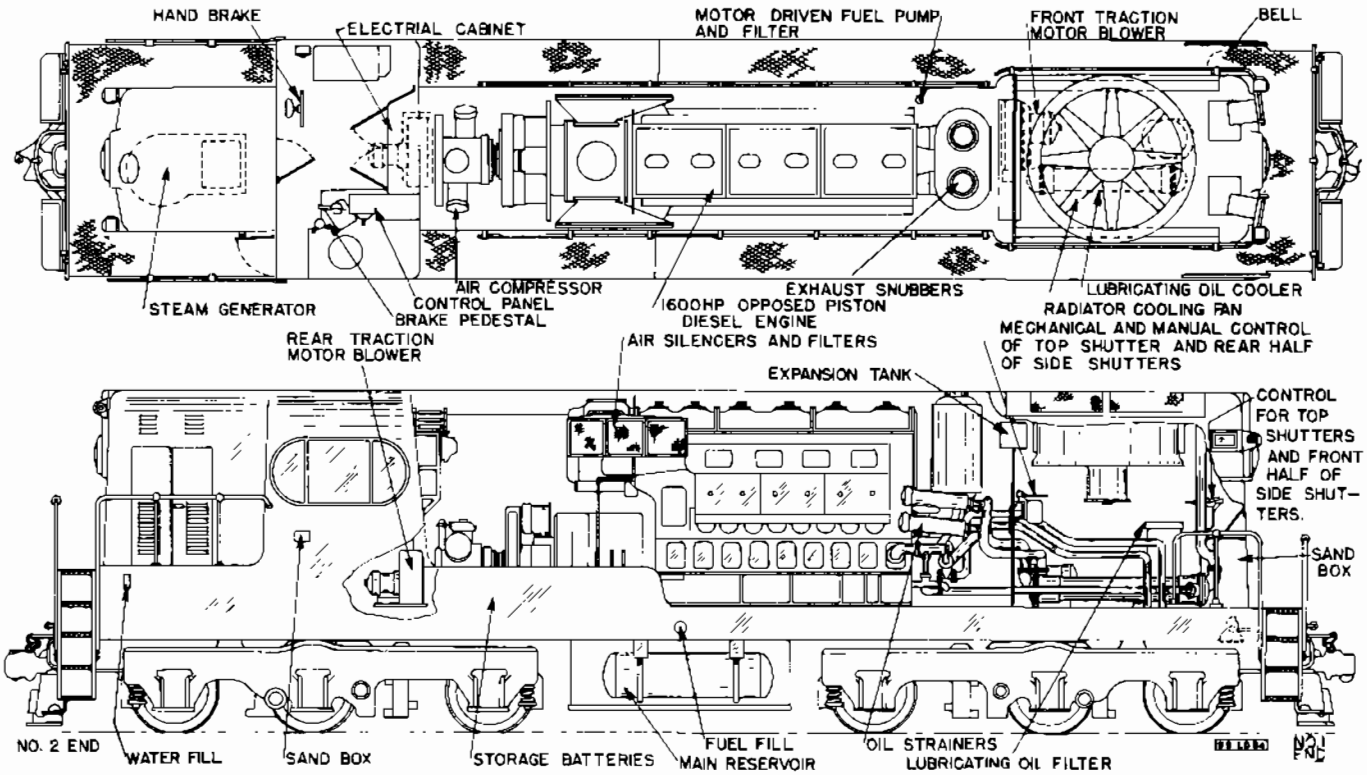
The expanding and burning of the gases continues until nearly the end of the power stroke when the lower piston begins to uncover the exhaust ports allowing the burned gases to escape to the atmosphere through the exhaust system. As the rotation



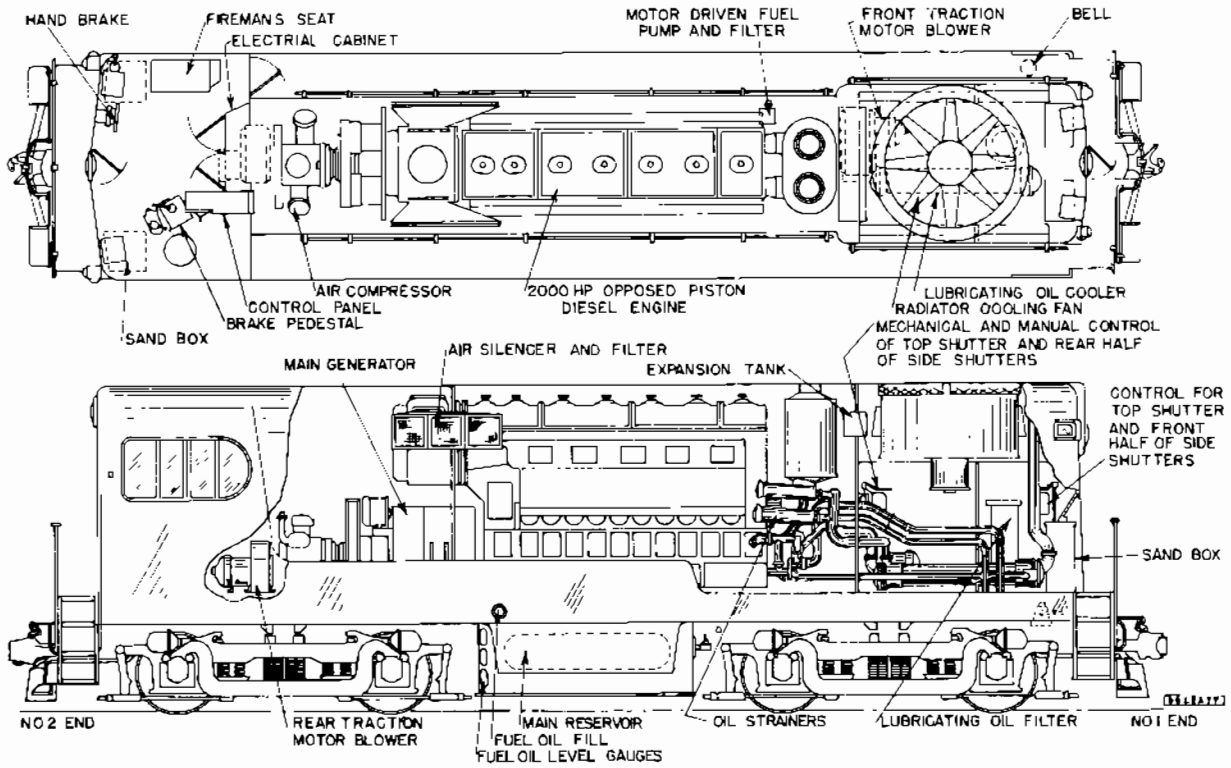
Illus. A1 Engine Arrangement and Firing Order



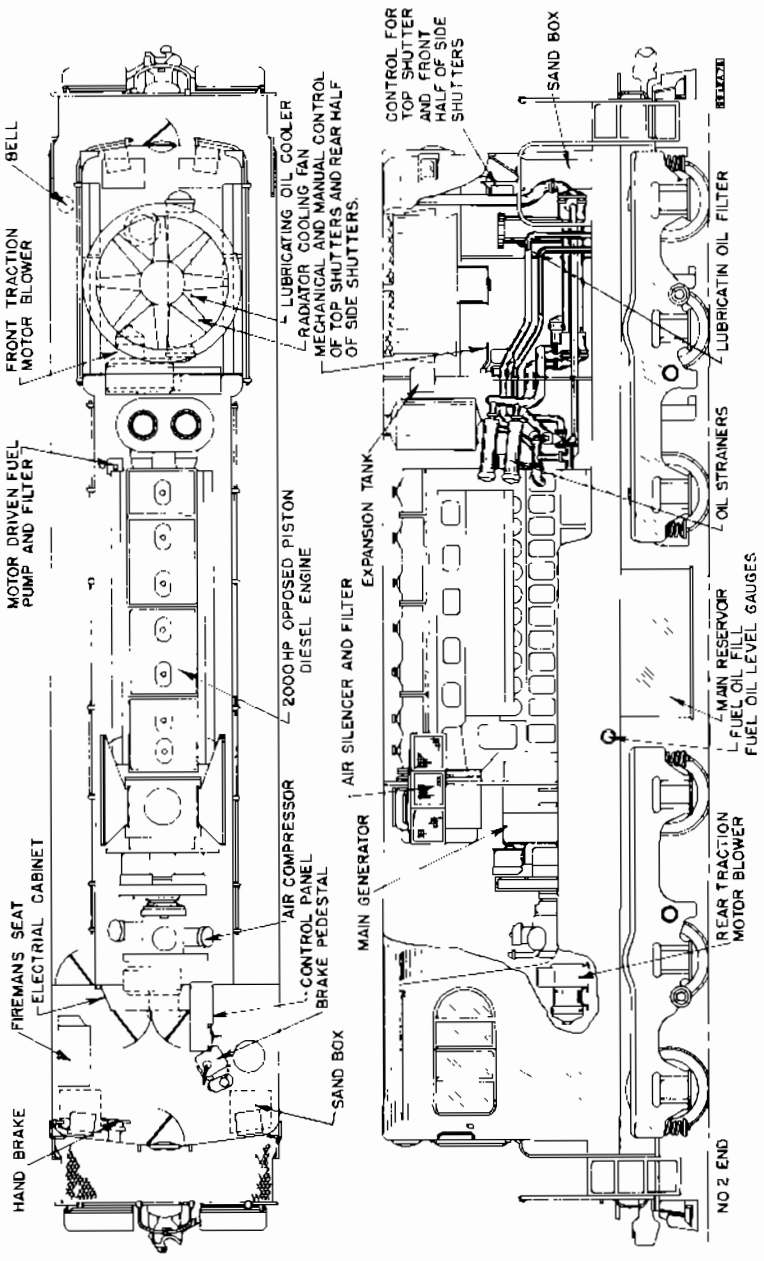
Illus. A2 General Arrangement 1600 HP Unit Type H16-44



Illus. A3 General Arrangement 1600 HP Unit Type H16-66



Illus. A4 General Arrangement 2000 HP Unit Type H20-44



Illus. A5 General Arrangement 2000 HP Unit Type H20-66

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 ports 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.

b. Electrical Rotating Equipment

1. **Traction Motors**

   Type—Westinghouse 370

2. **Main Generator**

   Type—Westinghouse 472-A

   The main generator furnishes power to the traction motors, and is directly connected to the engine crankshaft through a flexible coupling. The main generator is also utilized as a starting motor for the diesel engine by connecting the storage battery to the generator starting field and armature. The starting circuits are controlled by magnetic contactors which operate when the engine start button is pressed.

3. **Exciter**

   Type—Westinghouse YG-45-D, 75 volt Direct Current.

   The exciter furnishes main generator excitation, and is mounted on the main generator and belt-driven by a V-belt assembly from the main generator shaft.

4. **Auxiliary Generator**

   Type—Westinghouse YG-46-A, 75-volt Direct Current. Capacity 7.5 KW.

   The auxiliary generator provides power for controls, battery charging, and lighting. It is mounted on the main generator opposite from the exciter, and is belt-driven by a V-belt assembly from the main generator shaft.

   The auxiliary generator is regulated for 72-volts at idling and 75-volts at full speed by the voltage regulator.

5. **Fan Generator**

Type—Westinghouse YG-47-A. 125 volt, Direct Current.

The fan generator supplies current for the radiator fan motor and two traction motor blower motors. The fan generator is mounted on the end of the main generator shaft.

6. **Radiator Fan Motor**

Type—Westinghouse Y-62-A. 125 volt Direct Current.

7. **Traction Motor Blower Motors** (Two)

Type—Westinghouse Y-61-A

c. Air Compressor

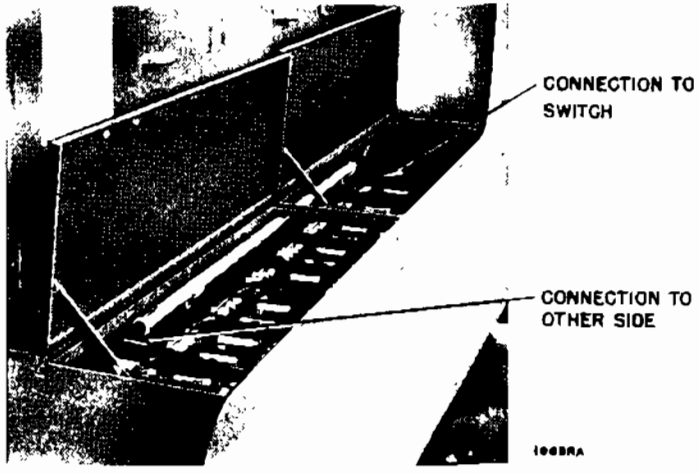
The air compressor is driven at engine speed through a flexible coupling to the main generator shaft. Maximum capacity is 262 CFM at full engine speed, and 92 CFM at idle engine speed. Maximum horsepower is 70.

d. Transition

Traction motors are permanently connected in series-parallel and hence require no transition, but do use automatic field shunting in four steps. Shunting differs from transition in that no power circuits are completely opened.

e. Operating with a Unit Shut Down

If necessary, one unit can be cut out and operation continued with the remaining units.



Illus. A6 Storage Battery

101A2. Locomotive Controls

a. Controller (Units with Westinghouse Electric Corp. Controller)
The throttle, reverse, and selector levers on the controller and the automatic and independent air brake valves control all locomotive operation. Breakers and switches must first be in proper position.

1. **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.

2. **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.

3. **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.

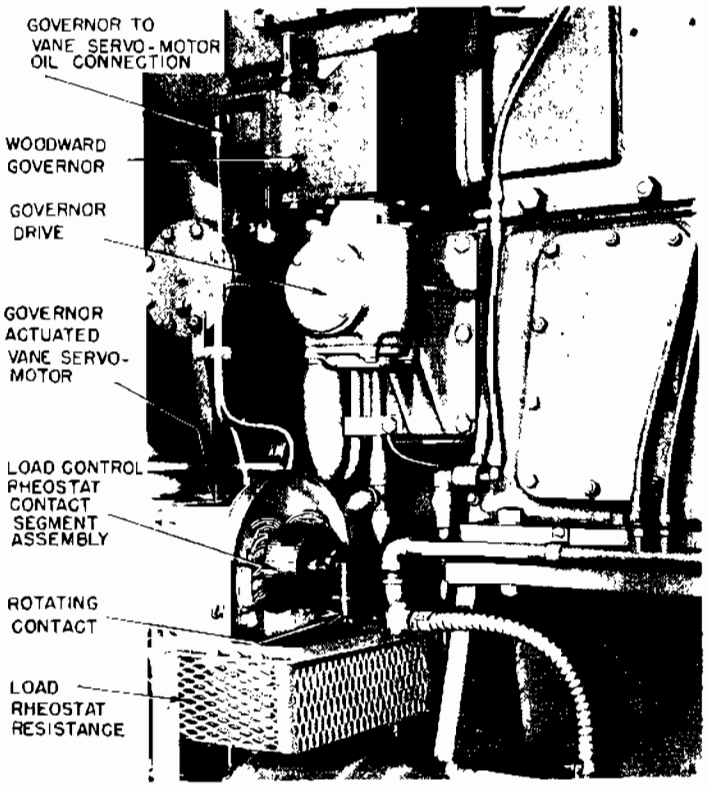
Normal operation is in position 1 when not in dynamic braking or operating with units of different model or manufacture. For operation with mixed units, follow special instructions. There is no connection between the selector lever and the automatic field shunting circuits of this locomotive; only to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

4. **Lever Interlocking**

Control stand levers are interlocked as follows:

a. 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".

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



Illus. A7 Governor and Load Control Rheostat

c. The **selector** handle cannot be moved from 1 to "OFF" unless the throttle handle is in "IDLE". It can be moved through 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.

d. 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".

e. 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. Controller (Units with Westinghouse Air Brake Co. Control)

The throttle lever and automatic and independent air brake valves control all locomotive operation. Breakers and switches must first be in proper position.

The throttle lever is designed to operate horizontally in two slots, with a connecting vertical slot which has a neutral position and locking device midway between top and bottom. The UPPER horizontal slot is for REVERSE operation, and the LOWER horizontal slot for FORWARD operation. There is no separate reverser.

NEVER REVERSE THROTTLE WITH LOCOMOTIVE IN MOTION. Doing so may cause serious flashovers of traction motors and main generator causing considerable damage to electrical equipment.

On the pneumatic-type throttle, there are no notches other than first notch at which power circuits close at idle engine RPM.

On the electric throttle, there are nine notches; idle, and 1-8 for running. Each notch closes electric contacts energizing engine governor solenoids as shown in the table in Sec. 101A3.

c. Engine Speed Control—Pneumatic Throttle

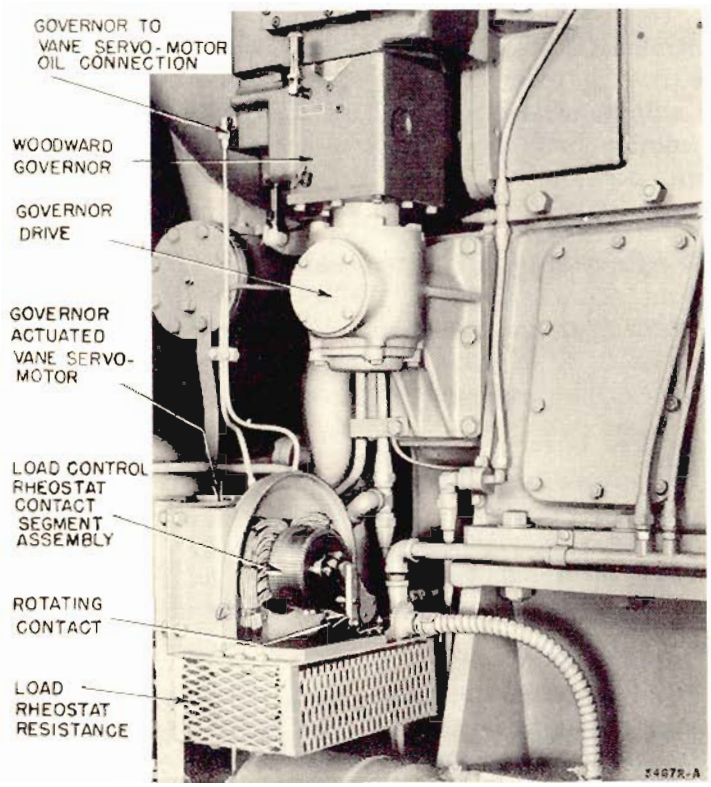
Engine speed control is accomplished by an air control valve mounted in the throttle and an actuator device incorporated in the top of the engine governor housing. Locomotive control air at 80 lbs. pressure is supplied to the air control valve. The air control valve delivers variable pressure in accordance with the throttle position. The actuator responds directly to the throttle, so with changes in the air control valve pressure the actuator takes positions in proportion to the pressure applied to it by the air control valve. Thus the speed of the engine and the power output is directly controlled thru the throttle.

d. Engine Speed Control—Electric Throttle

See Section on the Engine Governor.

e. Locomotive Run Switch

This switch controls the exciter field circuit. Switch must be in "OFF" position to start engine or pump up air and should be kept in "OFF" position until ready to operate locomotive.



Illus. A7 Governor and Load Control Rheostat

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f. Engine Start Button

This button energizes the engine starting contactors G + and G — For button to operate, Locomotive Run switch must be "OFF" and isolator (if used) in "IDLE" or "START" position.

g. Engine Stop Button

Pressing this button will stop the engine once it is brought to idle speed by the throttle, or isolator (if used). With electro-hydraulic throttle-governor control, the stop button **energizes** the governor "D" solenoid. With pneumatic throttle control, the stop button **de-energizes** the governor shutdown solenoid. On some units with MU control, the stop button is omitted and a "STOP" position on the isolator substituted.

h. Ground Relay Reset Button

To be operated when ground relay alarm occurs. ALWAYS BRING ENGINE TO IDLE TO RESET GROUND RELAY.

i. Isolator (used only on units with multiple-unit control)

The isolator provides control of the diesel engine independently of the throttle of the leading unit.

"STOP" Position (if used instead of a stop push button) will stop the engine.

"START" or "IDLE" Position

Engine is said to be "isolated" or "off the line" and will remain at idling speed regardless of throttle position. Power contactors P1 and P2, exciter field contactor EF, and throttle contactor TV cannot close. No power will be delivered to the traction motors. Other units are not affected.

If the engineer's throttle has a "stop" position, it will not shut down an engine which has been isolated.

The engine can be started only with the isolator in the "START" or "IDLE" position.

"RUN" Position

This places the engine under the engineer's controls, or "on the line". On some units there is a "RUN TRAIL" position for trailing units and a "RUN LEADING" position for the lead unit.

j. "POWER OFF" Light (if used)

The "POWER OFF" light indicates tripping of the PC switch, opening of power contactors, and dropping of engine speed to idle. Light will come on when a safety control, locomotive overspeed, train control, or emergency air brake application occurs.

The PC switch (when used) operates the PCR relay which opens power and governor control circuits to the controller. The effect is the same as if the throttle were returned to idle manually.

Fuel Pump Operation is Not Affected

To reset the PC switch, return throttle to idle and lap automatic brake valve until application pipe pressure builds up to normal.

k. Wheel Slip Light

The wheel slip light indicates wheel slippage of one or more driving axles.

l. Circuit Breakers

Circuit breakers include a **Control Breaker** energizing circuits not controlled by the **Control Fuse** (see 13-d), and a **Fuel Pump Breaker** used on units equipped with multiple-unit and electric throttle control. 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".

m. Fuel Pump Breaker (used only with multiple-unit electric throttle control)

This breaker must be "ON" in the leading unit to energize the fuel pump switches in each unit which start each individual fuel pump.

n. Fuses

Fuses aboard are as follows:

1. **100-amp. Battery Charging Fuse**

   Located on cab side of high voltage cabinet.

   ALWAYS SHUT ENGINE DOWN TO REPLACE THIS FUSE, otherwise serious arcing and personal injury may occur.

   Blowing of this fuse will be shown by a continuous discharge reading on the battery charging ammeter in front of the engineer.

2. **400-amp. Cooling Fan Motor Fuse**

   Located on engine side of high voltage cabinet.

   ALWAYS SHUT ENGINE DOWN TO REPLACE THIS FUSE, otherwise serious arcing and personal injury may occur.

   Blowing of this fuse will result in a hot engine alarm.

3. **225-amp. Traction Motor Blower Motor Fuse**

   Located on engine side of high voltage cabinet.

   ALWAYS SHUT ENGINE DOWN TO REPLACE THIS FUSE, otherwise serious arcing and personal injury may occur.

   Blowing of this fuse will result in a "Blower Stopped" alarm.

4. **25-amp. Control Fuse and 25-amp. Excitation Fuse**

   Located on cab side of high voltage cabinet.

   Blowing of either fuse causes loss of power.

5. **25-amp. Locomotive Lights Fuse**

   Located on cab side of high voltage cabinet. Controls all lights except headlights and cab lights.

6. **25-amp. Headlight Fuse**

   Located on cab side of high voltage cabinet. Controls headlight circuits.

7. **25-amp. Cab Light Fuse**

   Located on cab side of high voltage cabinet. Controls cab light circuits.

o. Main Battery Switch

This is a double pole knife switch located on the cab side of the high voltage cabinet. It connects all control and lighting circuits to the battery except the cab lights.

p. Traction Motor Cutout Knife Switches

These are located on the cab side of the high voltage cabinet.

Switch TMCO 1 cuts out traction motors on No. 1 truck.

Switch TMCO 2 cuts out traction motors on No. 2 truck.

Main generator power is automatically reduced 50% when a truck is cut out. This is done by energizing the engine governor overriding solenoid to send the load regulator to minimum field.

q. Control Air Gauge

This gauge is located in front of the engineer and indicates pressure of control air used to operate the power contactors, pneumatic throttle (if used) and reverser. (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.) Normal control air pressure is 80 ± 5 lbs. The reducing valve and shutoff cock are located in the lower part of the high voltage cabinet.

r. Battery Ammeter

This meter is located in front of the engineer and indicates charging current to or discharge current from the battery. With engine running, this meter should always indicate a charge. If battery is fully charged, charging current will be very small. A continuously high charge reading should be reported for attention. A continuous discharge reading with the engine running indicates a blown battery charging fuse. (See item 14-a.)

s. Engine Overspeed Reset Lever

The engine overspeed reset lever is located on the engine above the governor. To reset, pull lever as far as possible in the direction shown by the arrow until it latches. Overspeed trip is set for approximately 950 RPM.

101A3. Governor and Speed Control

The engine governor is the Woodward Type PG with

1. Electro-hydraulic speed control.
2. Built-in engine low oil pressure shutdown protection.
3. External 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, traction motor cutout, or "Low Power" operation (if used).

a. Electro-Hydraulic Speed Control

Governor speed control utilizes four solenoids in the governor energized through four control trainline wires running from the lead unit through 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	A	B	C	D		Approx. RPM Engine Speed
Stop Position of Button or Isolator				*	(Unit Affected)	0
Stop				*	(All Units)	0
Idle						300
1						300
2	*					380
3			*			460
4	*		*			540
5		*	*	*		620
6	*	*	*	*		700
7		*	*			780
8	*	*	*			850

b. Pneumatic-Hydraulic Speed Control—See "Engine Control—Pneumatic Throttle" Sec. 101A2 Par. c.

c. 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 pressure" alarm light will show on the control panel of the unit affected.

A push button on the engine side of the governor housing will move out approximately ⅜" exposing a red band around the bottom. To stop the alarm,

1. Push in botton on governor. Thus will put out yellow alarm light.
2. Isolate unit. This will stop alarm bells.

The governor push button will trip only from an actual low oil pressure alarm and not if the engine stops for any other reason.

A time delay is provided so that after a low oil alarm the engine may be started and idled for approximately forty seconds so 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 4 PSI at idle will shut the engine down after the 40 second time delay. Pressure less than 15 PSI at full engine speed will shut the engine down without a time delay.

d. Load Regulator

The load regulator 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.

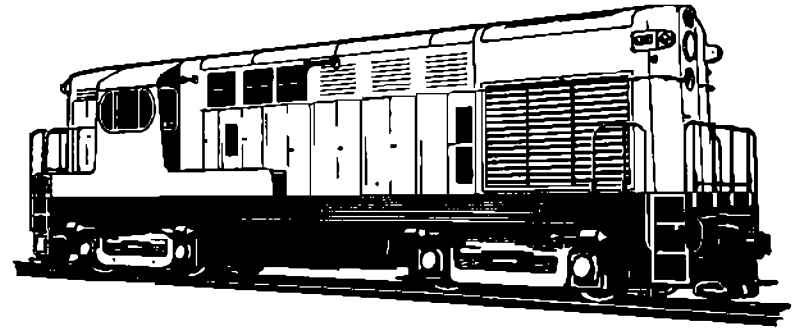
Brush arm travel is from 7 o'clock at minimum field to 5 o'clock at maximum field.

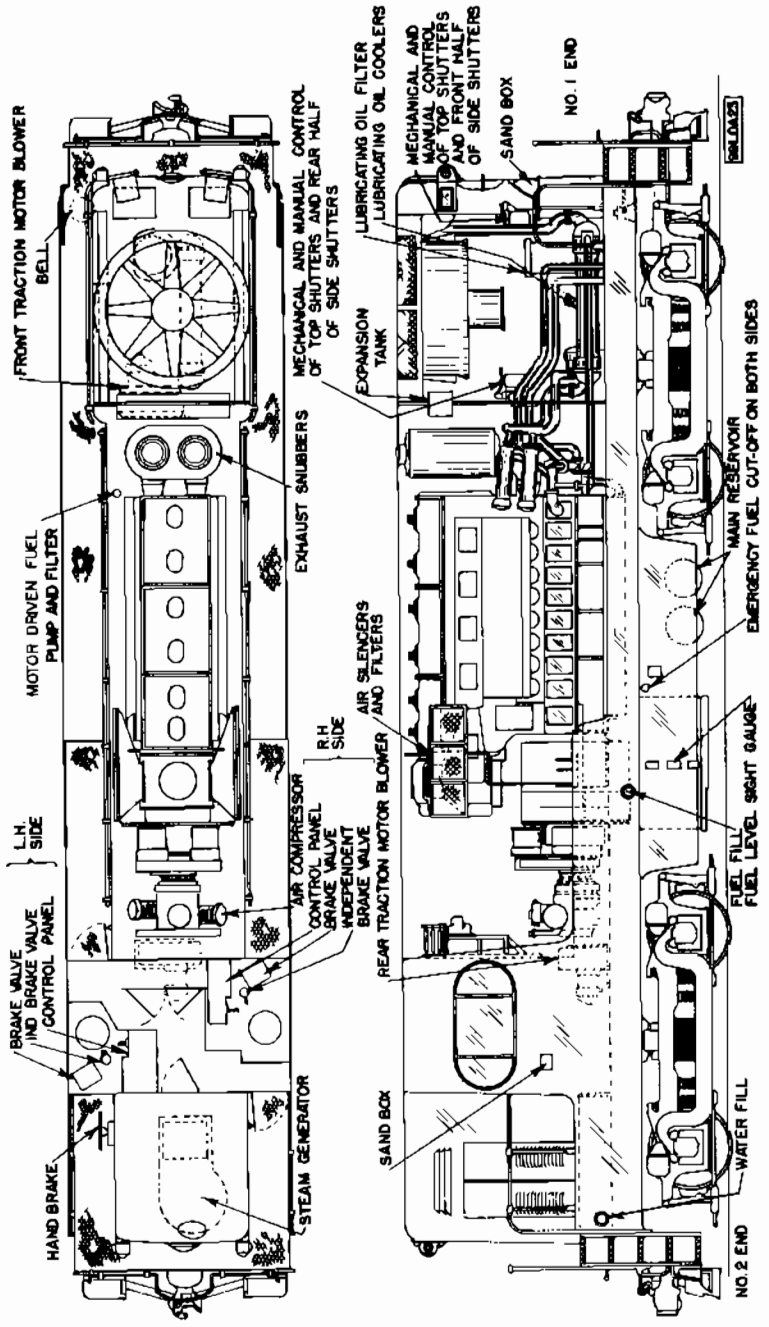
The governor is provided with a load control pilot valve which is connected to the tail road of the power piston and also the speed setting piston by a floating lever and linkage. The governor pilot valve plunger will be centered when the fuel injection setting is correct for the speed setting. This does not constitute a torque control since the centered position of the valve is dependent on speed setting and not on the actual engine speed.

If engine load tends to exceed the rated figure, the engine fuel control linkage through the power piston will cause the governor pilot valve to allow oil to flow to the load regulator. The regulator will move in a direction to insert more resistance in the exciter battery (4-pole) field. This reduces the load on the main generator and prevents overloading. In like manner the load regulator operates to prevent underloading and to give full fuel for each throttle position.

e. 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. At full throttle the "Speed" pointer should be at 8 and the "Fuel" pointer between 6 and 8.





Illus. A8 General Arrangements of 1600 H.P. Dual Control Unit

Section 102A Data 1600 HP Class

A General Data	H-16-44	H-16-64	H-16-64
Whyte Symbol	0-4-4-0	0-6-6-0	0-6-6-0
Weight on Drivers, Loaded, Ready for Service	243 000	168 000	300 000
Number of Drivers	8	8	12
Diameter of Drivers	42"	42"	42"
Size of Journals —Roller	6½ x 12	6½ x 12	6½ x 12
Tractive Effort 25% Starting Adhesion	60 750 lbs.	42 000 lbs.	75 000 lbs.
Maximum Continuous Tractive Effort:			
Gear / Pinion / Max. M.P.H.			
68 / 15 / 65	52,500 lbs.	52,500 lbs.	78,700 lbs.
63 / 15 / 70	48,600 lbs.	48,600 lbs.	72,900 lbs.
62 / 17 / 80	42,200 lbs.	.....	.....
60 / 19 / 90	36,600 lbs.	.....	.....
Engine Rating for Traction (at Sea Level)			
B.H.P. at 850 R.P.M.	1600 H.P.	1600 H.P.	1600 H.P.
Engine Idling Speed—R.P.M.	300	300	300
Minimum Radius of Curve — Locomotive only	150'0"	155'0"	155'0"
Length Overall—Inside Knuckles	54'0"	55'0"	55'8"
Height Overall—Above Rails	14'6"	14'6"	15'0"
Width—Outside Grab Irons	10'4"	10'4"	10'4"
Fuel Oil Capacity—Gals.	900	800	800
Lub. Oil Capacity (oil change—New Fill) Gals.	300	300	300
Lub. Oil Capacity (Eng. Add to Eng. Full) Gals.	50	50	50
Cooling Water Capacity (to Overflow) Gals.	160	175	175
Cooling Water Overflow Low to Overflow) Gals.	35	35	35
Heating Water Capacity Gals.	740	740	740
Air Compressor Crankcase Lub. Oil			
Capacity—Gals.	3 5	3.5	3.5
Sand Capacity—Cu. Ft.	28	28	28
B Weight			
The approximate weights for lifting purposes of principal parts are listed below:			
Engine with Sub-base Generator and Exciter	42,100	42,100	42,100
Engine and Sub-base (dry)	33,000	33,000	33,000
Truck complete with motors	42,000	52,000	57,000
Traction Motor only—complete	7,380	7,380	7,380
Truck Frame without Axles, Wheels or Motors	9,380	14,000	14,000
One pair of Wheels with Axle and Gear	3,930	3,930	3,930
Main Generator with Aux. Generator and Exciter	14,930	14,930	14,930
Exciter and Auxiliary Generator and Sheaves	1,180	1,180	1,180
Vapor Steam Heating Boiler	3,200	3,200	3,200
Elesco Superheater Boiler	5,300	5,300	5,300
Engine Blower	2,000	2,000	2,000
Upper Crankshaft	1,600	1,600	1,600
Engine Sub-base	4,500	4,500	4,500
Locomotive Hatch—Per Section	350	350	350
Engine Top Cover	300	300	300

Section 102B Data 2000 HP Class

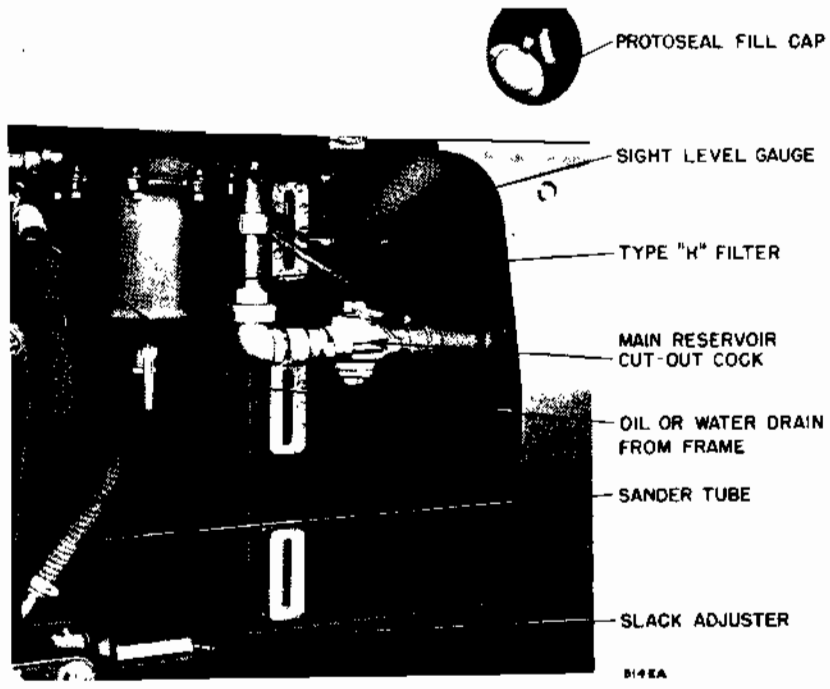
A General Data	H20-44	H20-66
Whyte Symbol	0-4-4-0	0-6-6-0
Weight on Drivers, Loaded, Ready for Service	250,000	280,000
Number of Drivers	8	12
Diameter of Drivers	42"	42"
Size of Journals	6½ x 12	6½ x 12
Tractive Effort 25% Starting Adhesion	62,500	70,000
Maximum Continuous Tractive Effort	42,000	64,200
Engine Rating for Traction (at Sea Level) B.H.P. at 850 R.P.M.	2,000	2,000
Engine Idling Speed—R.P.M.	300	300
Minimum Radius of Curve—Locomotive only	150'0"	155'0"
Length Overall—Inside Knuckles	51'0"	52'8"
Height Overall Above Rails	14'6"	15'0"
Width Outside Grab Irons	10'6"	10'6"
Fuel Oil Capacity—Gals.	1200	1200
Lub. Oil Capacity (oil change—New Fill) Gals.	350	350
Lub. Oil Capacity (Engine Add to Engine Full) Gals.	60	60
Cooling Water Capacity (to Overflow) Gals.	225	225
Cooling Water Capacity (Low to Overflow) Gals.	35	35
Air Compressor Crankcase Lub. Oil Capacity—Gals.	3.5	3.5
Sand Capacity—Cu. Ft.	28	28
B Weight		
The approximate weights for lifting purposes of principal parts are as listed below:		
Engine with Sub-base, Generator and Exciter	57,100	57,100
Engine and Sub-base (dry)	39,250	39,250
Truck complete with motors	42,000	57,000
Traction Motor only—complete	7,380	7,380
Truck Frame without Axles, Wheels or Motors	9,380	13,000
One pair of Wheels with Axle and Gear	3,930	3,930
Main Generator, Auxiliary Generator and Exciter	16,450	16,450
Exciter and Aux. Generator and Sheaves	950	950
Blower	2,500	2,500
Upper Crankshaft	2,085	2,085
Engine Sub-base	5,100	5,100
Locomotive Hatch—Per Section	350	350
Engine Top Cover	340	340

SECTION 104A. LOCOMOTIVE OPERATION

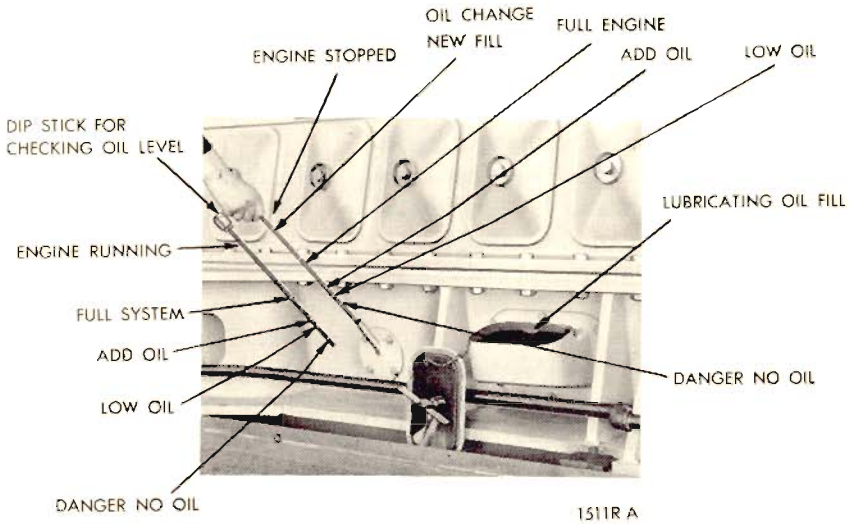
104A1. Locomotive Operation

a. Before Operating Locomotive

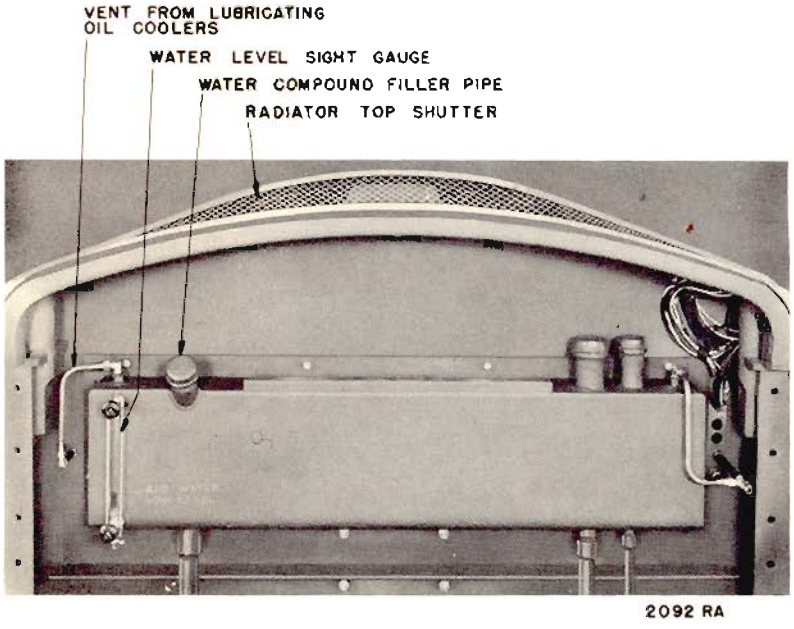
1. Drain main air reservoirs, intercoolers and dirt collectors.
2. Check hand brake for holding.
3. Check fuel supply, Illus. A1.
4. Check engine **lubricating oil level,** Illus. A2.
5. Check water level, Illus. A3.
6. Check sand and supplies.
7. Check air compressor oil level, Illus. A4.
8. Check governor oil level, Illus. A5.
9. Turn on light switches as required. The gauge light switch controls the gauge, number, and ground lights. The classification light switch turns on either the front or rear classification lights. 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.



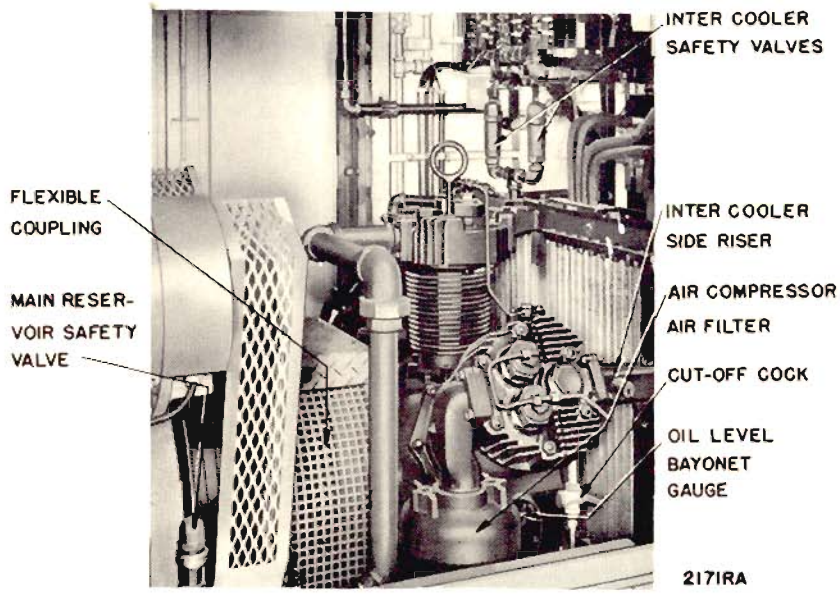
Illus. A1 Fuel Tank



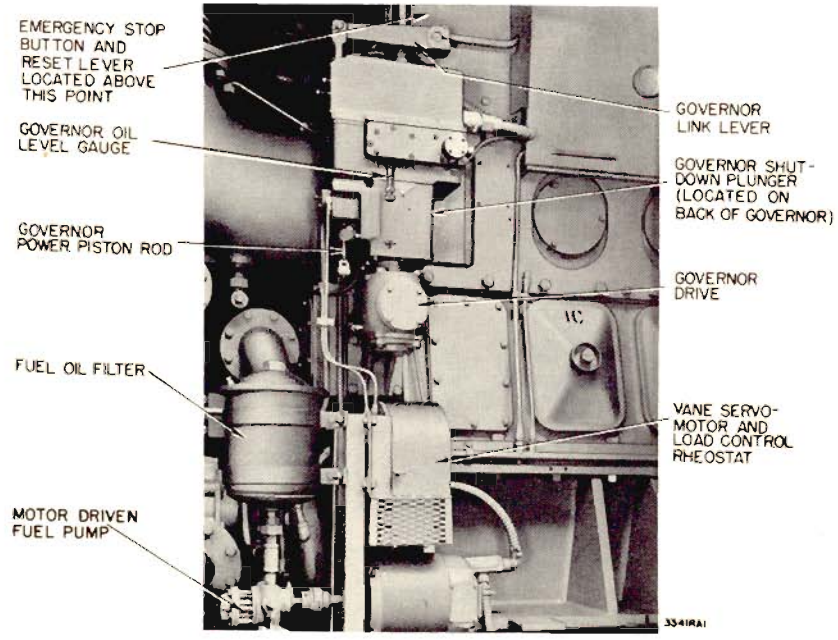
Illus. A2 Lubricating Oil Fill and Dip Stick



Illus. A3 Expansion Tank



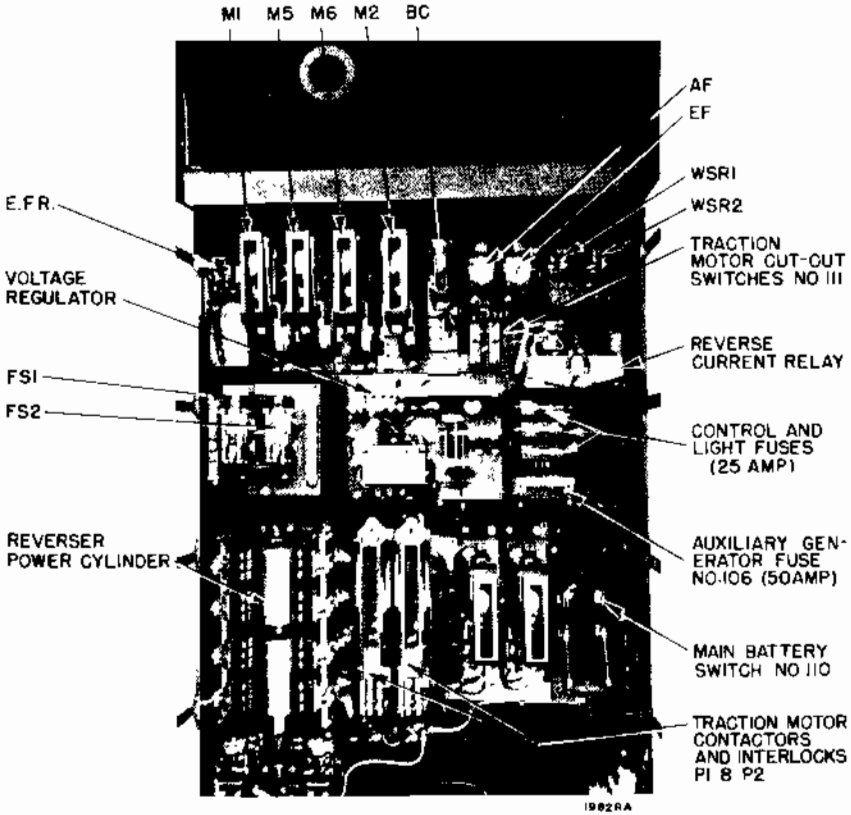
Illus. A4 Engine Room at Air Compressor



Illus. A5 Pneumatic-Hydraulic Governor

b-1. Preliminary Control Check (New Haven R.R. Units 560-569)

	Trailing Units	Leading Unit
1. Throttle Handle	Locked in Neutral	Neutral
2. Main Battery Switch	On	On
3. **Isolator Positions**		
To start engine	Idle	Idle
To put engine on line	Run Trail	Run Leading
To take engine off line	Idle	Idle
To stop engine (from leading unit, stops all engines. From trailing unit, stops trailing engine only.)	Stop	Stop
4. Control Breaker	Off	On
5. Fuel Pump **Breaker** (Energizes fuel pump trainline wire)	Off	On
6. Fuel Pump **Switch** (Connects fuel pumps to fuel pump trainline wire)	On	On
7. Locomotive Run Switch	Off	Off



Illus. A6 Electrical Cabinet—Switches and Fuses

8. Traction Motor Cutout Switches	Closed	Closed
9. Engine Overspeed Trip	Set	Set
10. Governor Low Oil Pressure Button	Set	Set
11. **6-DS Brake Equipment**		
Brake Valve Cutout Cock	Closed	Open
Transfer Cock	Open	Closed

b-2. Preliminary Control Check

(Units with Westinghouse Electric Controllers)

	Trailing Units	Leading Unit
1. Throttle Handle	Idle	Idle
2. Selector Handle	Off	Off
3. Reverse Handle	Removed	Neutral
4. Main Battery Switch	On	On
5. **Isolator Positions**		
To start engine	Start	Start
To put engine on line	Run	Run
To take engine off line	Idle	Idle
6. Control Breaker	Off	On
7. Fuel Pump **Breaker** (Energizes fuel pump trainline wire)	Off	On
8. Fuel Pump **Switch** (Connects fuel pumps to fuel pump trainline wire)	On	On
9. Locomotive Run Switch	Off	Off
10. Traction Motor Cutout Switches	Closed	Closed
11. Engine Overspeed Trip	Set	Set
12. Governor Low Oil Pressure Button	Set	Set
13. **24-RL Brake Equipment**		
Brake Valve Cutout Cock	Closed	Open
Rotair Valve	Lap	Pass. or Frt.
14. **6-DS Brake Equipment**		
Brake Valve Cutout Cock	Closed	Open
Transfer Cock	Open	Closed
15. **6-SL Brake Equipment**		
3-Position Cock	Trlg.	Lead
16. **6-BL Brake Equipment**		
3-Position Cock	Trlg.	Lead
	Trailing Units	**Leading Unit**
	Trailing Units	**Leading Unit**

b-3. Preliminary Control Check—Units with Pneumatic Throttle and Single Control

	Trailing Units	Leading Unit
1. Throttle	Locked in Neutral	Neutral
2. Main Battery Switch	On	On
3. **Isolator Positions** (Units with MU Control only)		
To Start Engine	Idle	Idle
To Put Engine on Line	Run	Run
To Take Engine off Line	Idle	Idle

4. Control Breaker	Off	On
5. Fuel Pump Switch	On	On
6. Locomotive Run Switch	Off	Off
7. Traction Motor Cutout Switches	Closed	Closed
8. Engine Overspeed Trip	Set	Set
9. Governor Low Oil Pressure Button	Set	Set
10. Throttle Rotair Valve	Closed	Open
11. Brake Valve Cutout Cock	Closed or Trlg.	Open or Lead
12. Rotair Valve (24-RL Equipment)	Lap	Pass. or Frght.
13. Transfer Cock (6-DS Equipment)	Open	Closed

b-4. Preliminary Control Check—Units with Pneumatic Throttle and Dual Control

	Trailing Units		Leading Unit	
	RH-Side	LH-Side	Control Side	Non-Control Side
1. Throttle	Both Locked in Neutral		Neutral	Locked Neutral
2. Main Battery Switch	On		On	
3. **Isolator Positions** (Units with MU control only)				
To Start Engine	Idle	.....	Idle	
To Put Engine on Line	Run	.....	Run	
To Take Engine Off Line	Idle	.....	Idle	
4. Control Transfer Switch	.....	RH-Side Operation	Control Side Operation	
5. Throttle Rotair Valve	Closed	Closed	Open	Closed
6. Control Breaker	Off	.....	On	
7. Fuel Pump Switch	On	.....	On	
8. Locomotive Run Switch	Off	Off	Off	Off
9. Traction Motor Cutout Switches	Closed		Closed	
10. Engine Overspeed Trip	Set		Set	
11. Governor Low Oil Pressure Button	Set		Set	
12. Brake Valve Cutout Cock	Closed	Closed	Open	Closed
13. Rotair Valve (24-RL Eq.)	Lap	Lap	Pass. or Frt.	Lap
14. Transfer Cock (6-DS Eq.)	Open	Open	Closed	Open

c. To Start Engine and Put On Line

1. Set up controls according to the **Preliminary Control Check** in b. On a multiple-unit locomotive the **isolator** must be in **IDLE** position if there is an engine start button. If there is no engine start button, pull out isolator handle in **START** position.
2. **On single-unit locomotives with no isolators, the Locomotive Run Switch must be in OFF to start the engine.**
3. Press **start button** or pull out **isolator** handle in **START** position. Hold until engine fires. If the engine fails to fire after making several revolutions, release as continued cranking will run down the batteries. The engine should start firing in four to six seconds. If the engine was cold when started ,allow to warm up to 100 degrees before moving locomotive.
4. Put engine on line by placing **isolator** in **RUN** position. **ENGINE WILL NOT DELIVER POWER IF EITHER CONTACTOR STICKS CLOSED.**

d. To Stop Engine

1. Turn isolator to STOP position (New Haven Units 560-569). Press **engine stop** push button (all other units) after bringing throttle or isolator to IDLE position.
2. Snap OFF Fuel Pump **Switch.**
3. If leaving unit, also:
   (a) Lock throttle in NEUTRAL or remove reverse handle.
   (b) Snap OFF **Control** breaker.
   (c) Set independent and hand brakes.
4. 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 stop must be reset. The reset lever is located just below the "Emergency Stop" button.
5. CAUTION: Before stopping the engine, except in an emergency, wait until the water temperature drops to 165° F.

e. Alarm Bell—Units with MU Control

Both units have an alarm bell which rings when any of the four warning circuits are energized and the warning lights burn. Four circuits covered are: electrical circuit ground, high engine temperature, traction motor blowers stopped, and low lubricating oil pressure. When the alarm rings and none of the four indicator lights in the leading unit are

burning, the trouble is in the trailing unit and it will be necessary to check the indicator lights in that unit to determine the trouble. If the trouble is in the leading unit it will be evidenced by the proper light coming on as well as the ringing of the alarm bell. See Section 107A1 "Automatic Alarm and Safety Devices".

f. **After the Engine is Running**

1. Check the battery ammeter. With the engine running, this meter should always indicate a charge. After the locomotive has been in operation for a period of time, the reading should show a small charge only. A continuously high charge reading should be reported for attention.
2. See that the control air pressure gauge indicates 80 to 85 pounds pressure.
3. Normal lubricating oil pressure as shown on the engineer's gauge should be not less than 6 pounds with engine idling and 24 pounds at full speed.
4. Fuel oil pressure on the engineer's gauge should not be less than 5 pounds. See trouble shooting section for possible causes of low fuel or lube oil pressures. (Sec. 104A2)
5. At the thermometers on the control panel, check the temperature of both the lubricating oil (entering the engine) and the jacket water (out of the engine). These should average about 165° with 75° atmospheric temperature. These temperature readings will vary, depending on engine load and atmospheric conditions. On hot days, 105-110° F., the cooling water temperature may rise to 195° and the lubricating oil temperature to 175° F. with satisfactory operation. If these temperatures continue to rise, a hot engine alarm will result and power should be reduced.

g. **Before Moving Locomotive**

1. Make air tests.
2. Test horn, bell, and sanders.
3. Release hand brake.
4. Move selector lever to: (Units with Westinghouse Electric controller only.)
   (a) Position 1 when locomotive consists entirely of Fairbanks-Morse units.

   (b) Position required for operation of trailing units when locomotive includes units of different model or manufacture.
5. Move reverse lever to desired position.

h. **To Move Locomotive**

1. Snap ON **Locomotive Run** Switch.
2. Place foot on safety control pedal (if used) and release independent brake.
3. Open throttle as required.

i. **To Pump Up Air On Train**

1. Move **reverse** lever to NEUTRAL or OFF.
2. Snap OFF **Locomotive Run** Switch.
3. Open throttle as required.
4. Return throttle to IDLE and snap ON **Locomotive Run** switch.

j. **Starting a Train**

1. **Use of Sand**
   On this locomotive it is permissible to use sand whenever necessary to forestall wheel slippage. To obtain maximum performance, use of sand is recommended (railroad instructions permitting) where slippage is likely to occur.
   Sanders are provided ahead of each truck in either direction. If wheel slipping occurs, notch off throttle until slipping stops. **SAND SHOULD NOT BE USED UNTIL SLIPPING STOPS.**

2. **Starting Freight Trains**
   (a) 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.
   (b) Open throttle to the first notch and note from the load ammeter that power comes on. Advance throttle until train begins to move. Bunching slack is normally unnecessary. If slack is bunched, be careful to avoid damage to knuckles and drawbars. Going beyond half throttle should not be necessary to start. If so, look for sticking brakes or coupler damage may

result. **Do not allow the locomotive to remain stationary with power on as serious damage to the main generator and traction motors will result.**

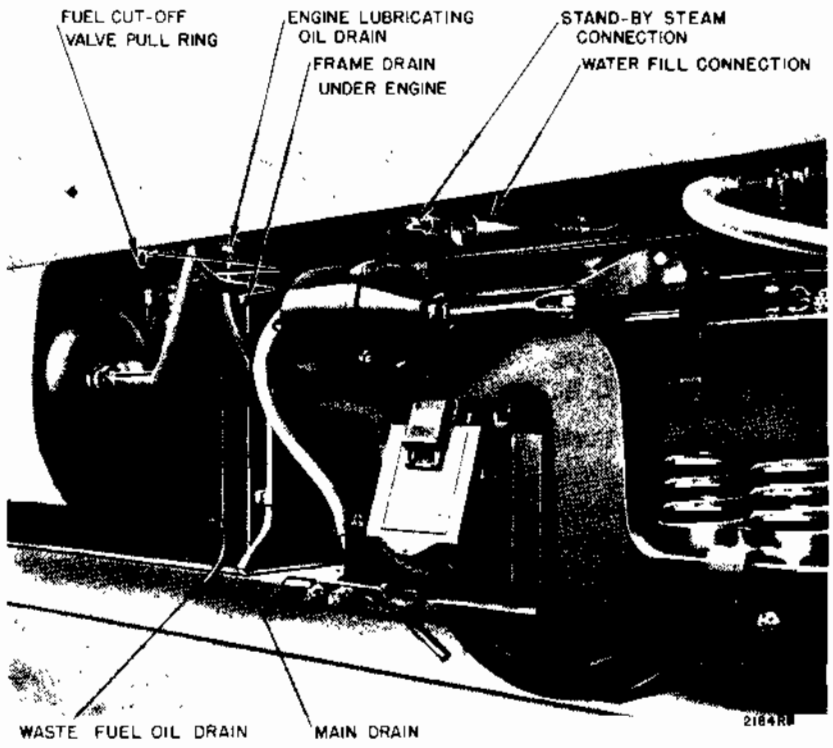
(c) The current required to start the train may move the load ammeter pointer into the overload (red) zone. This is permissible on starting and is recommended for good performance where conditions permit. **However, ammeter pointer must steadily return to the continuous (white) zone or the tonnage is excessive.**

3. **Starting Passenger Trains**

(a) Place foot on safety control pedal and release brakes.

(b) Open throttle, considering:

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



Illus. A7 Water Fills, Steam Connection, and Water and Oil Drains

(2) Slack action, depending upon how many cars have Titelock couplers, and length of train.

(3) Rail Conditions.

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

k. **Low Power Control**

1. To aid in spotting cars, making soft couplings and in humping operations, locomotives can be equipped with "Low Power" control on railroad request. Pressing of the engineer's "Low Power" button will reduce power from that normally available as the throttle is notched out. The load regulator remains in minimum field in all throttle notches instead of moving clockwise from minimum field in the first and succeeding notches.

2. To return unit to normal power, the "High Power" button must be pressed. This allows the load regulator to travel from minimum field to its normal position.

3. "High Power" operation will cut in automatically with the throttle beyond 4th notch or 540 RPM (8-step throttles) or ⅔ travel and 650 RPM on pneumatic throttles. High power operation nullifies low power operation which will have to be reset by pressing the "Low Power" button if low power is again desired. CAUTION: **Do not press "Low Power" button beyond automatic high-power cut-in point, to avoid power cycling.**

l. **Load Limits**

1. **General Instructions**

The tonnage hauled must be limited to that which will allow the load ammeter pointer to remain in the white area when operating on the ruling grade. If the pointer goes into the red area, except temporarily when starting or accelerating the train, the locomotive is overloaded **AND TONNAGE MUST BE REDUCED OR HELP OBTAINED.**

Exception: In certain specific cases, operation in the overload (red) zone may be permissible for short periods on particular grades. In these instances, authorization will be given in the form of railroad orders or

bulletins after a study of operating conditions has indicated that the overload operation is safe.

2. **WHEN OPERATING WITH A PAIR OF TRACTION MOTORS CUT OUT, LOAD CURRENT MUST BE RESTRICTED TO ONE-HALF OF MAXIMUM CONTINUOUS.** This means the load current must not exceed one-half of the highest reading on the white scale (except when accelerating the train) when operating with two traction motors cut out. Engine power output (but not load current) is automatically reduced 50% on motor cutout by the energizing of the governor overriding solenoid which holds the load regulator at minimum field.
3. On steep grades or when rail conditions are bad, the load limit may be determined by the tonnage the locomotive can handle without slipping.

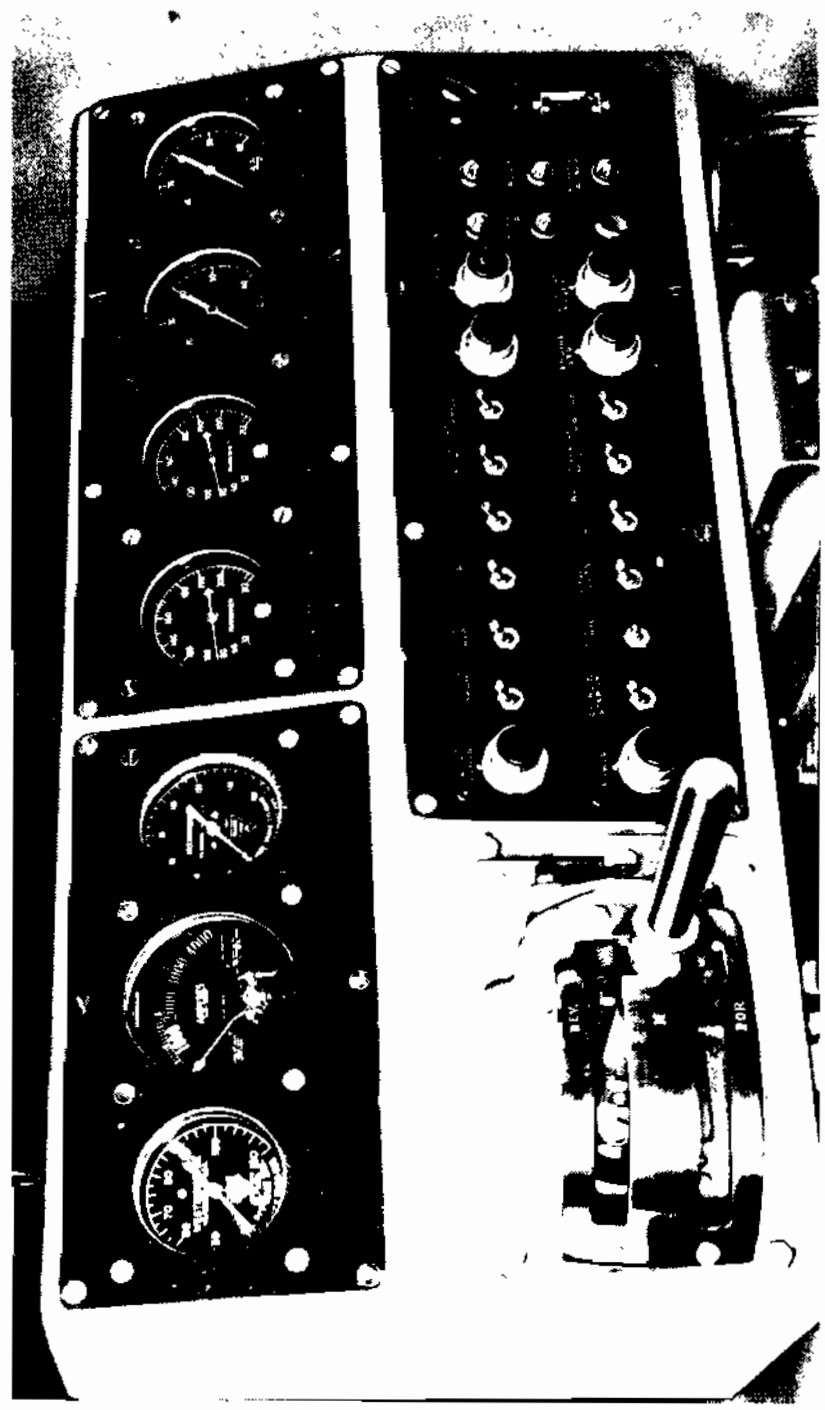
m-1. **Changing Ends — New Haven Units 560-569** (8-Step WABCO electric throttle and 6-DS air brake equipment.)

Before Leaving Cab:

1. Lock throttle in NEUTRAL.
2. Change isolator to RUN TRAIL position.
3. Make 20 lbs. brake pipe reduction and lap brake valve. Close brake valve cutout cock.
4. Open transfer cock.
5. Move independent brake valve to RELEASE.
6. Snap OFF **Locomotive Run** switch, **CONTROL BREAKER, and FUEL PUMP BREAKER.** Leave ON **FUEL PUMP SWITCH.** Engines will idle three or four minutes with fuel pumps stopped which will allow time to re-energize fuel pump control from **Fuel Pump Breaker** in new leading cab.

New Leading Cab:

1. Snap ON **Fuel Pump** and **Control** breakers.
2. Open brake valve cutout cock.
3. Close transfer cock.
4. Make air tests.
5. Change **isolator** to RUN LEADING position.
6. Unlock throttle.
7. Snap ON **Locomotive Run** switch when ready to move locomotive.



Illus. A8 Enginemen's Control Panel

m-2. **Changing Ends—Units with Westinghouse Electric Controller**

Before Leaving Cab:

1. Move **selector** to OFF and **throttle** to IDLE. **REMOVE REVERSE HANDLE.**
2. Make 20 lb. brake pipe reduction and lap brake valve. Close brake valve cutout cock, or move to TRLG. position.
3. Move Rotair valve to LAP. (24-RL air brake equipment only.)
4. Remove both brake valve handles.
5. Snap OFF **Locomotive Run** switch, **Control breaker,** and **Fuel Pump breaker. LEAVE ON FUEL PUMP SWITCH.** Engines will idle three or four minutes with fuel pumps stopped which will allow time to re-energize fuel pump control from **Fuel Pump Breaker** in new leading cab.

New Leading Cab:

1. Snap ON **Fuel Pump** and **Control** breakers.
2. Insert brake handles.
3. Move Rotair valve to PASS. or FRT. and apply full independent brake. (24-RL air brake equipment only.)
4. Open brake valve cutout cock and make air tests.
5. Replace **reverse** handle and move **selector** to desired position.
6. Snap ON **Locomotive Run** switch when ready to move locomotive.

m-3. **Changing Ends — Units with Pneumatic Throttle**

Before Leaving Cab

1. Lock **Throttle** in **NEUTRAL.**
2. Make 20 lb. brake pipe reduction, lap brake valve, and close brake valve cutout cock.
3. Remove both brake valve handles. (On 6-DS brake equipment handles are not removable.)
4. Move rotair valve to LAP. (24-RL brake equipment only.)
5. Open transfer cock (6-DS brake equipment only.)
6. Close throttle rotair valve.
7. Snap OFF **Locomotive Run** Switch and **Control** breaker. Check **Isolator.**

8. On dual-control units, check items 1 thru 6 at both control stations.

New Leading Cab (On dual-control units, at control station to be used)

1. Snap ON **Control** breaker and check **Isolator.**
2. Insert brake handles, move rotair valve to PASS or FRT as required (24-RL brake equipment) and apply full independent brake.

Illus. A11 Enginemen's Right Side Control Equipment —Multiple Unit Dual Control

m-2. **Changing Ends—Units with Westinghouse Electric Controller**

Before Leaving Cab:

1. Move selector to OFF and throttle to IDLE. **REMOVE REVERSE HANDLE.**
2. Make 20 lb. brake pipe reduction and lap brake valve. Close brake valve cutout cock, or move to TRLG. position.
3. Move Rotair valve to LAP. (24-RL air brake equipment only.)
4. Remove both brake valve handles.
5. Snap OFF **Locomotive Run** switch, **Control breaker,** and **Fuel Pump breaker. LEAVE ON FUEL PUMP SWITCH.** Engines will idle three or four minutes with fuel pumps stopped which will allow time to re-energize fuel pump control from **Fuel Pump Breaker** in new leading cab.

New Leading Cab:

1. Snap ON **Fuel Pump** and **Control** breakers.
2. Insert brake handles.
3. Move Rotair valve to PASS. or FRT. and apply full independent brake. (24-RL air brake equipment only.)
4. Open brake valve cutout cock and make air tests.
5. Replace **reverse** handle and move **selector** to desired position.
6. Snap ON **Locomotive Run** switch when ready to move locomotive.

m-3. **Changing Ends — Units with Pneumatic Throttle**

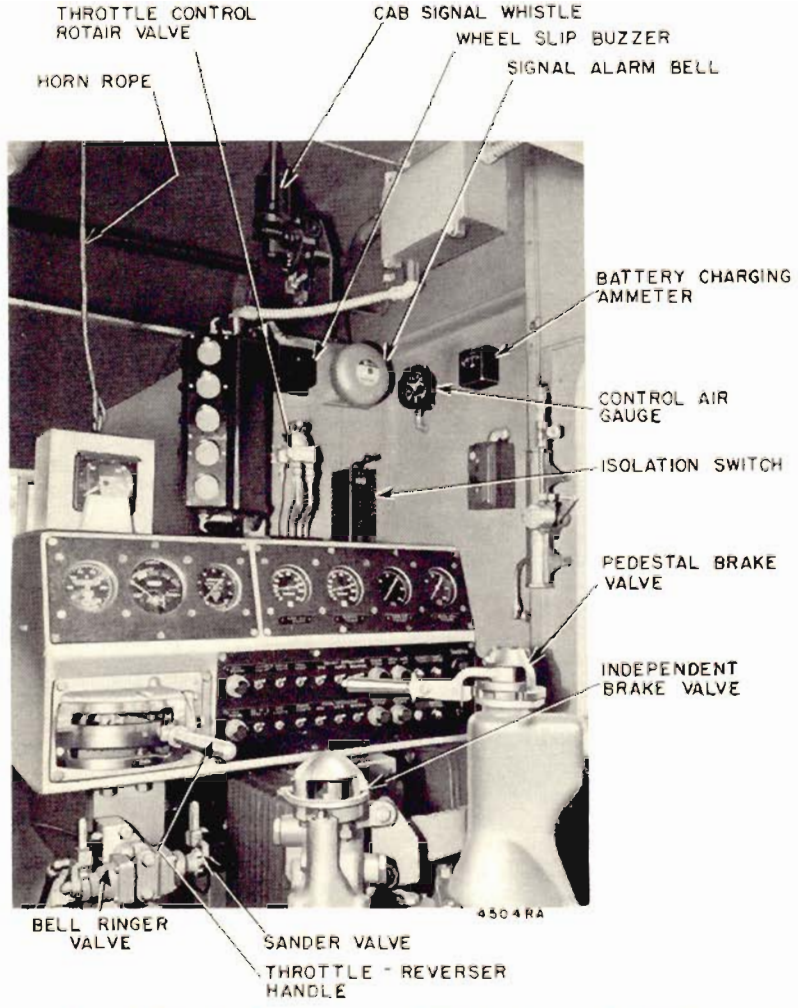
Before Leaving Cab

1. Lock **Throttle** in **NEUTRAL.**
2. Make 20 lb. brake pipe reduction, lap brake valve, and close brake valve cutout cock.
3. Remove both brake valve handles. (On 6-DS brake equipment handles are not removable.)
4. Move rotair valve to LAP. (24-RL brake equipment only.)
5. Open transfer cock (6-DS brake equipment only.)
6. Close throttle rotair valve.
7. Snap OFF **Locomotive Run** Switch and **Control** breaker. Check **Isolator.**

8. On dual-control units, check items 1 thru 6 at both control stations.

New Leading Cab (On dual-control units, at control station to be used)

1. Snap ON **Control** breaker and check **Isolator.**
2. Insert brake handles, move rotair valve to PASS or FRT as required (24-RL brake equipment) and apply full independent brake.



Illus. A11 Enginemen's Right Side Control Equipment —Multiple Unit Dual Control

m-2. **Changing Ends—Units with Westinghouse Electric Controller**

Before Leaving Cab:

1. Move **selector** to OFF and **throttle** to IDLE. **REMOVE REVERSE HANDLE.**
2. Make 20 lb. brake pipe reduction and lap brake valve. Close brake valve cutout cock, or move to TRLG. position.
3. Move Rotair valve to LAP. (24-RL air brake equipment only.)
4. Remove both brake valve handles.
5. Snap OFF **Locomotive Run** switch, **Control breaker,** and **Fuel Pump breaker. LEAVE ON FUEL PUMP SWITCH.** Engines will idle three or four minutes with fuel pumps stopped which will allow time to re-energize fuel pump control from **Fuel Pump Breaker** in new leading cab.

New Leading Cab:

1. Snap ON **Fuel Pump** and **Control** breakers.
2. Insert brake handles.
3. Move Rotair valve to PASS. or FRT. and apply full independent brake. (24-RL air brake equipment only.)
4. Open brake valve cutout cock and make air tests.
5. Replace **reverse** handle and move **selector** to desired position.
6. Snap ON **Locomotive Run** switch when ready to move locomotive.

m-3. **Changing Ends — Units with Pneumatic Throttle**

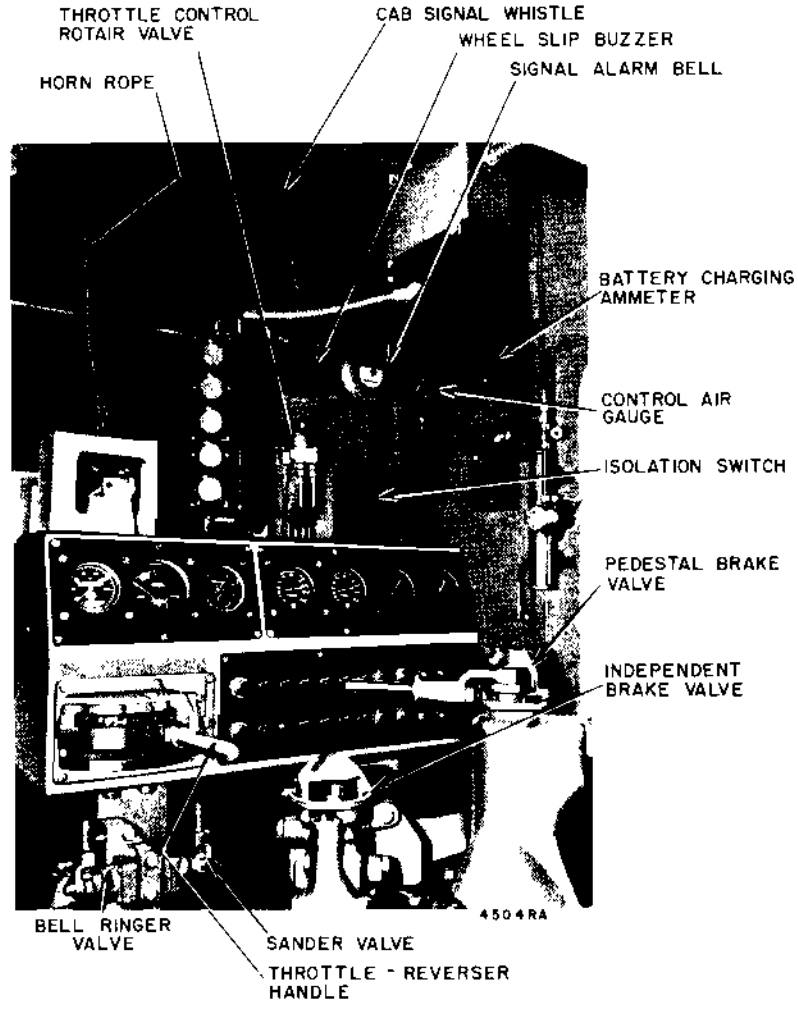
Before Leaving Cab

1. Lock **Throttle** in **NEUTRAL.**
2. Make 20 lb. brake pipe reduction, lap brake valve, and close brake valve cutout cock.
3. Remove both brake valve handles. (On 6-DS brake equipment handles are not removable.)
4. Move rotair valve to LAP. (24-RL brake equipment only.)
5. Open transfer cock (6-DS brake equipment only.)
6. Close throttle rotair valve.
7. Snap OFF **Locomotive Run** Switch and **Control** breaker. Check **Isolator.**

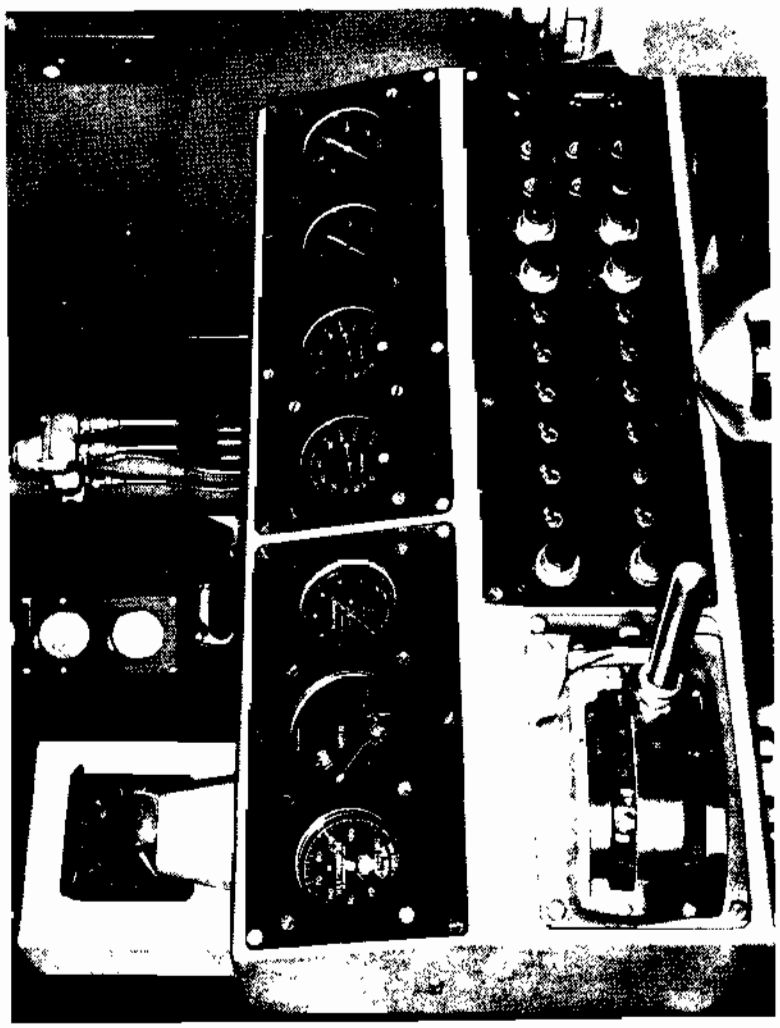
8. On dual-control units, check items 1 thru 6 at both control stations.

New Leading Cab (On dual-control units, at control station to be used)

1. Snap ON **Control** breaker and check **Isolator.**
2. Insert brake handles, move rotair valve to PASS or FRT as required (24-RL brake equipment) and apply full independent brake.

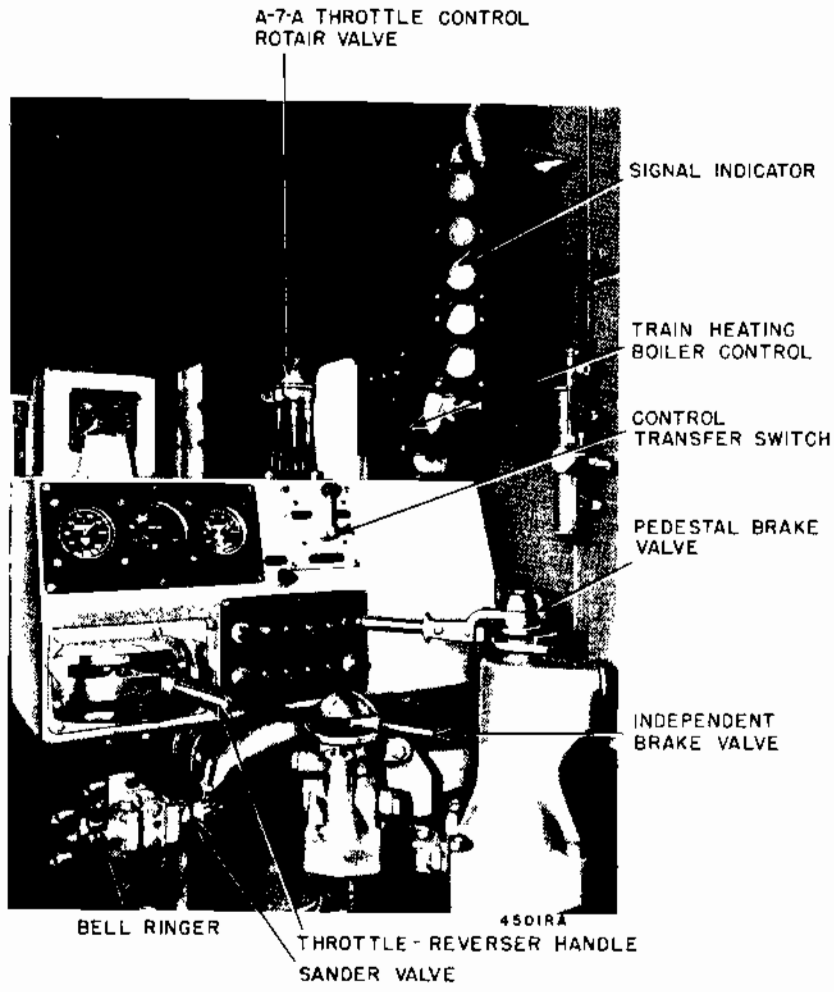


Illus. A11 Enginemen's Right Side Control Equipment —Multiple Unit Dual Control

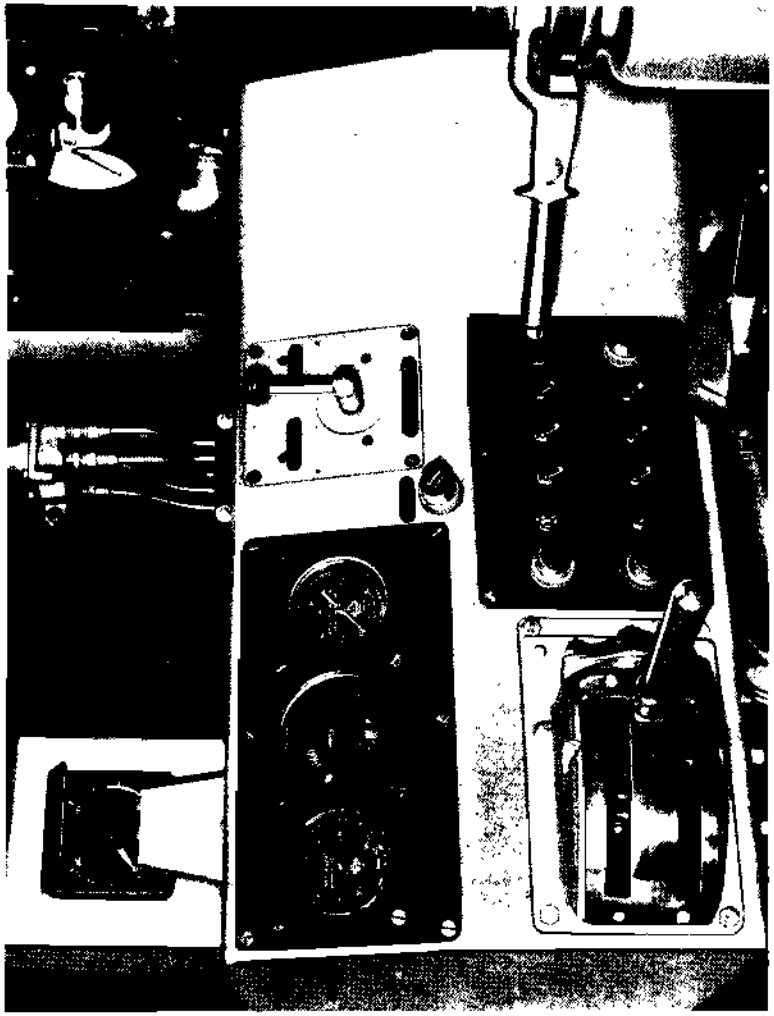


Illus. A12 Enginemen's Right Side Control Panel—Multiple Unit Dual Control

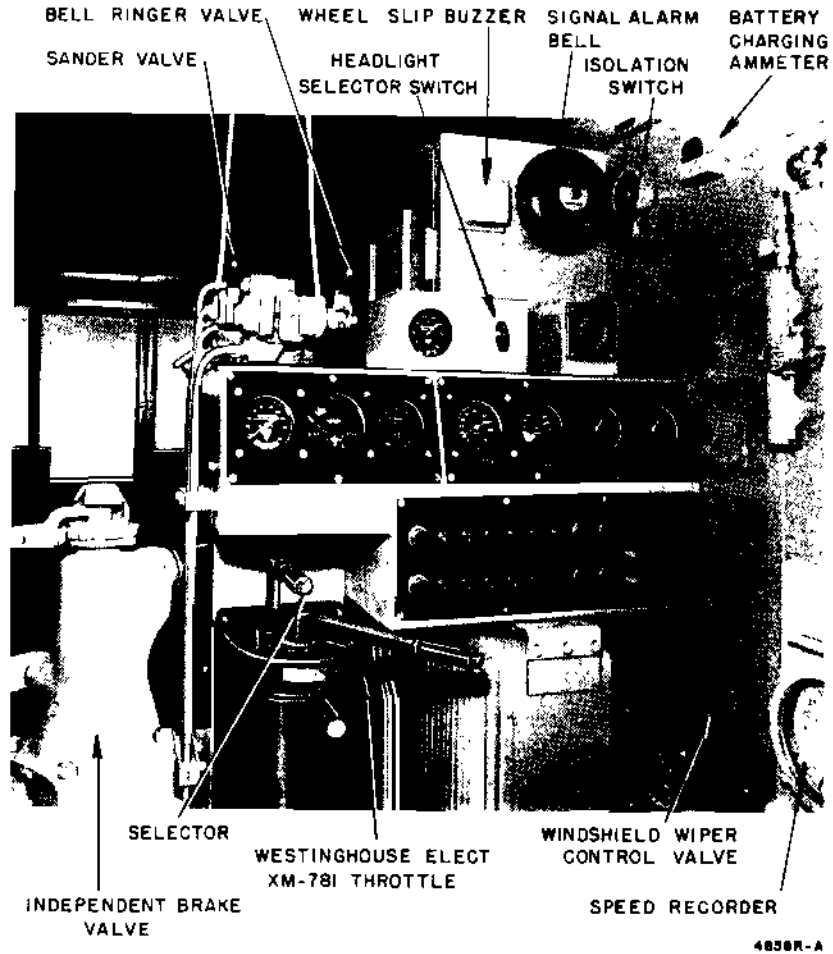
3. Close transfer cock. (6-DS brake equipment only.)
4. Open brake valve cutout cock and make air tests.
5. Open throttle rotair valve.
6. On dual-control units, check on non-operative control side that **Locomotive Run** switch is OFF and throttle and brakes cut out. Check that **Control Transfer Switch** is in correct position.
7. Unlock throttle and snap ON **Locomotive Run** switch when ready to move locomotive.



Illus. A13 Enginemen's Left Side Control Equipment —Multiple Unit Dual Control



Illus. A14 Enginemen's Left Side Control Panel—Multiple Unit Dual Control



Illus. A15 Enginemen's Control Equipment—Westinghouse XM-781 Electric Throttle

m-4. **Changing Sides—Units with Dual Control and Pneumatic Throttle**

Before Leaving Controls:

1. Lock **Throttle** in NEUTRAL and snap OFF **Locomotive Run** switch.
2. Make 20 lb. brake pipe reduction, lap brake valve, and brake valve cutout cock.
3. Remove both brake valve handles. (On 6-DS brake equipment handles are not removable.)
4. Move rotair valve to LAP. (24-RL brake equipment only.)
5. Close throttle rotair valve.
6. Move **Control Transfer Switch** to change over control to other side.

Controls on New Side

1. Insert brake handles, move rotair valve to PASS or FRT as required (24-RL brake equipment) and apply full independent brake.
2. Open brake valve cutout cock and make air tests.
3. Open throttle rotair valve.
4. Unlock throttle and snap ON **Locomotive Run** switch when ready to move locomotive.

n. **To Cut a Pair of Traction Motors**

Traction motors on No. 1 truck are cut out by opening knife switch TMCO 1 in the electrical cabinet, and likewise No. 2 truck by switch TMCO 2.

CAUTION: ALWAYS ISOLATE ENGINE OR BRING THROTTLE TO IDLE BEFORE OPERATING EITHER SWITCH.

Main generator output is automatically reduced 50% when a pair of traction motors is cut out. This is done by P contactor interlocks which energize the governor overriding solenoid to keep the load regulator in minimum field in all throttle notches.

o. **Ground Relay Action**

If ground relay repeatedly trips, first isolate unit or bring throttle to idle. Cut out a pair of traction motors and return engine to line. If necessary, repeat with other pair of traction motors, isolating engine first. If relay still trips, leave unit isolated.

p. **Operating with Leading Unit Shut Down**

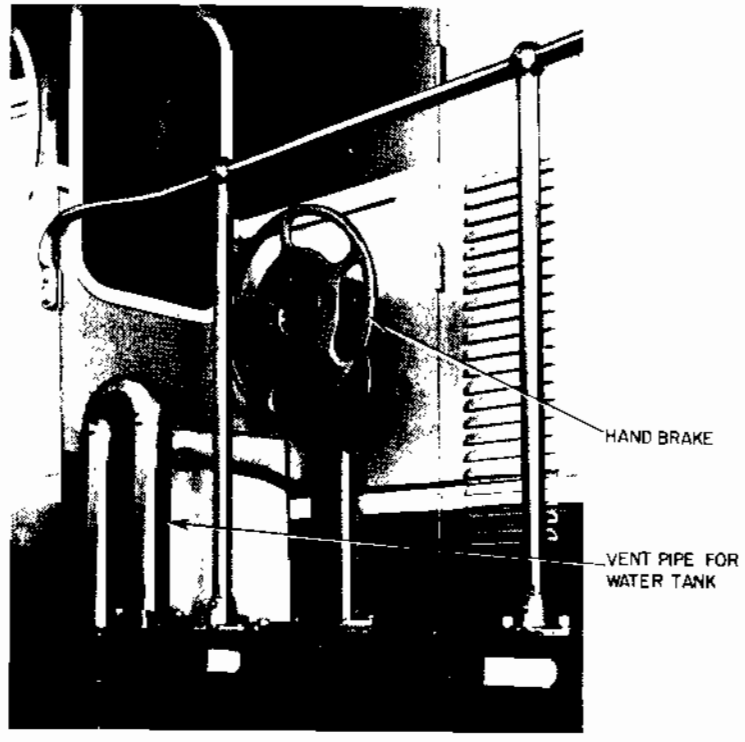
Snap OFF **Control** and **Fuel Pump** breakers on leading unit and ON in trailing unit. Avoid having both sets of breakers on at the same time as battery equalizing currents may be enough to damage control wiring.

q. **Passing Over Railroad Crossings**

When approaching a railroad crossing, throttle should be reduced so that load ammeter reads 500 amps. or below, and kept in that position until all locomotive units have passed over the crossing. This will minimize the possibility of tracton motor flashovers because of brushes being jolted off the commutator.

r. **Reversing**

Bring locomotive to a dead stop before moving reverse handle for opposite locomotive movement. Applying power



Illus. A16 Hand Brake Arrangement on 1600 H.P. Dual Control Units

in reverse direction, before locomotive stops, may cause serious damage to traction motors.

s. **Operating Through Water**

Do not operate locomotive through water more than 4 inches over top of rail, and then at a speed not exceeding 3 MPH. After passing through water, snap OFF **Locomotive Run** Switch, move reverse handle to OFF, and open throttle half way for about ten minutes. This will allow water to be dried off traction motors.

t. **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.

u. **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 damage.**

v. **Attention on the Road**

1. A check of the instruments on the control panel should be made at intervals during the operation of the locomotive.
2. Check the level of the lubricating oil and cooling water twice during each 8 hour shift when operating in the yard, and when convenient at stops in road service.
3. Investigate immediately any unusual sounds or odors.
4. Never exceed the maximum safe speed of the locomotive.

Gear Ratio	Maximum Safe MPH
15:68	65
15:63	70
17:62	80
19:60	90

w. **Visual Inspection at Stops**

If time permits during stops, make a visual inspection of the under part of the unit. Watch for hot journals, hot motor axle bearings, or hot armature bearings.

Note any fuel oil, lube oil, water, air or steam leaks. Check

and report any of the above as well as any loose or dragging parts.

x. **To Rerail Locomotive**

The locomotive can be rerailed by spiking down a rerailing frog in the usual manner and cutting out the motors on the derailed truck. Proceed in the conventional manner taking care that the wheels do not slip off the frog or rails during rerailing. Otherwise serious damage may result to the traction motors or gear cases. Use the remaining two motors in "low power" and proceed slowly.

The brakes should be set at 10 pounds and the throttle moved cautiously so that the locomotive will move very slowly, and will not slip back when the throttle is returned to OFF position.

y. **Freezing Weather Precautions**

During freezing weather, certain precautions must be taken to safeguard the locomotive equipment. Ice formation may hinder the operation of the radiator shutters. If the engine is to be shut down during freezing weather for any great length of time, arrangements must be made to connect to standby steam or to drain the system. For more detailed instructions regarding draining system, refer to section 118A "Cooling System."

z. **Towing**

1. When necessary to prepare the locomotive for deadheading, stop the engine as directed in paragraph "d".
2. Set up air brake equipment as follows:
   (a) Place handle of both brake valves in RUNNING.
   (b) Except on 6-DS equipment where handles are not removable, remove both brake valve handles. If locomotive is to be moved with an attendant or messenger, leave the independent brake valve handle in place.
   (c) Move brake valve cutout cock to CLOSED position (24-RL and 6-DS equipment) or to DEAD position (6-BL and 6-SL equipment.)
   (d) Open dead engine cock on control valve (24-RL equipment) or on distributing valve (6-DS, 6-BL, and 6-SL equipment).
   (e) Set Rotair valve in PASS. position (24-RL equipment only.)

(f) If for any reason it is desirable to keep the maximum braking power of the locomotive lower than standard, proceed as follows:

(1) On 24-RL equipment, insert a 28 lb. safety valve in the No. 16 control pipe in the tee applied for this purpose. A usual practice is to remove one of the two compressor intercooler safety valves for this purpose, lowering the setting from 60 to 28 lbs. After deadheading, be sure to return safety valve to intercooler and raise setting back to 60 lbs.

(2) On 6-DS, 6-BL, or 6-SL equipment, reduce the adjustment on the safety valve on the distributing valve so that the brake cylinder pressure will not exceed 28 pounds in case of an emergency brake application.

3. Locomotive should never be towed at a speed greater than ⅔ its rated maximum safe speed. (See paragraph "u".)

aa. **Throttle Operation When Brakes Go Into Emergency**

1. On a brake-valve initiated emergency application, return throttle to IDLE immediately to avoid damage to traction motors. On locomotives equipped with a PC switch, this is taken care of automatically.
2. On a train-initiated emergency application, throttle should be eased off gradually to avoid flattening wheels on the locomotive. Follow railroad instructions.

ab. **Before Splitting or Joining Units**

1. Check that both throttles are locked in IDLE or NEUTRAL.
2. Snap OFF **Control** breaker, **Fuel Pump** breaker, and **Locomotive Run** switch on both units.

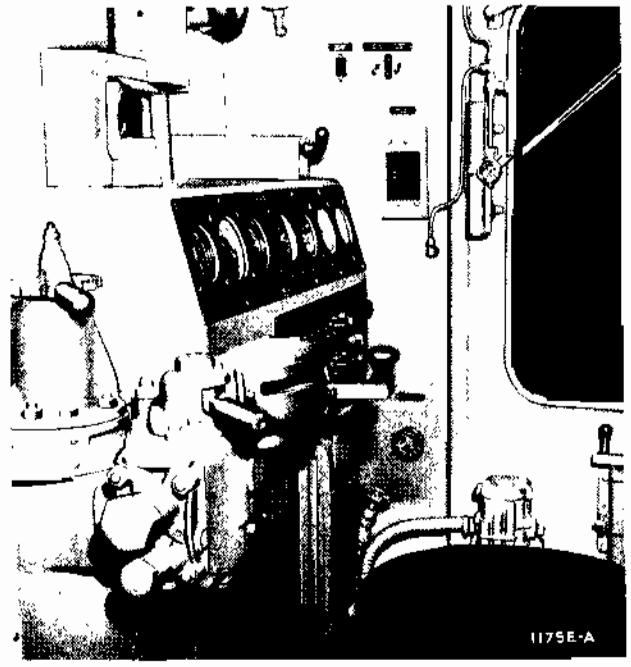
ac. **Heavy Knocking or Other Unusual Engine Sounds**

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

ad. **To Take Locomotive Out of Service**

1. Snap OFF **Locomotive Run** switch, **Control** breaker, **Fuel Pump** breaker, and **Fuel Pump** Switch.
2. Stop engine.

3. Lock throttle in IDLE or NEUTRAL.
4. Remove reverse handle (if used).
5. Pull both traction motor cutout switches.
6. Pull main battery switch.
7. Apply hand brake.
8. Snap OFF cab light switch.
9. Water system must be protected from freezing in cold weather either by adding heat to the cooling system by connecting to the standby steam supply, Illus. A7, or by completely draining the system. For instructions on draining the cooling system refer to Sec 118A.



Illus. A17 Enginemen's Control Equipment

(New Haven R.R. Units 560-569)

SECTION 107A. ALARMS, SAFETY DEVICES, AND TROUBLE SHOOTING

107A1 Alarms

Listed below is each alarm, how it affects the unit, and steps necessary for correction. Alarm bells will ring in all units of a multiple-unit locomotive, but indicator lights will burn only on control panel of unit affected, for **Ground Relay Tripped, Blowers Stopped, Low Oil Pressure**, and **Hot Engine.**

Light	Action	To Correct Condition
Ground Relay Tripped	Drops power and brings engine speed to idle. On Units with electro-pneumatic throttle control, engine stops if ground relay trips in 5th or 6th throttle positions. This is because the governor "D" solenoid remains energized alone, which shuts engine down.	1. Bring throttle or isolator to IDLE. 2. Reset relay by pressing reset button on engineer's control panel. This will put out light and stop bells. 3. Return engine to line. 4. If relay repeatedly trips, inspect unit for grounds and correct same. 5. If no grounds are found, cut out a pair of traction motors ISOLATING ENGINE FIRST. Reset relay and return engine to line. If relay again trips, repeat with other pair of traction motors. If relay still trips, leave unit isolated. 6. The ground relay can be cut out by pulling the relay knife switch, but this should be done ONLY IN CASE OF AN EMERGENCY and only as authorized by railroad instructions.
Traction Motor Blowers Stopped	Alarm Only	Check 225-amp. blower fuse on back of electrical cabinet. If fuse is good, check both blowers for cause of stopping.
Low Lubricating Oil Pressure	Shuts engine down.	Reset button on governor and start engine. A time delay of 40 seconds allows engine to idle so cause can be investigated. Check first for dirty filters, and low oil level in the engine. Sometimes low pressure lube oil surges will momentarily occur which will give false alarm shut-

Light	Action	To Correct Condition
		downs. These may come from hot oil or too quick throttle operation. Governor adjustment may be faulty, in which case REPORT FOR CORRECTION AND DO NOT TAMPER.
Hot Engine	Alarm Only	1. If unit is equipped with a steam generator operating, check that steam admission valves are closed to engine water system. 2. Check 400 amp. radiator fan motor fuse, and fan. 3. Check engine water level. 4. Check shutters. 5. If hot engine persists, isolate engine, cut out a pair of traction motors, and return engine to line. This will cut engine loading 50% at full throttle. Or reduce throttle to allow engine to cool.
Wheel Slip	Light will burn on all units, and power will be cut off on unit affected.	Follow instructions in Sec. 104A, par. j.
Power Off	Indicates PC Switch has tripped.	See Sec. 101A.

107A2 Safety Devices Not Actuating Alarms

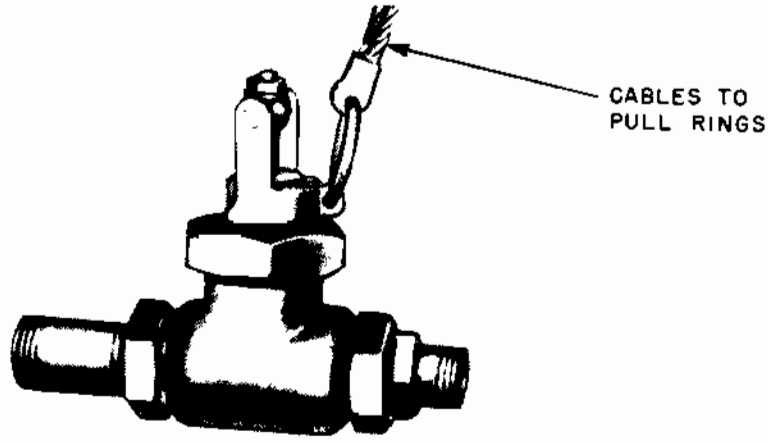
a. Engine Overspeed Trip

If engine speed exceeds 950 RPM, the overspeed trip will return the fuel control rod to "No Fuel" position, shutting down the engine. Rest trip by latching reset lever. Trip must also be reset if engine is stopped by pushing in the Emergency Stop Button above the governor.

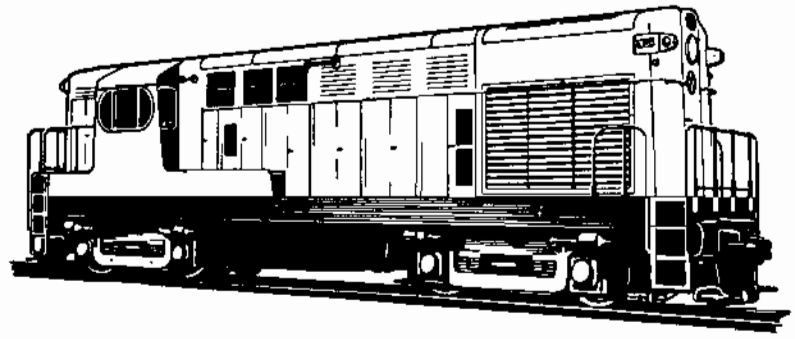
b. Emergency Fuel Cutoff Valve

The safety cutoff valve, Illus. A1, shutting off the flow of fuel oil from the main tank to the fuel system, is operated by any one of three pull cables terminating in red rings. One ring is located in the cab near the engineman and the other two rings are on either side of the locomotive frame adjacent to the fuel tank. Do not pull this cable except in an emergency or in case of fire.

The valve is reset by pushing the yoke down around the top of the valve into a latched position. Illus. A1 shows the valve with the yoke in a latched position.



Illus. A1 Fuel Oil Cut-off Valve



107A3 Alarm Summary and Trouble Shooting

Trouble Cause	Alarm Light	Eng. Stops	Eng. To Idle	Power Off	Unit Not Fully Loading
Low Oil Pressure	Yellow	Yes	—	Yes	—
Eng. Overspeed Tripped	—	Yes	—	Yes	—
Ground Relay Tripped	White	—	Yes	Yes	—
Blower Relay Tripped	Red	—	—	Yes	—
Isolator in "Stop"	—	Yes	—	Yes	—
Aug. Gen. Fuse Blown	—	—	—	—	—
		(Causes low battery)			
25 Amp. Control Fuse Blown	—	—	—	Yes	—
25 Amp. Excitation Fuse Blown	—	—	—	Yes	—
Wheel Slip	Wheel Slip	—	—	Yes	—
Wheel Slip or Blower Relay Stuck Open	—	—	—	Yes	—
LOP Not Closing	—	—	—	Yes	—
Pair Traction Motors Cutout	—	—	—	—	Yes
V-Belts Slipping on Exciter	—	—	—	—	Yes
Low Fuel Pressure	—	—	—	—	Yes
Engine Isolated	—	—	Yes	Yes	—
Starting Contactor Stuck Closed	—	—	—	Yes	—
TV Contactor Not Closed	—	—	Yes	Yes	—
Jumper Cable Loose	—	—	Yes	Yes	Yes
Emergency Fuel Cutoff	—	Yes	—	Yes	—
Fuel Pump Breaker Tripped	—	—	Yes	Yes	—
Control Breaker Tripped	—	—	Yes	Yes	—
Low Control Air Pressure	—	—	—	Yes	—
Faulty Interlocks or Contacts	—	—	—	Yes	Yes
Governor or Load Regulator out of Adjustment	—	—	—	—	Yes

(DO NOT ADJUST ON ROAD)

LOCOMOTIVE TROUBLE SHOOTING

Little or No Fuel Pressure When Fuel Pump Switch Is on

1. **Fuel Pump fails to run, or stops;**
   a. Main battery switch not closed.
   b. Fuel pump breaker tripped on lead unit.
   c. Fuel pump switch not closed.
   d. Control jumper between units not making contact.
2. **Fuel pump runs but little or no pressure shows:**
   a. No fuel in tank.
   b. Emergency fuel cutoff tripped.
   c. Battery weak.
   d. Leaks in pump suction line.

   e. Worn pump packing rings.
   f. Pump relief valve sticking.
   g. Clogged pressure filter.

Engine Fails to Rotate When Start Buttons Is Pressed

1. Fuel pump breaker not closed on leading unit.
2. Weak battery. If engine room lights go very dim or out, generator is receiving starting current but battery is too weak to rotate generator.
3. Starting contactors not closing. Check (1) Isolator. Must be in "Idle". (2) "Out" interlock on EF contactor. Must be closed.

Engine Rotates but Fails to Fire

1. Overspeed tripped.
2. Low oil shutdown button on governor not reset.
3. No fuel pressure.
4. Isolator in "STOP" position.

Air Pressure Fails to Build Up

1. Angle cocks in wrong position.
2. Main reservoir drain cock open.
3. Compressor or main reservoir safety valve loose or stuck open.
4. Dirty compressor governor or magnet valve.

Diesel Engine Fails to Increase Speed Above Run 1 Throttle Position

1. Engine isolator not in "RUN" position.
2. TV contactor not closing or making good contact. Check
   a. Ground relay. Must not be tripped.
   b. Starting contactors. Must be open.

Load Ammeter Shows No Current When Throttle Is Notched Out With Locomotive Not Tending To Move

1. Diesel engine isolated..
2. Control breaker or locomotive run switch not closed.
3. Control air pressure less than 70 lbs. (Should be 80 lbs. on gauge in cab.)
4. 25 Amp. control fuse blown.
5. 25 Amp. excitation fuse blown.
6. AF contactor not closing. Oil pressure switch should be closed in line to AF coil.

7. TV contactor not closed. Check
   a. Isolator position.
   b. Ground relay. Must **not** be tripped.
   c. Starting contactors. Must be **open.**
8. Power contactors not closed. Check
   a. AF interlock. Must be closed.
   b. TDR relay. Must be energized.
9. TDR relay not energized. Check
   a. Blower relay, BL. Must be de-energized.
   b. TV contactor. Must be closed.
10. EF contactor not energized. Check
    Power contactor interlocks. Must be **closed.**
    b. Wheel slip relays. Normally closed contacts must be making,

Unit Loading Only Partially

1. Pair of traction motors cut out.
2. Lack of fuel due to suction or pressure filter plugged, or broken line,
3. If a trailing unit, loose jumper cable between units.
4. Governor, load regulator, or field shunt relays out of adjustment. DO NOT ADJUST ON ROAD. REPORT FOR CORRECTION.
5. V-belts slipping on exciter.

Loss of Power on All Units

All fuel pumps stopped.

1. Lead unit fuel pump breaker tripped.

Fuel pumps running but no power, and engines won't go above idle.

1. Lead unit control breaker tripped.

Fuel pumps running but no power although engines repond to throttle.

1. Lead unit locomotive run switch not closed.

SECTION 109A. DIESEL ENGINE ACCESSORIES

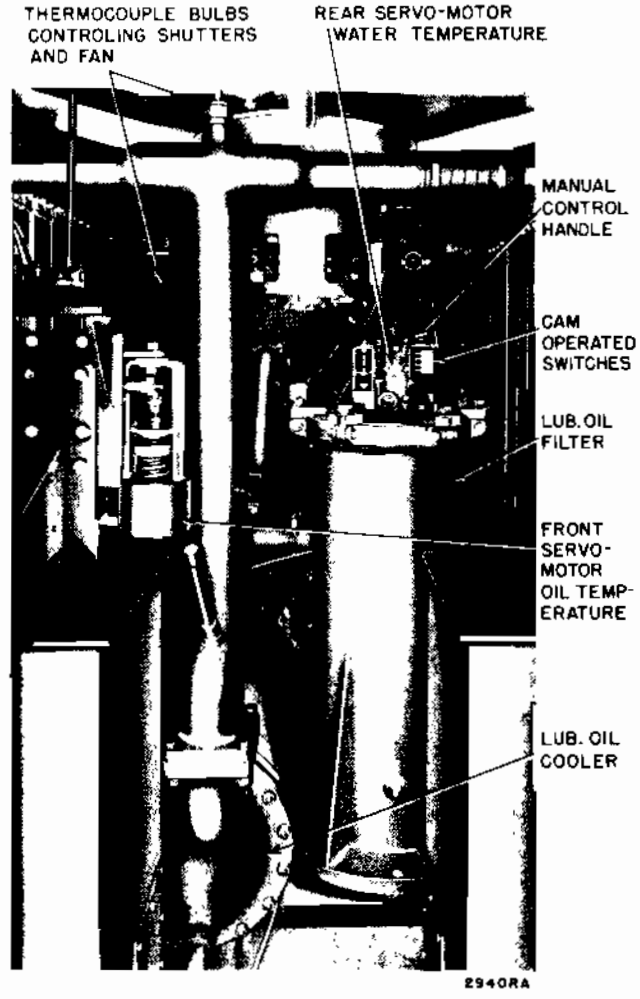
109A1. Diesel Engine Accessories

a. Fuel Oil Filter

The fuel oil filter is of the cartridge type. Fuel oil pressure below normal (5 pounds) indicates that the filter cartridge needs changing.

b. Fuel Oil Pump

This pump draws fuel oil from the storage tank and circu-



Illus. A1 Radiators, Cooler, and Filters

lates it thru the fuel oil filter to the supply headers on each side of the engine. Pressure should build up immediately when the switch is turned on.

c. Fuel Tank

The fuel tank has 3 sight glasses for indicating the level of the fuel. All filler pipes are provided with Protectoseal caps as required for safety. The units are provided with two fill pipes, one on either side of the locomotive.

d. Lubricating Oil Cooler

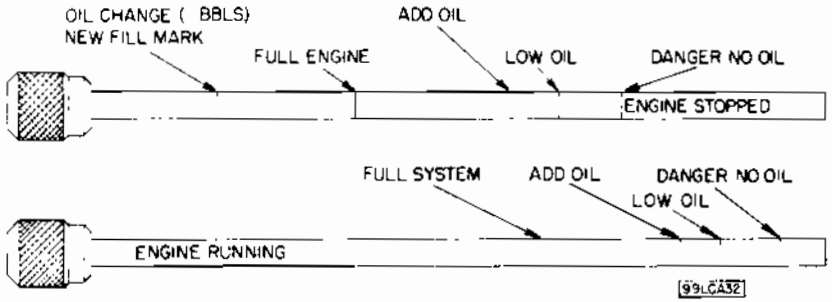
Illus. A1 shows the cooler and filter as located in the radiator enclosure. The lubricating oil cooler is of the tube type. The heat from the lubricating oil passing through the tube bundle is absorbed by the cooling water circulating around the tubes. The cooling water passes from the coolers through the radiators where the heat is dissipated into the atmosphere by the flow of air through the radiator sections.

e. Lubricating Oil Filter

This filter has ample capacity to keep the lubricating oil clean between maintenance periods. It is made up of 3 tubes or elements containing a packing of cotton waste for filtering the impurities from the oil. The cooler is so connected that part of the lubricating oil is constantly by-passed through it.

f. Lubricating Oil Gauge Dip Stick

Each side of the oil level gauge dip stick (Illus. A2 Sec. 104A) is calibrated. One side is marked "ENGINE STOPPED," the other "ENGINE RUNNING." The amount of oil circulating in the system is represented by the space on the dip stick between the "OIL CHANGE-NEW FILL" and "FULL ENGINE" marks.



The dip stick can be read either with engine stopped or running but care should be exercised that the correct side of the stick is read agreeing with whether the engine is running or stopped.

Oil need not be added until oil level has reached "Add Oil" mark, because of reserve supply.

g. Engine Cooling System

The jacket water and oil cooling water radiator shutters and cooling fan are automatically operated by their respective temperature control. See Illus. A3 Sec. 104A. Manual controls are provided to permit adjustment in case of failure of any of the temperature control equipment. Higher temperatures than those listed below should be reported.

Jacket Water or Lub. Oil	Average	May reach on long runs with safety	May Reach
At 75° F. Atmospheric Temperature	165°	190°	
At 110° F. Atmospheric Temperature			195°

SECTION 115A. AIR BRAKE EQUIPMENT
6-SL, 6-BL, and 6-BS

AUTOMATIC BRAKE VALVE

The automatic brake valve handle has six positions: Release, Running, Holding, Lap, Service, and Emergency.

Release Position provides a large and direct passage from the main reservoir to the brake pipe. It is used under some conditions to speed up train brake release. However, its value is limited and many railroads block off the position on the handle so it cannot be used.

If the handle were allowed to remain in release position for any length of time, the brake system would charge to main reservoir pressure. To avoid this, the handle must be moved to Running position. To prevent the engineman from forgetting this, a small port discharges main reservoir air to atmosphere in release, with noise enough to call attention to the handle position.

Running Position is used to charge and release the train brakes. The brake pipe charges under feed valve control. The equalizing reservoir charges uniformly with the brake pipe, keeping the pressure on the two sides of the equalizing piston equal. The distributing valve release pipe is connected to atmosphere.

Holding Position is used to hold the locomotive brake applied while the train brakes are being released and their auxiliary reservoirs recharged to feed valve pressure.

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 gives a gradual reduction of brake pipe pressure to cause a service application. The gradual reduction prevents quick action.

Emergency Position is used for prompt and heavy application of brakes. A large and direct connection is made between brake pipe and atmosphere, causing a sudden and heavy discharge of brake pipe air.

Triple valves and distributing valve move to Emergency position, and locomotive brake cylinder pressure is maintained against leakage.

INDEPENDENT BRAKE VALVE

The independent brake valve handle has two positions, running and application zone. The valve is self-lapping. No brake valve handle fanning is necessary as the valve automatically builds up the application pressure to the amount corresponding to the handle position, and then laps.

The locomotive brakes may be released after an automatic brake application by depressing the independent handle in Running position.

BRAKE PIPE CUT-OUT COCK

6-SL and later 6-BL equipment use a 3-position brake pipe cut-out cock with positions "Lead", "Trailing", and "Dead".

6-DS and older 6-BL equipment use instead a 2-position cock with positions "Closed" and "Open".

Units with the 2-position cock arranged for multiple operation also use the Multiple Operation (or Transfer Valve) Cock described later.

3-Position Type

"Lead" position is to be used when the locomotive is the controlling unit, in single or multiple operation. The brake valve to brake pipe connection is open and the No. 9 connection is vented.

"Trailing" position is to be used when the locomotive is a trailing unit in multiple operation. The brake valve to brake pipe connection is closed and the No. 15 pipe is connected to the No. 9 pipe.

"Dead" position is to be used when the locomotive is hauled dead. The brake valve to brake pipe connection is closed and the No. 9 pipe is vented.

2-Position Type (Older Units Only)

"Closed" position closes the passage between brake valve and brake pipe. "Open" position opens this passage.

MULTIPLE OPERATION COCK
(Transfer Valve Cock)

This cock is used on No. 6-DS and older No. 6-BL equipment arranged for multiple-unit operation. For single-unit operation,

a dead engine, or the leading unit of a multiple-unit locomotive, the cock must be closed. On a trailing unit of a multiple-unit locomotive, the cock must be open.

DISTRIBUTING VALVE AND DEAD ENGINE COCK

The distributing valve used is Type 6-DKR (6-KR for single operation units) and functions to control the operation of the locomotive brakes in accordance with the movements of both brake valve handles.

The dead engine cock, mounted on the distributing valve (mounted separately on single operation units) must be open when the locomotive is to be hauled dead, and closed at all other times.

FEED VALVE

The type M-3-A feed valve has been used, but is now being superseded by the type D-24-B. The feed valve is attached to the brake valve body and regulates brake pipe pressure with the automatic brake valve in running or holding position.

SECTION 115B. AIR BRAKE EQUIPMENT 24-RL

Automatic Brake Valve

The six handle positions are:

Release	Lap
Running	Service
First Service	Emergency

Handle is removable in running position.

Cocks on the brake stand are:

a. Brake Valve 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.

b. Application Valve Cutout cock on the service application position is normally sealed in the "In" position. "Out" position cuts out the safety control, overspeed, and train control features.

Note: 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.

c. Full Release Selector cock on the left side of the rotary valve seat portion. (On some railroads this cock is blanked out.)

MR position (pointing away from engineer) allows air at main reservoir pressure (as in No. 6 ET or No. 8 ET equipment) to supply chamber above automatic rotary valve.

FV position (pointing toward engineer) allows air at feed valve pressure to supply chamber above automatic rotary valve.

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

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

e. Shifter Levers, on the left side of the rotary valve seat portion. Used only with electro-pneumatic brake installations.

"AU" automatic position gives normal automatic brake operation.

"SA" straight air position cuts in electro-pneumatic brake operation.

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.

K-2-A Rotair Valve

Positions are as follows:

"FRGHT" . . . . . Cuts in: Controlled emergency
Split-reduction (if used)
Supression timing (if used)
Independent brake valve

"PASS" . . . . . Cuts in: Controlled emergency
Cuts out: Split-reduction (if used)
Suppression timing (if used)
Trailing A units only

"FRGHT LAP"—Used in Independent brake valve
Cuts out: Automatic service split-reductions

"PASS LAPP"—Used in Trailing A units only
Cuts out: Independent brake valve

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 th 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.

Safety Control (When specified)

Releasing pressure on the foot pedal 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 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 car body above each truck on the right side of the unit.

D-24 Control Valve

This valve has two cocks and one cap:

1. **Dead Engine Cock**
   "Live" position provides main reservoir charging from the air compressor, and is the normal position.
   "Dead" position provides main reservoir changing from the brake pipe. Use only when locomotive is hauled dead in a train.

2. **Retarded Recharge Cock**
   "Frt" position restricts auxiliary reservoir charging.
   "Pass" position gives quick auxiliary reservoir charging.

3. **Graduated Release Cap**
   "Graduated" setting gives graduated independent release, for passenger service.
   "Direct" setting gives direct independent release, for freight service.

SECTION 116A. FUEL OIL SYSTEM

DESCRIPTION

The fuel system employs as follows, listed according to the flow of the fuel from the tank to the engine. Refer to the piping diagram on the following page.

1. Fuel supply tank underneath locomotive.
   The fuel tank is equipped with three sight glasses indicating fuel supply at any tank level.

2. Emergency fuel cut-off valve, located at fuel tank.
   For use in case of fire, pull rings at fuel filler pipes or in operating cab.

3. Fuel suction strainer, located on suction side of fuel transfer pump.

4. Fuel transfer pump, motor-driven through a flexible coupling and located below engine governor.

5. Pressure relief valve in transfer pump discharge line, to by-pass fuel back to tank in the event of a clogged pressure filter.

6. Fuel pressure filter, located on the pressure side of fuel transfer pump. Fuel oil pressure below 5 pounds indicates the filter cartridge needs changing.

7. Fuel pressure gage, mounted at engine control panel and indicating pressure supplied to engine fuel header.

8. Engine fuel headers, supplying engine fuel pumps and nozzles. Relief valve at header outlet.

9. Engine fuel pumps and nozzles.

10. Fuel return headers, passing excess clean fuel back to fuel tank.

FUEL TANK

Filling

Filling is from either side of the locomotive at a maximum rate of 250 gallons per minute. The three sight gages at each filler pipe indicate tank level. Fuel should be filtered before it

enters the tank, and should not be handled near an open flame.

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.

EMERGENCY FUEL CUT-OFF VALVE

This valve is 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 is located at the side of the fuel tank.

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 pounds is maintained by the relief valve at the header outlet.

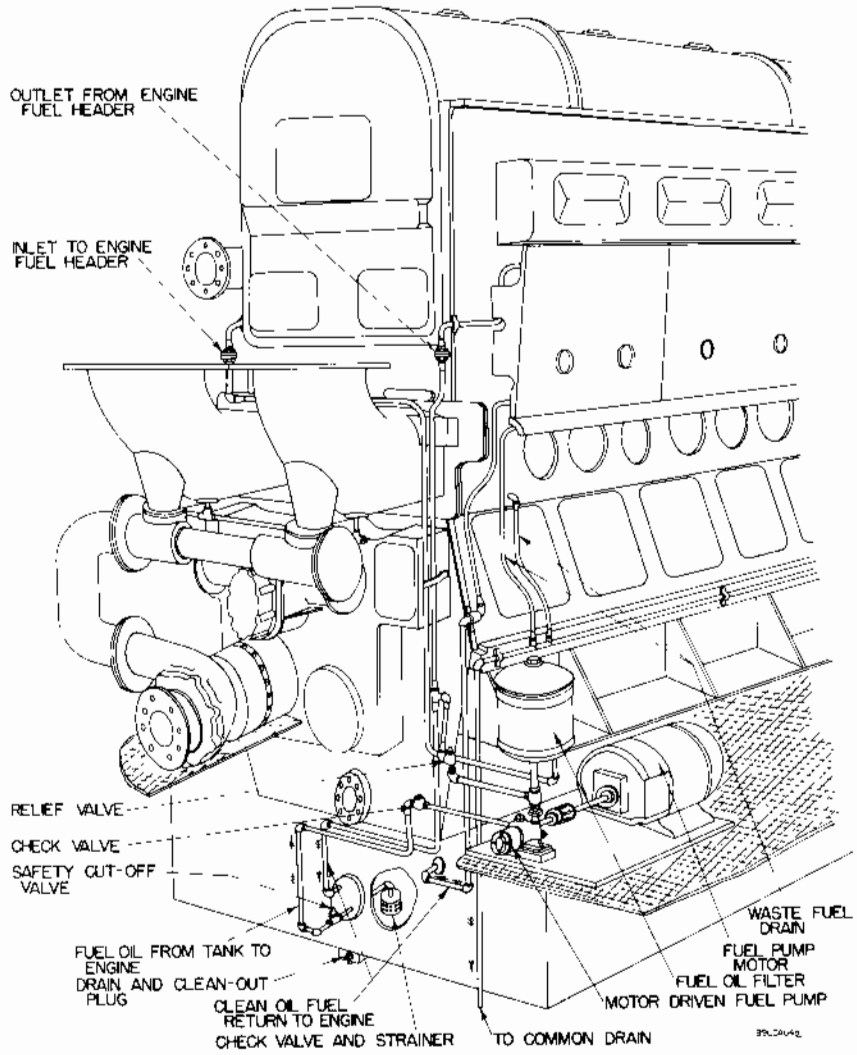
FUEL RETURN HEADERS

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 16 lbs. at idle and 25 lbs. at full engine speed. If the fuel pump runs and this pressure does not show, the following may be the cause:

1. No fuel in tank.
2. Emergency cut-off valve tripped.
3. Leaks in fuel pump suction line.



Illus. 1. Fuel Supply System

4. Clogged suction strainer.

5. Worn pump packing rings.

6. Pump relief valve sticking.

7. Clogged pressure filter.

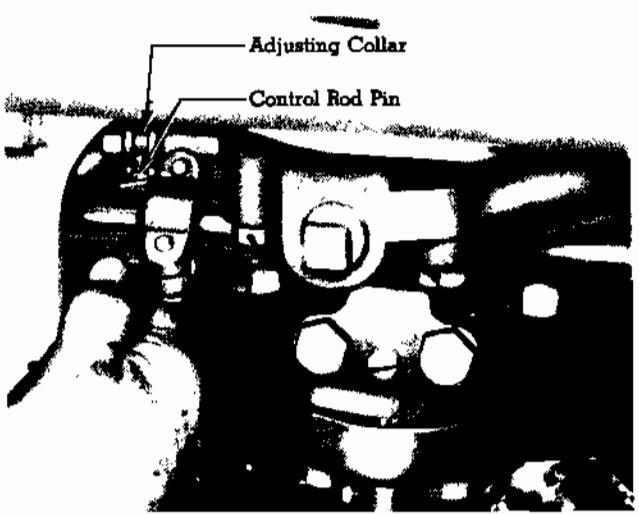
INJECTION TUBE FAILURE

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 the illustration below. 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.

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 pump not functioning properly.



Illus. 2. Fuel Injection Pump Cut-out

SECTION 117A. LUBRICATING OIL SYSTEM

117A1. Lubricating Oil System

a. Description

The engine lubricating oil system is of the pressure type designed to supply a continuous flow of oil to all bearing surfaces as well as to act as a cooling agent for the pistons. After engine lubrication and piston cooling, the oil flows to the engine sub-base.

Illus. A1 shows the lubricating oil system. The engine driven lubricating oil pump draws oil from the sub-base and forces it thru the two oil coolers. It is returned to the system at the lower lubricating oil header connection on the engine. A lubricating oil filter is installed in the system so that part of the oil flow is by-passed through the filter for filtration.

Water from the cooling system (Illus. A2) flows thru the tubes of the cooler absorbing heat from the oil. This heat is dissipated in the oil cooling water radiators by air from the cooling fan. The speed of the fan, as well as the opening of the shutters, is controlled by a temperature control device hydraulically operated. A thermo-couple bulb located in the oil line actuates the control device micro-switches which change the fan speed and opens the top shutters. The servo-motor opens the two radiator side shutters.

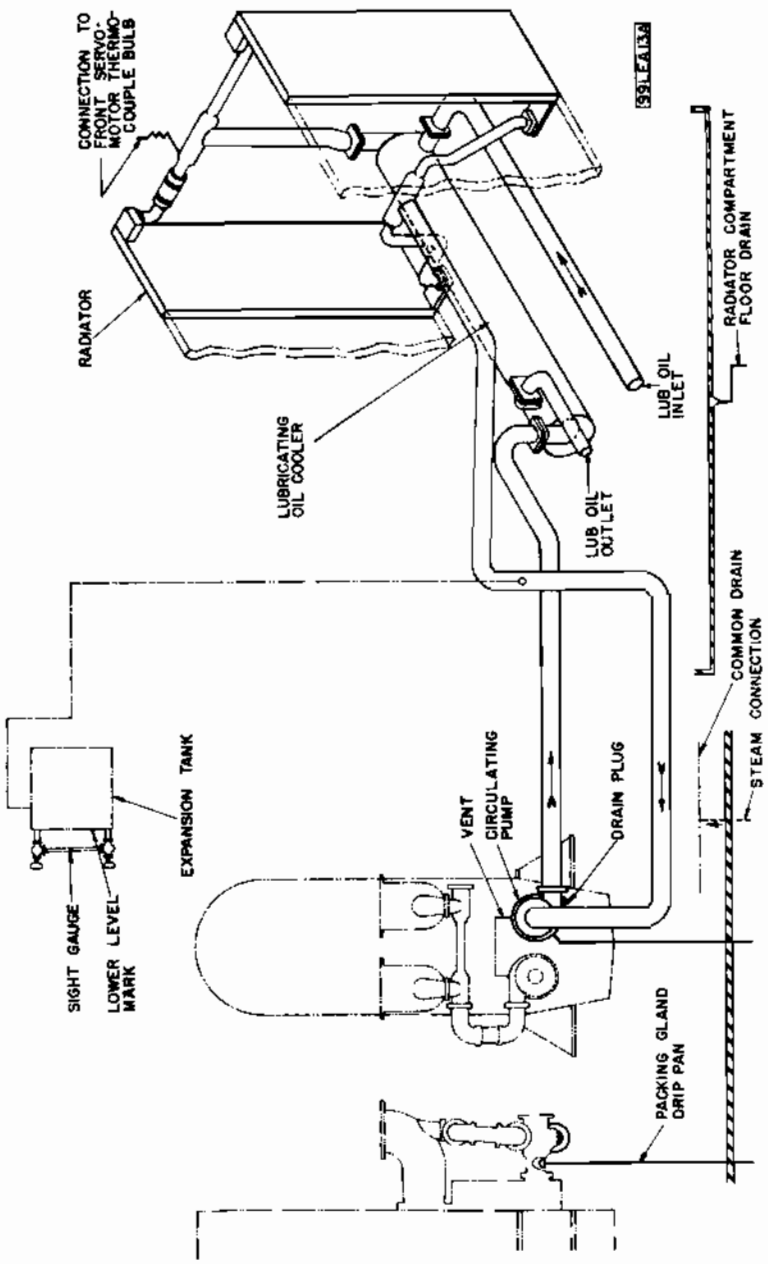
The servo-motor and micro-switches are set to open the shutters and start the fan when the lubricating oil reaches a temperature of approximately 150° F. The operation of the cooling system is more fully described in "Engine Jacket and Lubricating Oil Cooling Water" Sec. 119A1a.

b. By-pass Relief Valve

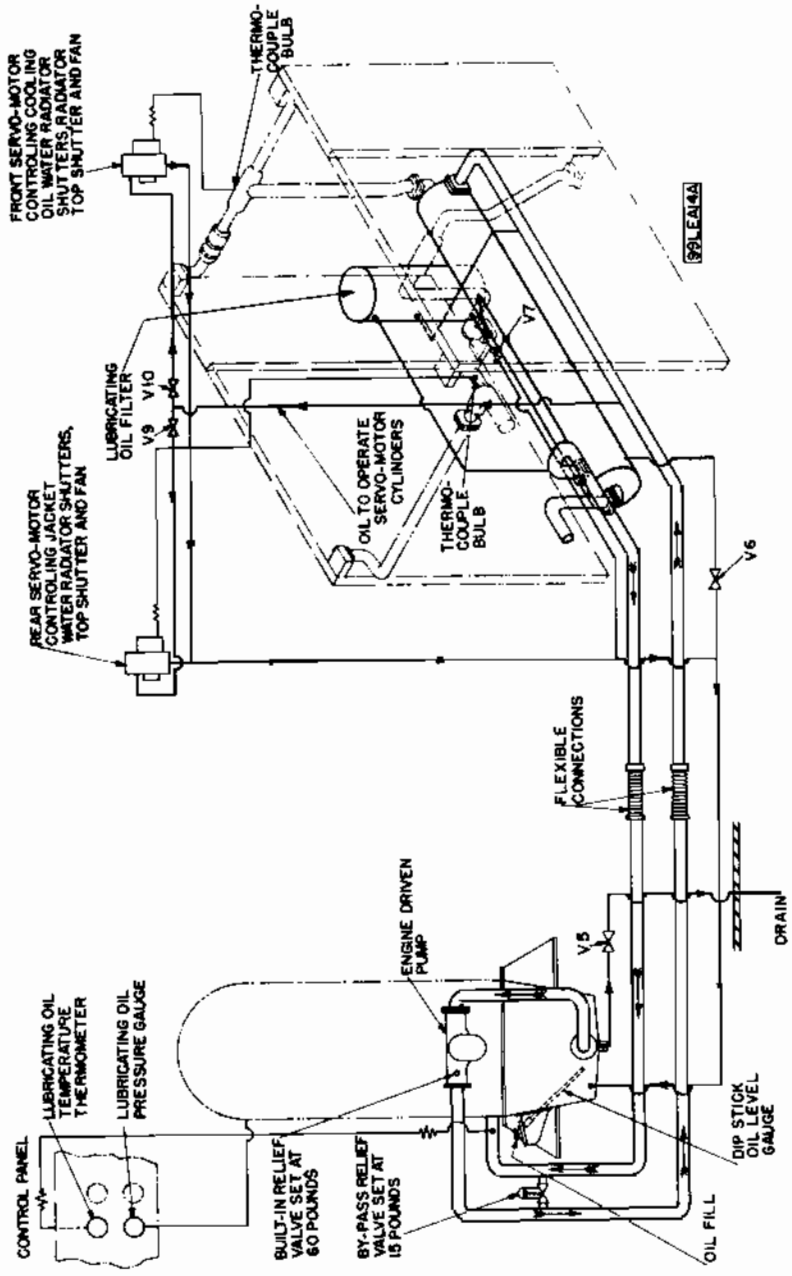
The by-pass relief valve set at 18 lbs. is also installed across the pipes to and from the lubricating oil coolers. The valve serves as a quick warm-up device and insures that the engine will get oil when the oil is cold by causing the cold oil to be by-passed around the coolers until it warms up and the pressure drops.

c. Drains

The engine can be drained by opening the valve V5, located near the oil drain connection to the engine sub-base. Remove the pipe plug from the lubricating oil connection beneath the locomotive. To drain the entire system also open valves V6 and V7 connecting the lines to and from the coolers to the return line to the engine sub-base. See Illus. A7, Sec. 104A1. The valves V9 and V10 should always be open.



Illus. A1 Lubricating Oil Cooling Water System



Illus. A2 Lubricating Oil System

d. Warming Up

The oil in the lubricating oil system, can be warmed up in freezing weather indirectly from the lubricating oil cooling water by connecting stand-by steam and opening drain valves V3 and V4 to the common drain.

e. Temperatures

For best operating oil temperatures see "Locomotive Operation," Sec. 104A, page 5, par. C.

f. Oil Pressure

A connection is made from a point in the engine lubricating system to a diaphragm in the shut-down mechanism of the governor. Pressures of less than 4 psi at idle will, after a certain time delay, cause the shut-down mechanism to trip and shut down the engine. Pressures of less than 15 psi at full engine speed will actuate the shut-down mechanism without a time delay.

A low lubricating oil pressure switch within the governor connects to an amber indicator light on the control panel. Lighting of this light indicates a failure of the engine lubricating oil pressures.

g. Filling the System

1. Initial Fill

When the system is being filled for the first time oil should be added until the level reaches the "Oil Change—New Fill" mark on the "Engine Stopped" side of the stick. After the engine has been run and the oil is distributed thru the system the level will be at the "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 is at the "Full Engine" or "Full System" mark on the dip stick, depending on whether the engine is stopped or running.

3. Oil Change

When changing the lubricating oil, first completely drain the entire system, (see paragraph "C") then add oil until the level reaches the "Oil Change—New Fill" mark on the "Engine Stopped" side of the dip stick. The level will drop to "Full Engine" mark after the engine has been run, due to the distribution of the oil thru the system.

Oil is added thru the engine fill opening on the side of the sub-base.

h. Overheating

If the high temperature indicator light comes on when the engine load is not excessive and the atmospheric temperature is not above 90° F., check the following as soon as possible:

1. Top and side shutter. Is it open in accordance with the demands of the servo-motor?

2. Radiator cooling fan to see if it is running.

3. The water level.

4. The temperature regulator or servo-motor if the fan is not running.

SECTION 118A ENGINE JACKET WATER COOLING SYSTEM

118A1. Engine Jacket Water Cooling System

The engine part of the cooling system consists of the exhaust elbows, exhaust manifolds, inlet and outlet elbows, the cylinder liners, and the water header. The cooling water from the pump discharge enters the exhaust nozzles and flows into the exhaust manifolds to the exhaust belts to cool the lower part of the cylinders. The water travels thru the inlet into the cylinder liner. Passages inside the cylinder liner jacket permit cooling water to surround the injection nozzle adapters. The water continues to travel upward within the cylinder liner water jacket, cooling the cylinders. It then emerges from the top of the cylinder thru the outlet elbows and on into the water header on the side of the engine.

The water leaves the engine from the water header and is piped to the radiators, Illus. A1. After being cooled by the air circulated thru the radiators by the radiator cooling fan, the water returns to the pump suction. A constant head is maintained on the system by the equalizer line to the expansion tank.

a. Thermometers and Indicator Lights

Connections for the remote reading thermometer and the high temperature indicator light on the control panel are provided in the engine to radiator line. The high temperature switch is set to light the indicator light at 190° F.

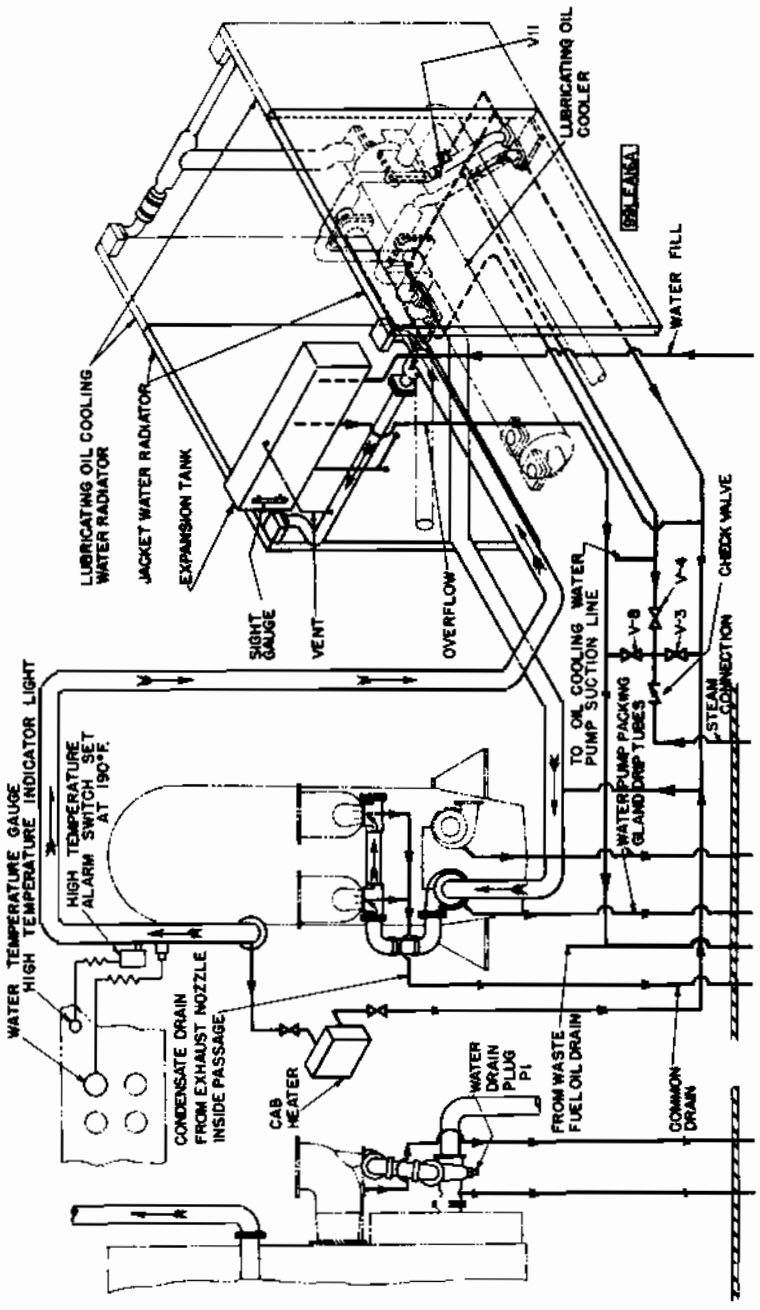
b. Temperature Control and Servo-motor

The thermocouple bulb operating the temperature regulating servo-motor of the jacket water system is located in the engine water discharge line. This servo-motor controls the two radiators, side shutters, the top shutters over the cooling fan, and the 3-speed fan.

The temperature control switches operated by the servo-motor are set to open the top shutter and to control the 3 speeds of the fan as required. The servo-motor directly controls the shutter operation and the fan speed position. This device is so calibrated as to maintain an average temperature of approximately 160° F. This operation is described in greater detail in "Engine Jacket Water and Lubricating Oil Cooling Water," Sec. 119A.

c. Water Level and Filling

Water should be added to the system when the level in the



Illus. A1 Engine Jacket Water Cooling System

expansion tank sight gauge drops below the "Low Level" mark behind the gauge. Water is added at the hose connection near the front truck at the right side of the locomotive. Add until it runs out the common drain pipe. See Illus. A7, Sec. 104A1.

d. Freezing Precautions

During freezing weather when the locomotive is out of service, the locomotive must be protected from freezing by connecting to a stand-by steam line or the cooling water system must be completely drained. To add steam, attach hose to connection provided and open valves V3, V4 and V11, Illus. A1. Valve V8 must be closed tight. Throttle steam at valve V3 and V4 when warming up. If steam is not available, the cooling system must be drained.

Before operating the unit, be sure that valves V3, V4, and V11 are closed. Valve V8 is closed at all times except when draining.

e. Draining

To drain the radiator and jacket water cooling systems, open valves V3 and V8 in the drain line and remove P1 in each of the water pumps.

f. Cold Weather Operation

After the engine has warmed up and all pressures and temperatures have reached the minimum figures as listed in "After the Engine is Running," Sec. 104A1c, the temperature control mechanism will automatically allow uninterrupted use of the locomotive. In the event of ice formation on the shutters, remove ice at first opportunity.

g. Overheating

If the yellow high temperature indicator light comes on when the engine load is not excessive and the atmospheric temperature is not abnormal, check the following as soon as possible:

1. The shutter linkage. Is it open in accordance with the demands of the servo-motor?
2. Radiator fan motor and fuse.
3. The water level.
4. The thermostat or servo-motor.
5. The oil pressure to servo-motor.

SECTION 119A. RADIATOR COOLING AIR SYSTEMS

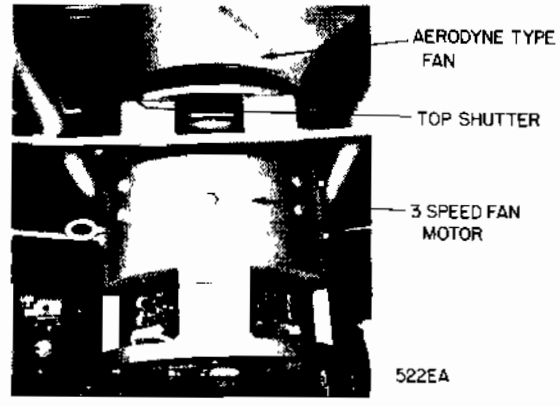
119A1. Cooling Air System

a. Engine Jacket Water and Lubricating Oil Cooling Water

Efficient cooling of the engine is effectively accomplished by passing the engine jacket water and the lubricating oil cooling water thru air cooled radiators. See Illus. A1.

Temperature operated switches for operating the shutters and for controling the speed of the fan motor are part of both front and rear servo-motors of the temperature control mechanism. The servo-motors are both located in the radiator enclosure and are caused to operate by temperature rises in the thermo-couple bulbs installed in the discharge piping of the engine and the oil coolers.

Both the jacket water and the lubricating oil temperature control servo-motors are equipped with 4 micro-switch contacts. A temperature rise causing either servo-motor to move to the first contact position will open the top shutters. The other three contacts provide step operation of the three speed fan. These fan speeds are designated as low, medium, and high. The rear servo-motor controls the engine jacket water temperature and the front servo-motor the temperature of the lubricating oil. When the temperature of the jacket water entering the engine exceeds 150 F., the rear servo-motor opens the rear side shutters. Likewise, the front servo-motor opens the front side shutters when the temperature of the oil exceeds 160 F., thus insuring a proper viscosity of oil entering the engine.



Illus. A1 Radiator Cooling Fan

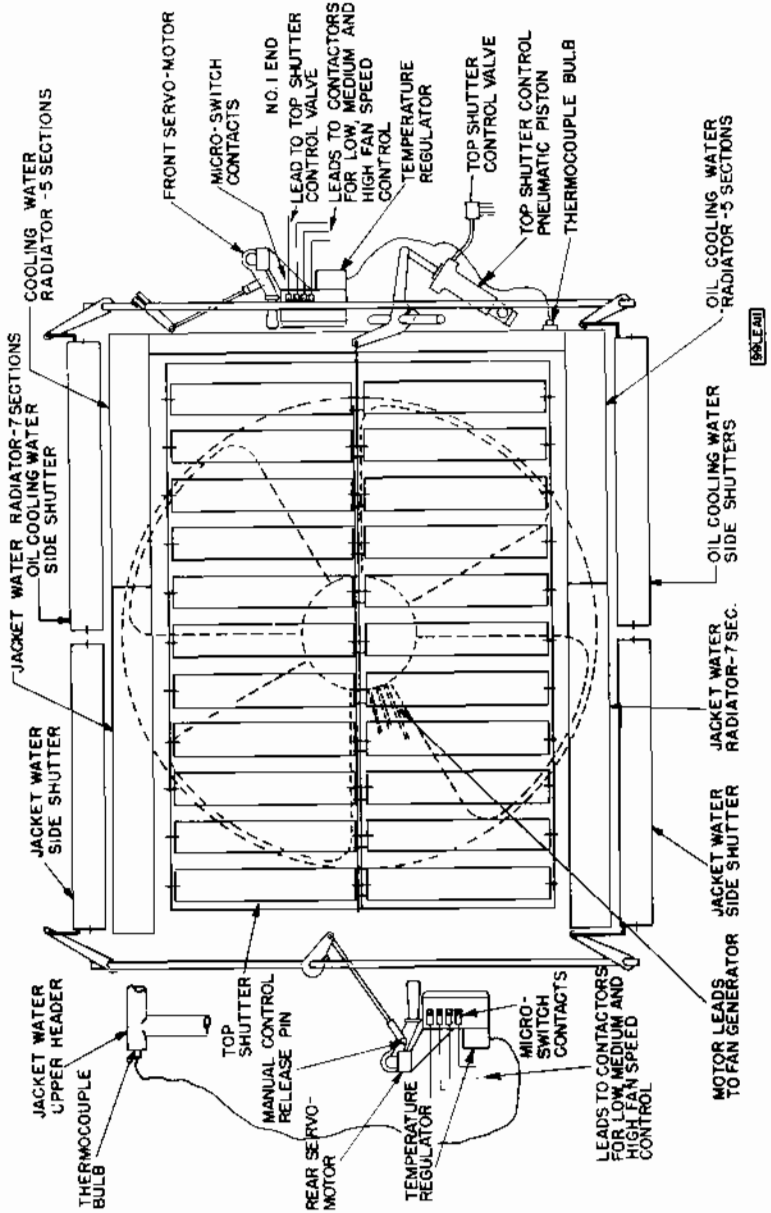
The top shutters are, as indicated above, operated by either the front or rear servo-motor as the temperature of the jacket water reaches 160 F. or the oil reaches 150° F. and the first contact is closed. If the temperature of either or both systems continues to rise, the servo-motors continue to move and the second contact is eventually closed, starting the fan in the low speed position. At this point, the side shutters begin to open. This movement continues as the temperature rises, the shutters opening wider and the fan speed increasing to medium. When the movement reaches the maximum and the fourth temperature switch contact is closed, the fan is operating at high speed and the side shutters are completely open.

The reverse action takes place as the engine cools, stepping down the fan speed and gradually closing the shutters. The fan will keep running and the shutters will remain open on either system until proper cooling is made and the cut-out temperature is reached. The movement of the side shutters is slow and gradual, and will follow the higher and lower temperatures closely. The top shutters will close last of all.

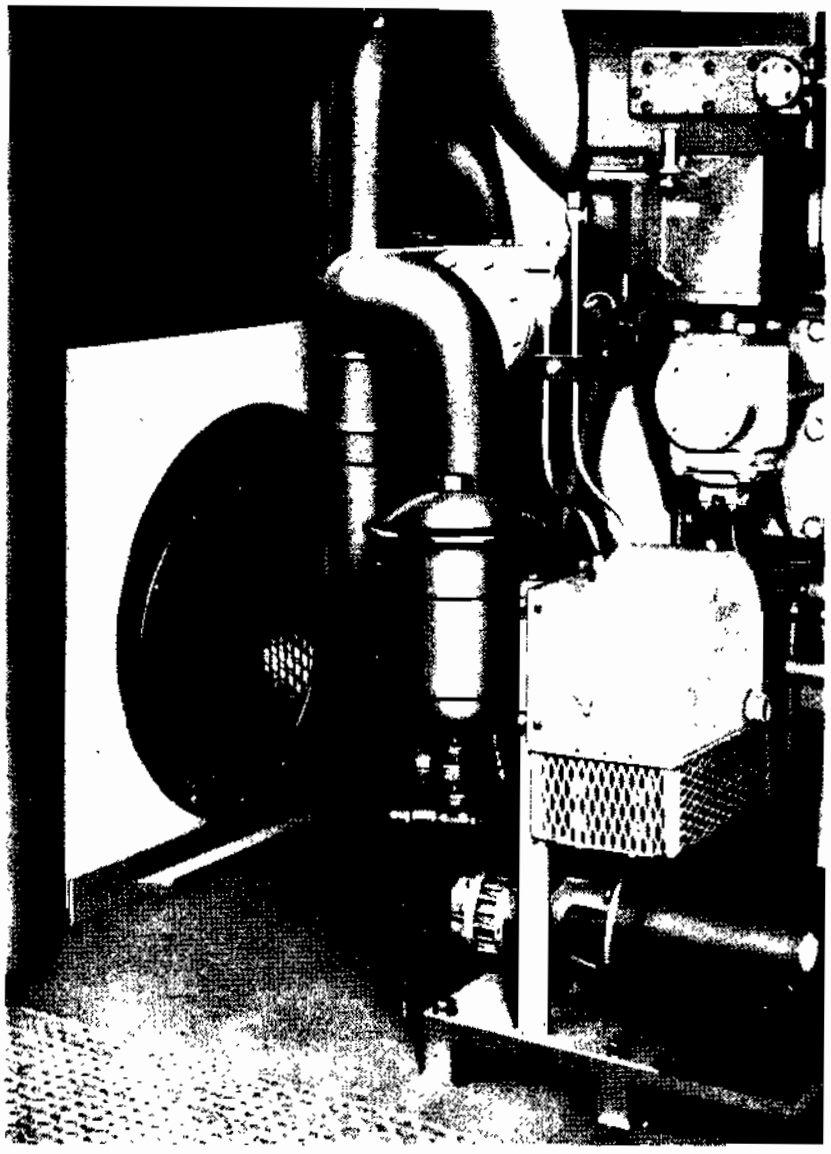
Manual shutter control is provided on both systems in conjunction with the automatic control. The control handles are locked by a spring button and are readily accessible. When manual operation is necessary, the fan speed and shutter position is selected at the discretion of the operator. A careful watch of temperatures must be kept and care must be taken so as not to overheat the engine.

b. Engine Room Ventilation and Traction Motor Blowers

The engine room and generator compartment ventilating air enters thru louvers along the top side of the engine compartment enclosure. The front traction motor blower draws part of it's suction from the compartment at the pump end of the engine and part from the atmosphere thru the air duct. This affords a certain amount of ventilation. The rear traction motor blower takes its suction from behind the air compressor, ventilating the generator end of the engine compartment. The generator and the auxiliary generators are ventilated by air drawn from the generator compartment. Illus. A3 shows ventilation air duct to the front traction motor blower.



Illus. A2 Cooling Air System



Illus. A1 Traction Motor Blower Air Duct—Front Truck

SECTION 120A. TRAIN HEATING

120A1. Steam Heating - Vapor—Clarkson

a. Introduction

The instructions contained in this book are for the guidance of personnel engaged in the operation of OK-DSN series and DSK series steam generators. A general description of the steam generator is given, the operating technique is outlined and a trouble shooting section is provided for the operator.

The symbol number after each device mentioned in the text refers to the piping schematic chart, figure 9. The numbers are used to facilitate identification of the various devices.

The chart shows the various controls and devices on the OK series of steam generators and outlines the flow of fuel, water and steam. The chart is to be used for the DSK series also—the two types of steam generators are schematically identical, with the following minor exceptions:

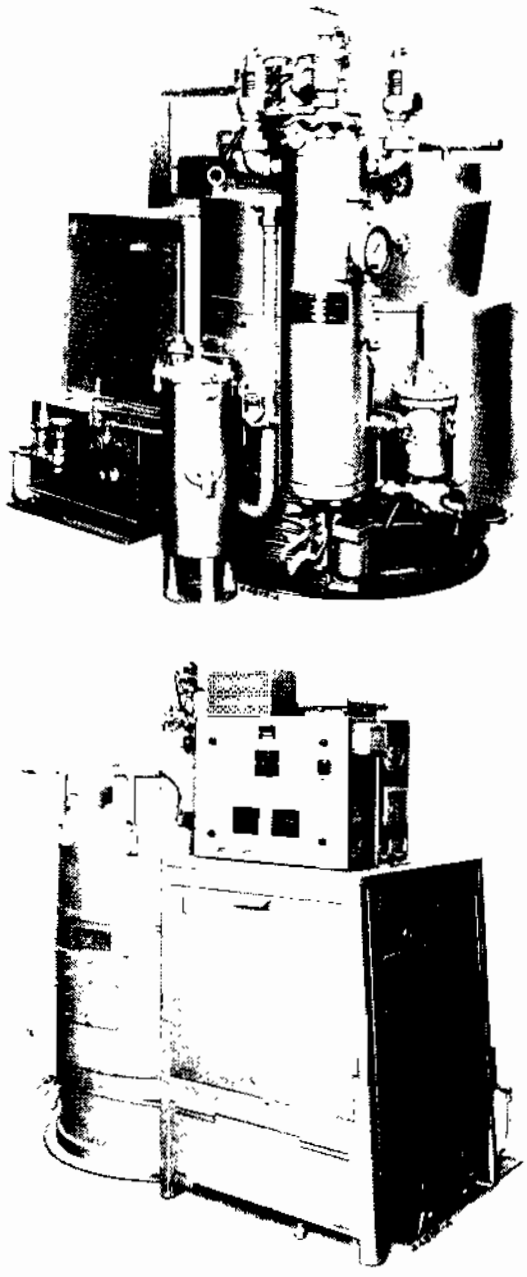
1. The water strainer manifold-231 shown on the chart is not used on DSK models.
2. DSK models have the fuel solenoid valve-104 located in the fuel line ahead of the fuel nozzle pressure gauge-207; on OK models the fuel solenoid valve is located directly over the fuel spray head-105, as shown on the chart.
3. An air solenoid valve is used on DSK models, instead of the air switch-101 shown for OK models.
4. On DSK units the steam temperature limit control-110 is located at the top of the coils instead of at the bottom, as shown for OK steam generators.

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

b. Description

Steam generators of the 4630 and 4530 series have a rated capacity of 3000 pounds of water evaporation per hour; 4616 steam generators have a rated evaporative capacity of 1600 pounds per hour. 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



Illus. A1 Vapor-Clarkson Steam Generator

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.

c. Before Starting

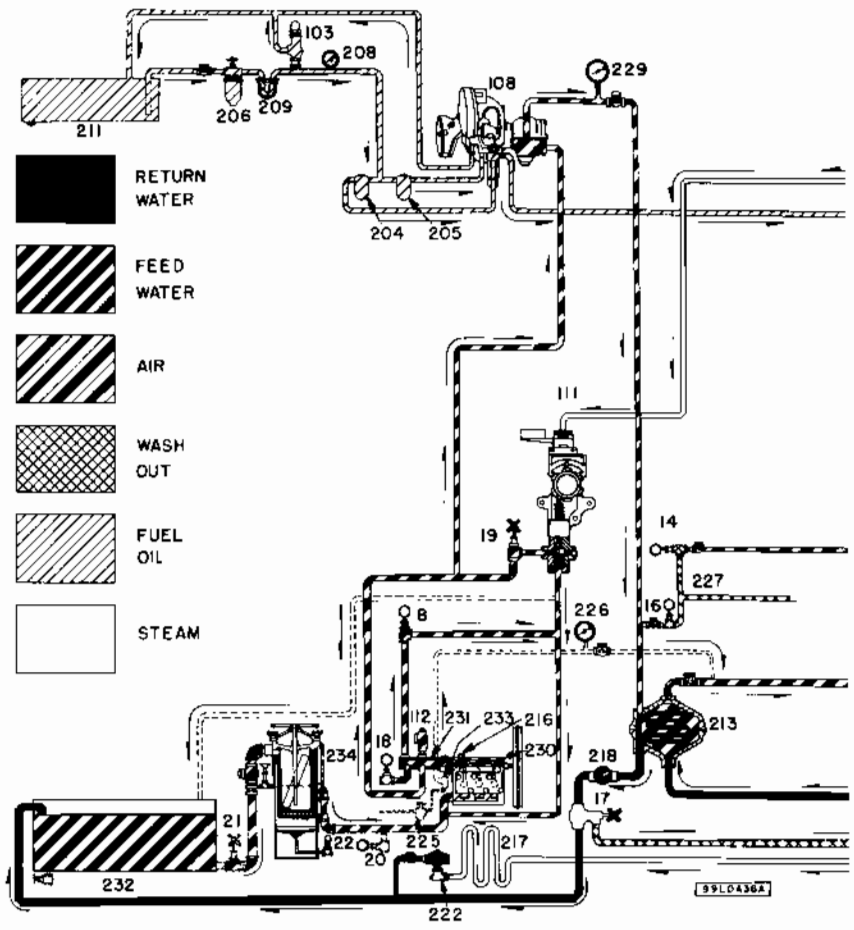
On OK models, the valves designated by *odd* numbers must be OPEN during normal operation of the steam generator. Valves designated by *even* numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted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

1. Make certain that the following valves are OPEN:
   Atomizing Air Shutoff Valve-1
   Coil Shutoff Valve-3
   Return Water Outlet Valve-9
   Steam Admission Valve-11 to Trainline Pressure Gauge-224

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



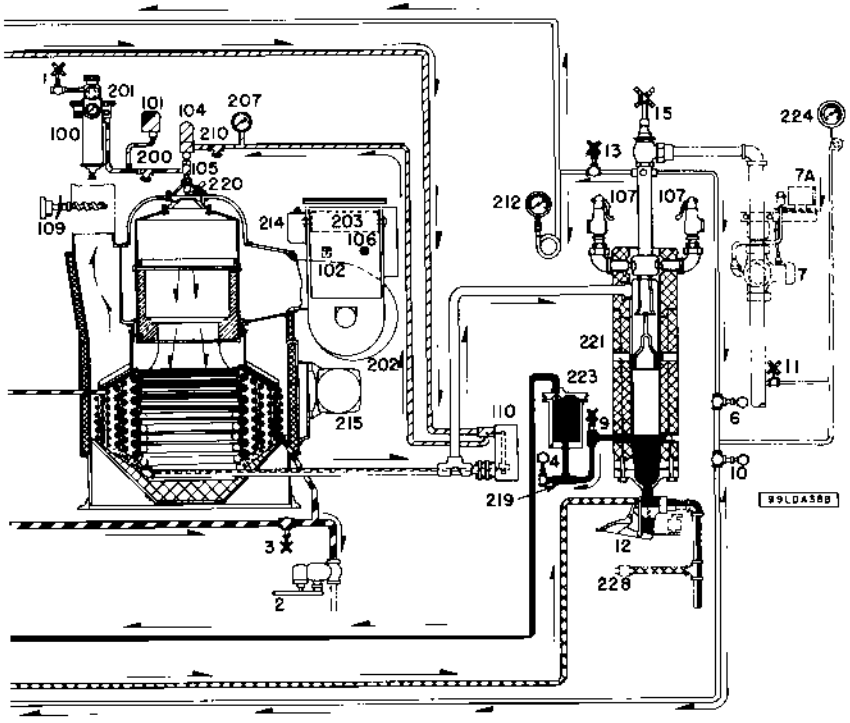
Illus. A2 Steam Generator Schematic Diagram

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 Gauge
225—Treatment Injector Filter
226—Treatment Injector Gauge
227—Washout Solution Inlet
228—Washout Solution Outlet
229—Water Pressure Gauge
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)

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 Shutoff 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 Gauge
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



—Vapor-Clarkson Steam Generator

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
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

APPURTENANCES

200—Atomizing Air Strainer
201—Atomizing Air Pressure Gauge
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 Gauge
208—Fuel Pressure Gauge (At fuel pressure regulator)
209—Fuel Pump
210—Fuel Strainer
211—Fuel Tank
212—Generator Steam Pressure Gauge

213—He
214—Ig
215—Mo
216—Oi
217—Ra
218—Re
219—Re
220—Sp
221—St
222—St
223—St
224—Tr
225—Tr
226—Tr
227—W
228—W
229—W
230—W
231—W
232—W
233—W
234—W
(S

Steam Admission Valve-13 to Water By-Pass Regulator-111
Three-Way Washout Valve-17
Water By-Pass Regulator Shutoff Valve-19
Water Supply Stop Valve-21

2. Be sure that the following valves are CLOSED:
Coil Blowdown Valve-2
Layover Connection Shutoff 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.

d. To Fill

1. Open the atomizing air shutoff 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.

e. 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 gauge-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 shutoff 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 minutes; 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 in fig. 9.
3. The steam generator should come up to full operating pressure in one or two minutes; it may take 10 or 15 minutes to build up the required operating steam pressure in the trainline.

f. 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.

g. 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 shutoff valve-7.
2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gauge-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 blowndown valve.
5. Fill the coils with water.
6. Close the atomizing air shutoff 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.

h. 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 shutoff valve-6 and the inlet valve-10 to the radiation on idle steam generators.

CAUTION: Layover connection shutoff valve-6 must be closed when trainline shutoff 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.

i. 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.

j. 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 and for poorly adjusted pulley belts. On OK units check the setting of the belt tension adjuster. 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.

k. 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 outfire 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:* Trun the 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 cutout switch on the servo and close the fuel solenoid valve-104).

Be sure that the pump belts have proper tension, 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 gauge-229 still registers low, close the water by-pass regulator shutoff 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 gauge 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.

l. 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 shutoff valve-19 and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

m. Remote Control Equipment

The remote control panel is located on the fireman's side of the locomotive cab. Mounted on it are a master switch to make the panel operative, and push-button switches to operate the separator blowdown valve-12 and the remote control trainline shutoff valve-7. Three warning lights are mounted on the panel and connected to the alarm circuit of the locomotive. The lights are marked "boiler off", "hot engine" and "low oil". A trainline steam pressure gauge is mounted on the panel.

A soot blower switch is also provided. It is to be used only when a steam generator of the CFK type is included in the installation. The remote control trainline shutoff valve-7 can be closed from the cab; it must be opened manually, however. Depress the reset lever-7a on the trainline shutoff valve-7 to the position marked "open".

n. 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.

SECTION 121A MISCELLANEOUS ACCESSORIES

121A1. Miscellaneous Accessories

a. Fuel Supply System: Illus. A2, Sec. 116A
Tank
Protectoseal Fill Cap
Safety Cut-off Valve
Motor Driven Fuel Supply Pump
Fuel Oil Filter
Relief Valve

b. Lubricating Oil System: Illus. A1, Sec. 117A
Lubricating Oil Cooler
Lubricating Oil Filter
Lubricating Oil Strainers
By-pass Valve
Radiator Servo-Motor Thermo-Couple Bulb

c. Engine Jacket Cooling Water System: Illus. A1, Sec. 118A
Expansion Tank
Engine Temperature Switches
Radiator
Radiator Servo-Motor Thermo-Couple Bulb

d. Lubricating Oil Cooling Water System: Illus. A1, Sec. 117A
Radiator
Heat Exchangers

e. Cooling Air Systems: Illus. A1, Sec. 119A
Top and Side Shutters
Air Cooling Fan and Direct Connected Motor
Jacket Water Temperature Shutters
Servo-Motor and Temperature Switches (Oil)
Servo-Motor and Temperature Switches (Water)
Oil Cooling Water Temperature Shutters

f. Radiator Enclosure
Sand Storage Tank
Classification, Number, Gauge and Ground Light
Front Headlight
Front Truck Traction Motor Blower

g. Engine Enclosure
Fire Extinguisher
A Pyrene extinguisher is provided and is safe for use on electrical fires

Hood Lights
Batteries
Flexible Coupling
Rear Truck Traction Motor Blower
Fan Generator and Auxiliary Generator
Engine Scavenging Air Filter
Exhaust Snubber

h. Cab Enclosure

Cab Heater

A switch on the control panel starts the fan motor of the heater. Circulation of hot water thru the heater from the engine jacket system can be controlled by opening the gate valve above the heater.

An air duct, with a damper control is provided to allow fresh air to enter the cab. The air enters the duct from outside, passes through the heater and is circulated in the cab. Foul air is removed thru the outlet above the electrical cabinet. The air is changed completely about three times a minute.

Cab Heater Fan Motor Switch

Bell Ringer

The air operated bell ringer is mounted on the right side of the brake pedestal.

Sander

The sander valve is mounted to the right of the brake pedestal on the end of the control panel. Operation of this valve provides forward and back sanding.

Fire Extinguisher

The CO_2 extinguisher provided in the cab is safe on all types of fires and the crew should be thoroughly familiar with its operation.

Cab Lights
Rear Headlight
Windshield Wipers (Air Operated)
Sand Storage Tanks

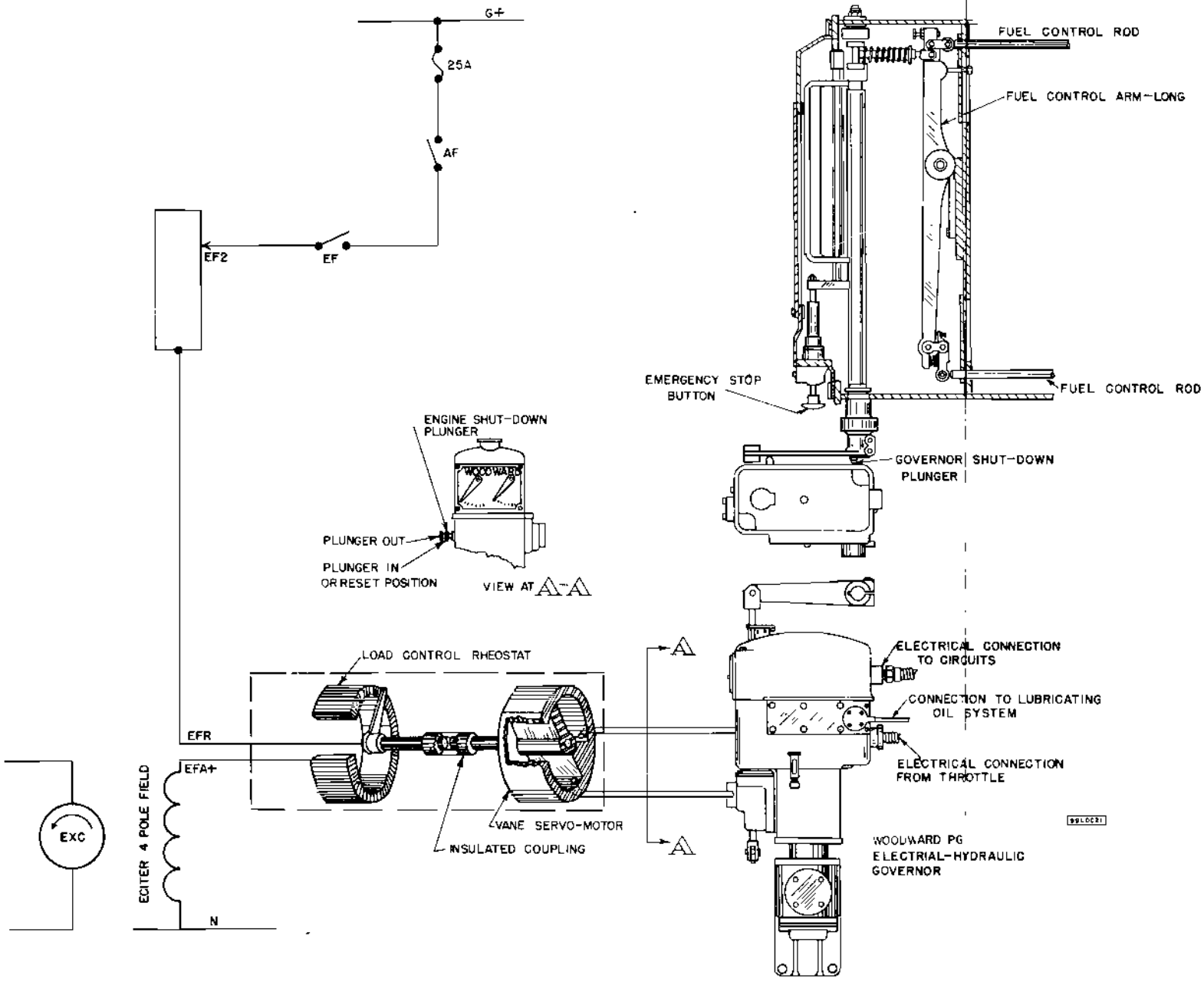
Hand Brake

The hand brake of the pedestal type is located at the rear of the cab on the fireman's side. Brakes are applied to the rear wheels on No. 2 truck.

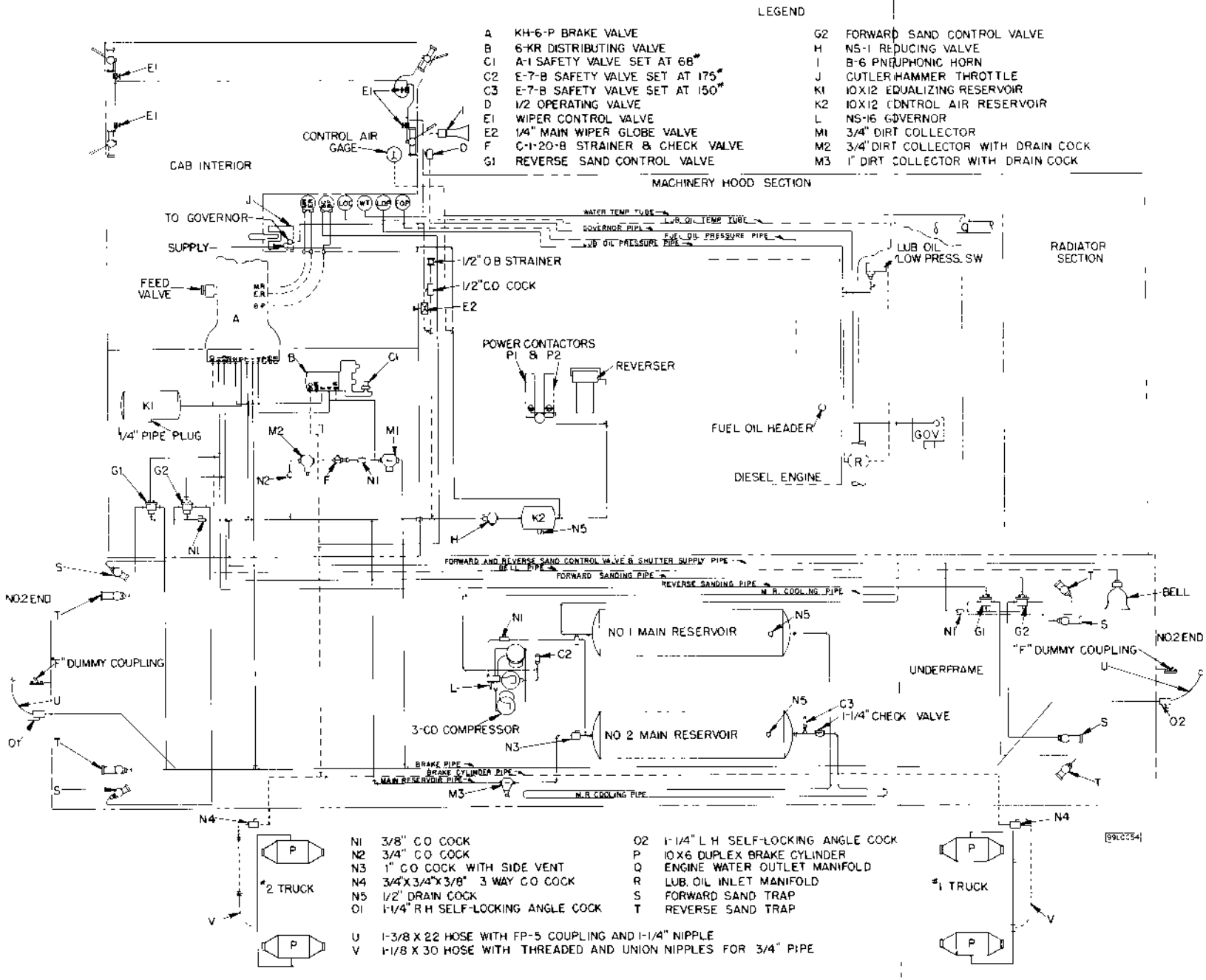
Sun Visors

Luggage Racks (Optional Equipment)
Tachometer (Optional Equipment)
Clothes Lockers (Optional Equipment)

i. Switchboard Switches and Fuses: Illus. A6, Sec. 104A
Main Battery Knife Switch (No. 110)
Traction Motor Cut-out Switches (No. 111)
Traction Motor Blower Fuse (225 Amp.)
Auxiliary Generator Fuse (100 Amp.)
Control, Governor, and Light Fuses (25 Amp.)
Radiator Fan Motor Fuse (400 Amp.)



Illus. A1 Governor and Autoload Control



Illus. 2. Control and Air Brake Schematic Piping Diagram

SCHEMATIC ELECTRICAL DIAGRAM

The General Schematic Electrical Diagram, Illus. A3, covers the starting, power control and lighting circuits. The following is offered as a brief explanation of the workings of the electrical circuits used in these locomotives.

Legend and Function of Apparatus

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 publication.

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 some electrical equipment.

Symbol	Device	Function
AF	Auxiliary Generator Field Contactor	Energizes auxiliary generator field, exciter field, fan generator field, and fan-shutter controls.
AV, BV, CV, DV	Solenoids in Electro-Hydraulic Governor (See also ORS and TV)	Controls engine governor action. Energized from lead unit throttle. (Not used with pneumatic throttle.)
BC	Battery Charging Contactor	Connects the auxiliary generator to the battery and the low-voltage control circuits.
BL	Blower Protective Relay	If traction motor blower motor current fails, cut off power by de-energizing EF contactor.

Symbol	Device	Function
C	(Not on 1200 HP Units) Traction motor field shunting pilot relay, backward sequence.	Opens shunting contactors two at a time. De-energized by opening of Vc.
CC	Air Compressor Synchronizing Magnet Valve	When energized by CG, operates unloader to load air compressor.
CG	Air Compressor Governor Switch	Energizes CC and CS trainline wire to load all compressors simultaneously. Closed by main reservoir air pressure at 130 lbs.; open at 140 lbs.
EF	Exciter Field Contactor	Energizes exciter battery (4-pole) field controlling exciter and hence main generator output.
EFR	Exciter Field Reduced Contactor (Used only with "Low Power" button.)	When de-energized by pressing of low power button, opens to insert resistance in exciter battery (4-pole) field circuit.
EPS	See TPS.	Closes when main reservoir air pressure drops to 80 lbs., to energize TLV.
ETS	Engine Temperature Switch	Connected to thermo-bulb in engine water outlet manifold. Set to close at 195° F. Sounds alarm bells in all units and lights red light on control panel of unit affected.
For, Rev	Magnet valves, (if used) contacts and interlocks on the Reverser. "For" indicates those normally closed in "forward". "Rev" indicates those normally closed in "reverse". The Reverser is electro-pneumatically operated thru magnet valves "For" and "Rev".	Change direction of current thru traction motor fields. Westinghouse Type XR-126 reversers do not use magnet valves, and are straight pneumatically operated. Westinghouse Type XR-26, and Cutler-Hammer reversers do use magnet valves.

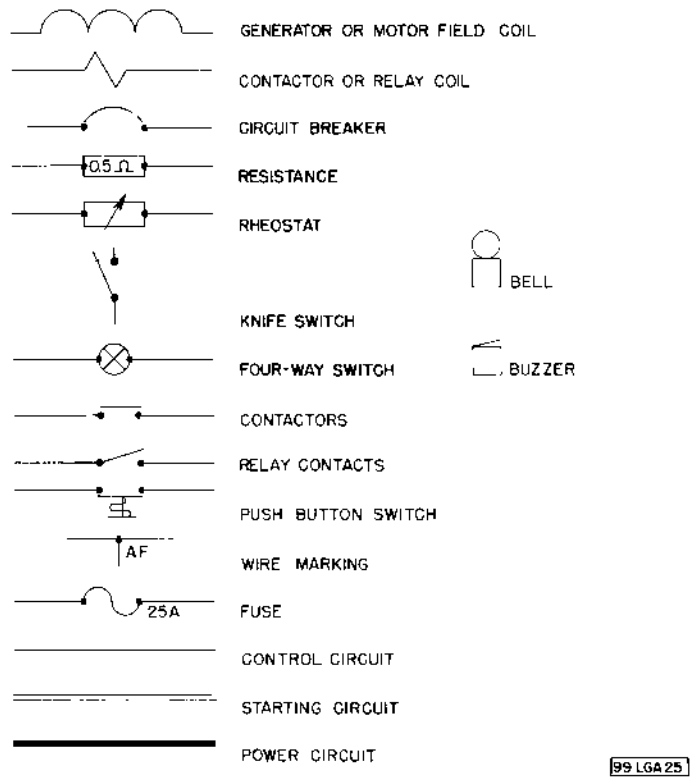
Symbol	Device	Function
FS1, FS2	Traction Motor Field Shunting Relays on 1200 HP units.	On 1200 HP units, control shunting contactors are energized by main generator voltage.
FPS	Forward Pressure Switch (Used only on older type pneumatic throttle.)	Sets reverser in forward direction. Closes at 50 lbs.; opens at 40 lbs. air pressure from the throttle.
G+, G-	Engine Starting Contactors	Connect main generator to battery for starting the engine.
GR	Ground Relay (Set at 150 volts either side of main generator to ground.)	Energized in event of a ground in the main power circuits. Alarm bells ring on all units, and alarm light burns on control panel of unit affected. De-energizes TV to bring engine speed to idle and de-energizes EF to remove power.
K-3 Switch	(Used only with older pneumatic throttles.)	Closes throttle control circuit. Set to close 2 lbs. below throttle first notch pressure, or at approx. 13 lbs. Set to open at 8 lbs.
LOCO RUN	Locomotive Run Switch	Energizes propulsion control circuits.
LOP	Oil Pressure Switch (Not used on newer units.)	To open AF contactor on engine shut-down. Set to open at 5 lbs. engine lube oil pressure.
LOS	Low Oil Switch (in Governor)	Shuts engine down if engine lubricating oil pressure falls too low for engine speed being maintained.
M1, M2, etc.	Traction Motor Field Shunting Contactors	Shunt traction motor fields to increase motor speed. Controlled by field shunt relays.

Symbol	Device	Function
Null Sw.	Nullifying Switch (Separate pressure Switch on older units.)	Contact in throttle closing at approximately 650 engine RPM to nullify low power control.
ORS	Overriding Solenoid (in Governor)	Prevents load regulator from going to maximum field during removal of excitation or cutting out of traction motors.
P1, P2	Power Contactors	Connects traction motors to the main generator.
PCR	Pneumatic Control Relay	Opens throttle control circuits when de-energized by closing of PCS. This drops power or braking on all units and brings all engines to idle speed.
PCS	Pneumatic Control Switch	Air pressure switch. Closes in event of emergency, safety control, overspeed, or train control air brake application. When closed de-energizes PCR.
RC	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.
RF1, RF2, RF3	Radiator Fan Contactors on 1200 HP units.	Control radiator cooling fan motor speeds.
RPS	Reverse Pressure Switch (Not used on newer type pneumatic throttles.)	Sets reverser in reverse direction. Closes at 50 lbs.; opens at 40 lbs. air pressure from the throttle.
S1-S4 S11-S44	Fan-Shutter Control Switches	Control SMV and fan contactors.

Symbol	Device	Function
SMV	Shutter Magnet Valve	Controls main reservoir air to the top shutter operating cylinder.
SPS	Sanding Pressure Switch	Energizes FSM or RSM and trainline wire SA when closed by engineer's sander switch.
SR	Signal Relay	Energizes alarm bells.
TDR	Time Delay Relay (Not used on 1200 HP Units)	Delays opening of power contactors (P1 and P2) until 2-1/2 seconds after excitation is removed, reducing contact tip burning.
T1, T2, T3	Traction motor field shunting time delay relays (not used on 1200 HP units)	Control timing of sequence in field shunting circuits.
T1A, T2A, T3A	Contacts of T1, T2, T3 for forward shunting sequence.	In forward shunting steps, prevents succeeding step from occurring until fifteen seconds have elapsed.
T1B, T2B	Contacts of T1, T2 T3 for backward shunting sequence.	In backward shunting steps, prevents succeeding step from occurring until fifteen seconds have elapsed.
TMCO	Traction Motor Cut-out Switch	Knife or selector switch to cut out traction motors on either truck by de-energizing contactor P1 or P2. P contactor interlocks energize ORS to insert resistance in exciter battery field to reduce main generator output 50%.
TPS	Throttle Pressure Switch (Termed EPS on some units)	Closes when main reservoir air pressure drops to 80 lbs., to energize TLV.

Symbol	Device	Function
TLV	Throttle Line Magnet Valve	When energized by TPS, closes off air in throttle line to give throttle control in event of loss of main reservoir air pressure.
TV	Throttle Contactor (Electric throttle control)	Brings engine speed to idle by de-energizing A, B, and C solenoids in the governor. Engine stops if TV is energized with throttle in 5th or 6th position, since governor D solenoid will shut down engine.
TV	Throttle Magnet Valve (pneumatic throttle control)	When de-energized, vents governor air line to bring engine speed to idle.
V	Traction motor field shunting pilot relay, forward sequence. (Not used on 1200 HP units.)	Closes field shunting contactors M1 to M8. Energized by Vv.
Vc	Traction motor field shunting voltage relay, backward sequence. (Not used on 1200 HP units.)	Controls backward field shunting sequence according to generator voltage. Energizes pilot relay C.
Vv	Traction motor field shunting voltage relay, forward sequence (Not used on 1200 HP units.)	Controls forward field shunting sequence according to generator voltage. Operates pilot relay V.
VR	Voltage Regulator	Regulates auxiliary generator voltage. Correct settings are 72 volts idling, 75 volts full speed.
W, W1 WM	Radiator Fan Motor Contactors on 1600 HP and 2000 HP units.	Control radiator cooling fan motor speeds.

Symbol	Device	Function
WS1, WS2	Wheel Slip Relays	Sound buzzer and light warning light at engineer's station when wheels slip on any unit; also automatically cut off power on unit affected by de-energizing contactor EF.



SUMMARY OF CONTROL EQUIPMENT ADJUSTMENTS IN EFFECT AT PUBLICATION OF THIS MANUAL

1. Field Shunt Relays

a) 1600 hp Units with Time Delay Control

	Vv	Vc
Pickup Volts	810	680
Dropout Volts	720	600

T1, T2, T3 time delay relays set at 3 to 15 seconds depending upon type of service. Refer to service bulletin.

b) 2000 hp Units with Time Delay Control

	Vv	Vc
Pickup Volts	950	830
Dropout Volts	870	750

T1, T2, T3 time delay relays set at 3 to 15 seconds depending upon type of service. Refer to service bulletin.

c) 1600 hp Units with Four Voltage Relays

	FS-1	FS-2	FS-3	FS-4
Pickup Volts	760	775	795	810
Dropout Volts	575	590	600	620

d) 1500 hp Units with Four Voltage Relays

	FS-1	FS-2	FS-3	FS-4
Pickup Volts	725	740	755	770
Dropout Volts	535	550	560	580

e) 2000 hp Units with Four Voltage Relays

	FS-1	FS-2	FS-3	FS-4
Pickup Volts	900	920	935	950
Dropout Volts	690	715	730	745

2. Generator Surge Relay

Type URD-27B. Set at 160 amps.

3. Ground Relay

Type UR-977H. Set at 150 volts G+ or N to ground.

4. Wheel Slip Relays

   Type UR-327C set at 50 volts across coil. (Resistors 1900 ohms)
   Types UR-477G and URC-527A set at 35 volts across coil. (Resistors 1900 ohms)
   Type URD-127A set at 14 volts across coil. (Resistors 500 ohms)

5. Oil Pressure Switch in AF Contactor Coil Circuit - Set to open at 3 to 5 lbs. Purpose is to open AF when engine is shut down so as to prevent current drain from the battery.

6. SPS (Sander Pressure Switch). Set to close at 15 lbs., open at 5 lbs.

7. PCS (Pneumatic Control Switch). Normally open type set to close at 40 lbs., open at 20 lbs. Normally closed type set to open at 20 lbs., close at 40 lbs.

8. EPS (Emergency Pressure Switch, added for break-in-two protection.)

   Set to close when main reservoir equalizing line pressure drops to 80 lbs. On closing will energize magnet valve T L V which traps air in engine throttle line.

9. TDR Relay - Power Contactors

   Set at 2-1/2 seconds or as close to this as possible.

10. Voltage Regulator

    Set at 72 volts idling, 75 volts full speed. Refer to maintenance bulletins.

11. Reverse Current Relay

    Dropout adjusted for a 20-amp. discharge. Pickup at 3 volts above battery voltage.

12. Exciter Battery (4-Pole) Field, Maximum Amperes

    Adjustable resistor set for following maximum current with engine at 850 rpm and load regulator at maximum field:

1500 hp	1600 hp	2000 hp
6 amps.	6 amps.	5 amps.

13. Exciter 2-Pole Field Resistor

1500 hp	1600 hp	2000 hp
12.5 ohms	10 ohms	7 ohms

14. Governor and Engine Fuel Rack Settings (See also Sec. 101A.)

    a) 1600 and 2000 hp
    Full load governor power piston gap is 3/8 inch. Engine fuel racks set at 16 total to correspond. Stop screw set at 17.5 total rack.

    Idle governor power piston gap is 15/16 inch. Engine fuel rack position at idle is determined by full-load setting. For details refer to governor maintenance bulletins. Governor linkage should be set for minimum field start on locomotive.

    b) 1500 hp
    Governor power piston gap not determined at this writing. Full-load total fuel rack is 15. On units with pilot valve in the governor, linkage in governor should be set for minimum field start on locomotive.

15. Load Regulator Timing - Units with Pilot Valve in Governor

    5-7 seconds minimum to maximum field
    10-14 seconds maximum to minimum field

16. Pneumatic Throttle Pressures

	Westinghouse Air Brake Co. E2 & 3-A2E-U Type Throttles	
	30 lb. Cam	60 lb. Cam
Off	0 lbs.	0 lbs.
Idle	15 lbs.	15 lbs.
Full	30 lbs.	60 lbs.
Tolerance	± 2 lbs.	± 4 lbs.

17. Radiator Fan and Traction Motor Blower Control Data

a) Maximum fan generator amps.	500
b) Maximum fan motor amps.	300
c) Maximum traction motor blower motor amps.	200
d) Full rpm, traction motor blowers	2200

e) Fan motor rpm, nominal within 5% variations, with variations, with Jeffrey fan:

First Speed		350
Second Speed		650
Third Speed		
@	0° F.	880
@	30° F.	925
@	70° F.	1000
@	110° F.	1080

18. Throttle Pressure Switch Settings, E-2 Throttles Only

a) FPS (Forward Pressure Switch); Close 50 lbs., Open 40 lbs.
b) RPS (Reverse Pressure Switch); Close 50 lbs., Open 40 lbs.

Note: These settings supersede the former 65 lb. settings so as to meet new I.C.C. break-in-two protection requirements.

c) K-3 Throttle Switch; Close 2 lbs. below first notch pressure, open at 8 lbs.
d) Null Switch; Close 38 lbs.

19. Engine Low Oil Pressure Switch Settings, Older Units Only

a) OPS Hi; Close 18 lbs., Open 14 lbs.
b) OPS Lo; Close 6 lbs., Open 3 lbs.

SEQUENCE CHART

1500 AND 2000 HP UNITS WITH PNUEMATIC THROTTLE CONTROL

OPERATION	MOTOR CONNECTION	THROTTLE	ISOLATOR	CONTACTORS: P1	P2	M1,M3	M2,M4	M5,M7	M6,M8	AF	G+ G−	EF	SOL'S: Fv	GOVERNOR	ORS	RELAYS: PCR	TDR	V4-V	T1	T2	T3	V6,C
SHUT DOWN	CONTROL & FUEL PUMP SWITCHES OPEN	IDLE	ISOL																			
SHUT DOWN	ENGINEER'S FUEL PUMP SWITCH CLOSED	IDLE	ISOL							●				●	●							
ENGINE START	CONTROL & FUEL PUMP SWITCHES CLOSED	IDLE	ISOL							●	●			●	●	●						
IDLING	ENGINEER'S FUEL PUMP & CONTROL SWITCHES CLOSED	IDLE	ISOL							●				●	●	●						
IDLING	ENGINEER'S FUEL PUMP CONTROL & LOCO RUN SWITCHES CLOSED	IDLE	IDLE							●				●	●	●						
IDLING	ENGINEER'S FUEL PUMP CONTROL & LOCO RUN SWITCHES CLOSED	IDLE	RUN							●				●	●	●						
MOTORING FORWARD SHUNTING	FULL FIELD	↓ TO 8	RUN	●	●					●				●	●	●						
	FIRST SHUNT	8	RUN	●	●	●				●		●		●	●	●		●				●
	SECOND SHUNT	8	RUN	●	●	●	●			●		●		●	●	●		●	●			●
	THIRD SHUNT	8	RUN	●	●	●	●	●		●		●		●	●	●		●	●	●		●
	FOURTH SHUNT	8	RUN	●	●	●	●	●	●	●		●		●	●	●		●		●		●
MOTORING BACKWARD SHUNTING	THIRD SHUNT	8	RUN	●	●	●	●	●	●	●		●		●	●	●		●		●		●
	SECOND SHUNT	8	RUN	●	●	●	●	●		●		●		●	●	●		●		●		●
	FIRST SHUNT	8	RUN	●	●	●	●			●		●		●	●	●		●		●		●
	FULL FIELD	8	RUN	●	●					●		●		●	●	●		●				●
IDLING		IDLE	RUN	●	●									●	●	●		●				
MOTORING ONE TRUCK CUT OUT	NO. 1 TRUCK CUT OUT	1-8	RUN		●					●		●		●	●	●		●				
	NO 2 TRUCK CUT OUT	1-8	RUN	●						●		●		●	●	●		●				

SEQUENCE CHART

FOR ENGINE GOVERNOR SOLENOID SEQUENCE SEE ENGINE GOVERNOR SECTION

OPERATION	MOTOR CONNECTION	SELECTOR	THROTTLE	ISOLATOR	CONTACTORS: P1	P2	M1, M3	M2, M4	M5, M7	M6, M8	AF	G+ G-	EF	TV	RELAYS: PCR	TOR	V_C-V_V	T1	T2	T3	VCC
SHUT DOWN	ENGINEER'S FUEL PUMP SWITCHES OPEN	OFF	IDLE	IDLE																	
ENGINE START	ENGINEER'S FUEL PUMP SWITCHES CLOSED	OFF	IDLE	START								●									
IDLING	ENGINEER'S FUEL PUMP SWITCHES CLOSED	OFF	IDLE	IDLE							●										
IDLING	ENGINEER'S FUEL PUMP & CONTROL SWITCHES CLOSED	OFF	IDLE	IDLE							●				●						
IDLING	ENGINEER'S FUEL PUMP CONTROL & LOCO RUN SWITCHES CLOSED	OFF	IDLE	IDLE							●				●						
IDLING	ENGINEER'S FUEL PUMP CONTROL & LOCO RUN SWITCHES CLOSED	OFF	IDLE	RUN							●			●	●						
IDLING	ENGINEER'S FUEL PUMP CONTROL & LOCO RUN SWITCHES CLOSED	1 TO 4	IDLE	RUN							●			●	●						
MOTORING FORWARD SHUNTING	FULL FIELD	1 TO 4	1 TO 8	RUN	●	●					●		●	●	●	●					
	FIRST SHUNT	1 TO 4	8	RUN	●	●	●				●		●	●	●	●	●				●
	SECOND SHUNT	1 TO 4	8	RUN	●	●	●	●			●		●	●	●	●	●	●			●
	THIRD SHUNT	1 TO 4	8	RUN	●	●	●	●	●		●		●	●	●	●	●	●	●		●
	FOURTH SHUNT	1 TO 4	8	RUN	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
MOTORING BACKWARD SHUNTING	THIRD SHUNT	1 TO 4	8	RUN	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
	SECOND SHUNT	1 TO 4	8	RUN	●	●	●	●	●		●		●	●	●	●	●	●	●		●
	FIRST SHUNT	1 TO 4	8	RUN	●	●	●	●			●		●	●	●	●	●	●			●
	FULL FIELD	1 TO 4	8	RUN	●	●	●				●		●	●	●	●	●				●
IDLING		1 TO 4	IDLE	RUN	●	●									●		●				
MOTORING ONE TRUCK CUT OUT	NO.1 TRUCK CUT OUT	1 TO 4	1-8	RUN		●					●		●	●	●	●					
	NO.2 TRUCK CUT OUT	1 TO 4	1-8	RUN	●						●		●	●	●	●					

TRACTION MOTOR FIELD SHUNTING

When a locomotive is starting a train, main generator current is high. By the time 15-30 mph is reached (depending upon gear ratio) at full throttle, current will have decreased and voltage increased to a point where the main generator can no longer absorb full diesel engine horsepower. This is because the generator voltage has reached the saturation point.

At this point if main generator voltage can be decreased by increasing the current, the engine can be kept loaded as locomotive speed increases.

This is accomplished on these locomotives by traction motor field shunting. This is done by connecting resistances in parallel around each pair of traction motor fields. Some of the motor current which had been flowing through the fields is by-passed or "shunted" around the fields. The effect is to increase motor current draw out of the main generator and to lower main generator voltage.

Field shunting is accomplished by closing the "M" contactors in pairs which connect the resistances around the fields. The pairs of contactors close near locomotive speeds where high generator voltage tends to retard locomotive acceleration. When a pair of "M" contactors closes, generator current rises. This can be observed by watching the load ammeter for the periodic slight jumps of the pointer as acceleration takes place at full throttle.

Control sequence is described as follows:

1. Voltage relay V_C picks up. Pilot relay C energizes. (On units with the current relay CR, relay C energizes when the control breaker is closed and there is no V_C relay.)

2. Near maximum generator volts, voltage relay V_V picks up.

3. Pilot relay V energizes.

4. Shunt contactors M1 and M3 close.

5. An interlock on M1 closes to energize time delay relay T1. After a few seconds time delay contact T1A closes to permit the next step of shunting to occur; and contact T1B opens.

6. Due to decreased generator voltage after shunt contactors M1 and M3 close, voltage relay V_V drops out, and pilot

relay V de-energizes. M1 and M3 contactor coils are then energized thru pilot relay C.

7. As locomotive speed increases further, main generator voltage again nears the maximum, and voltage relay V_V closes a second time (provided the time delay has elapsed to allow T1A to close) to start the sequence of the second step of shunting. This is similar to that of the first step. V again energizes, M2 and M4 close, and T2 energizes. V_V drops out and V de-energizes. C holds in M3 and M4. M4 being energized drops out T1 causing contact T1B to close. This makes a holding circuit for M1 and M3.

8. Third and fourth shunting steps operate likewise.

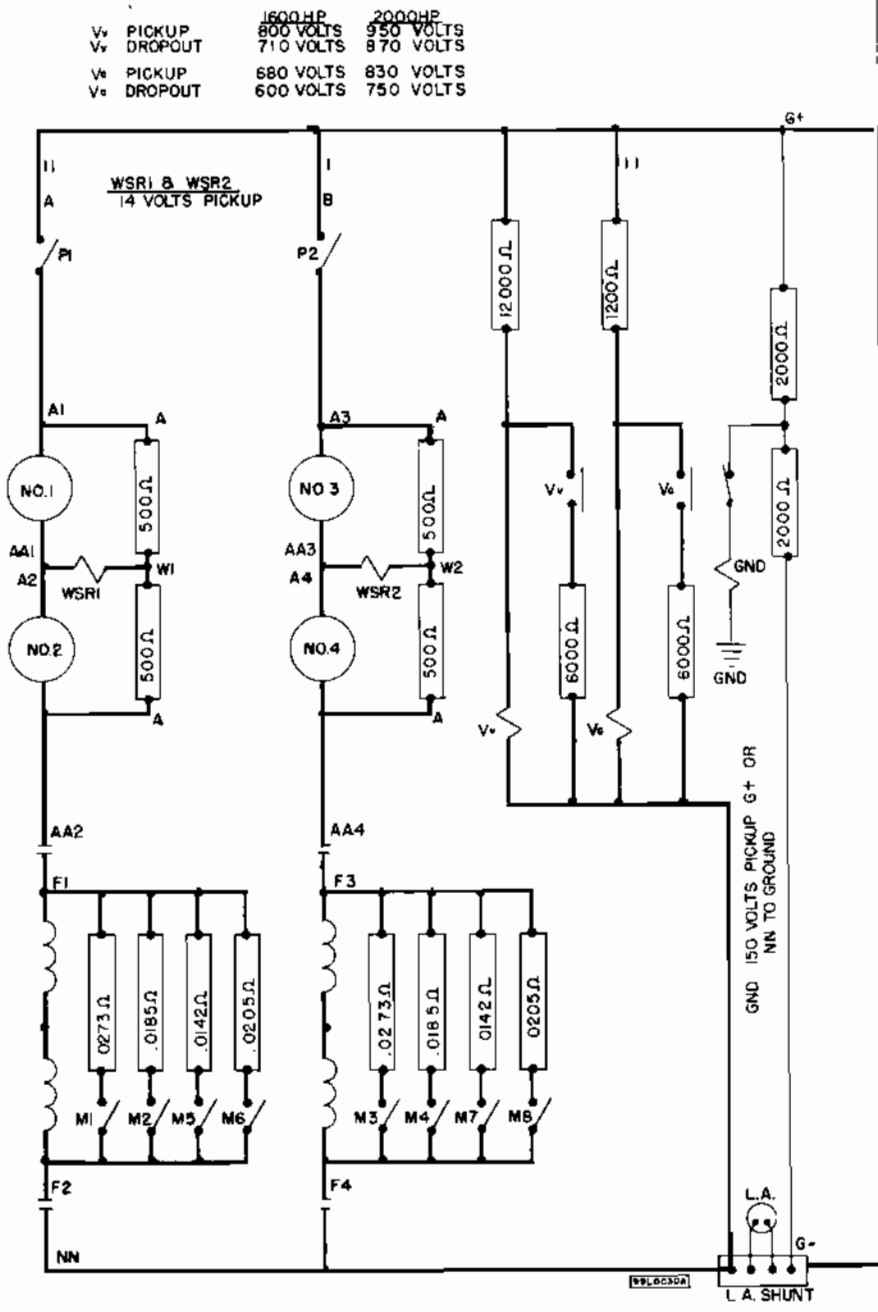
9. With the locomotive operating in the fourth step of shunting, assume that speed lessens due to a grade, raising generator current and lowering generator voltage. At approximately 850 traction motor amperes, current relay CR energizes to open pilot relay C. (On units with a V_C relay, pilot relay C is opened by the de-energizing of generator voltage relay V_C at approximately 900 traction motor amperes. These units have no CR current relay.)

10. Shunt contactors M6 and M8 drop out. Generator voltage increases and current decreases dropping CR (or picking up V_C) and reclosing pilot relay C. Time delay relay T3 energizes to keep M5 and M7 energized for the duration of the time delay.

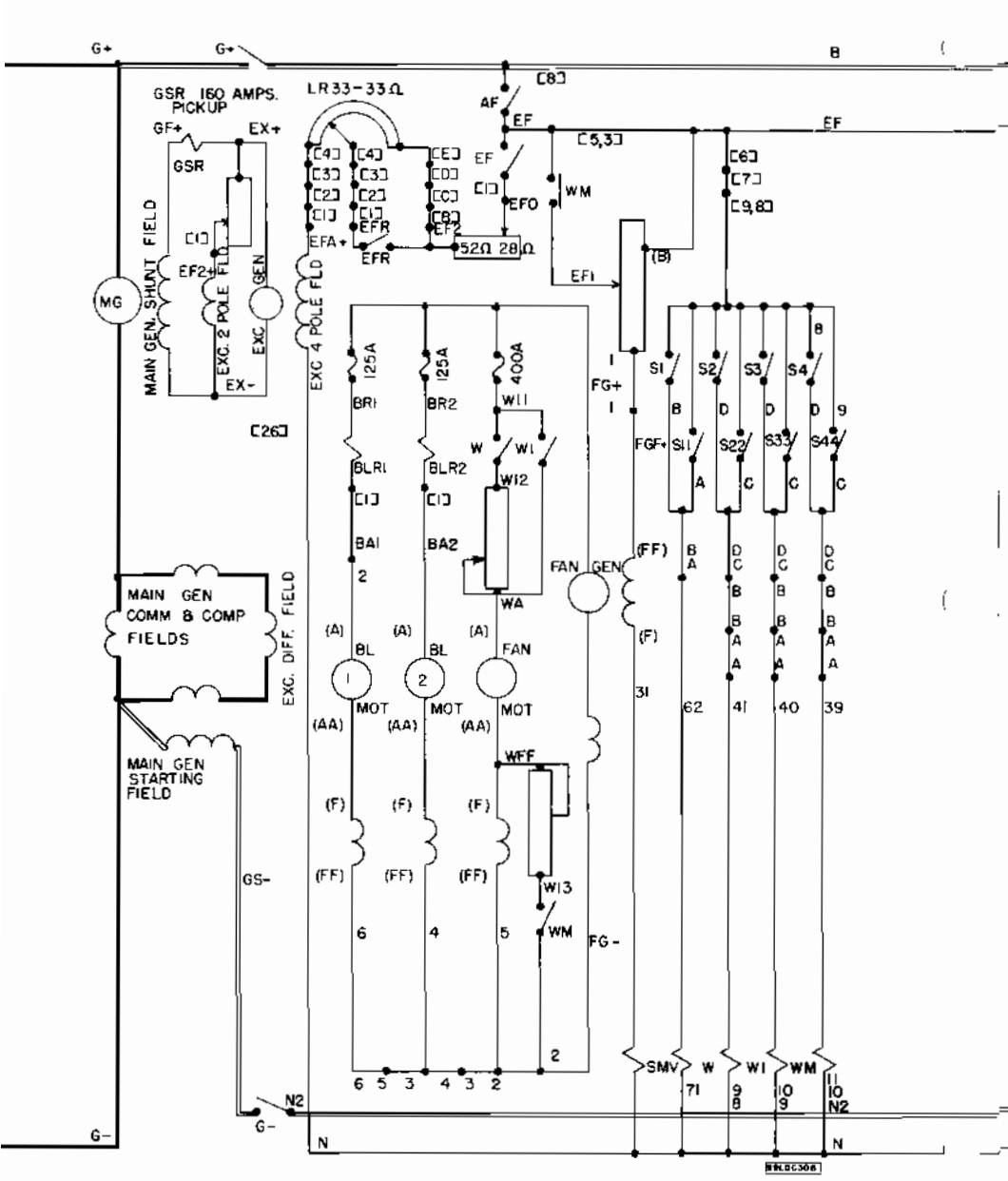
11. If speed lessons further, generator voltage again drops, and C re-opens. M5 and M7 drop out, provided the time delay has elapsed since M6 and M8 dropped out. (Contact T3B provides this.) C recloses. Time delay relay T2 energizes to keep M2 and M4 in for at least the duration of the time delay.

12. A further speed decrease decreases generator voltage a third time, opening C a third time. Sequence similar to that in step 9 follows.

13. With locomotive now back in the first step of shunting, generator voltage again drops to open C. M1 and M3 drop out, providing the time delay has elapsed since M2 and M4 dropped out. Locomotive is now operating in full field at low speed.

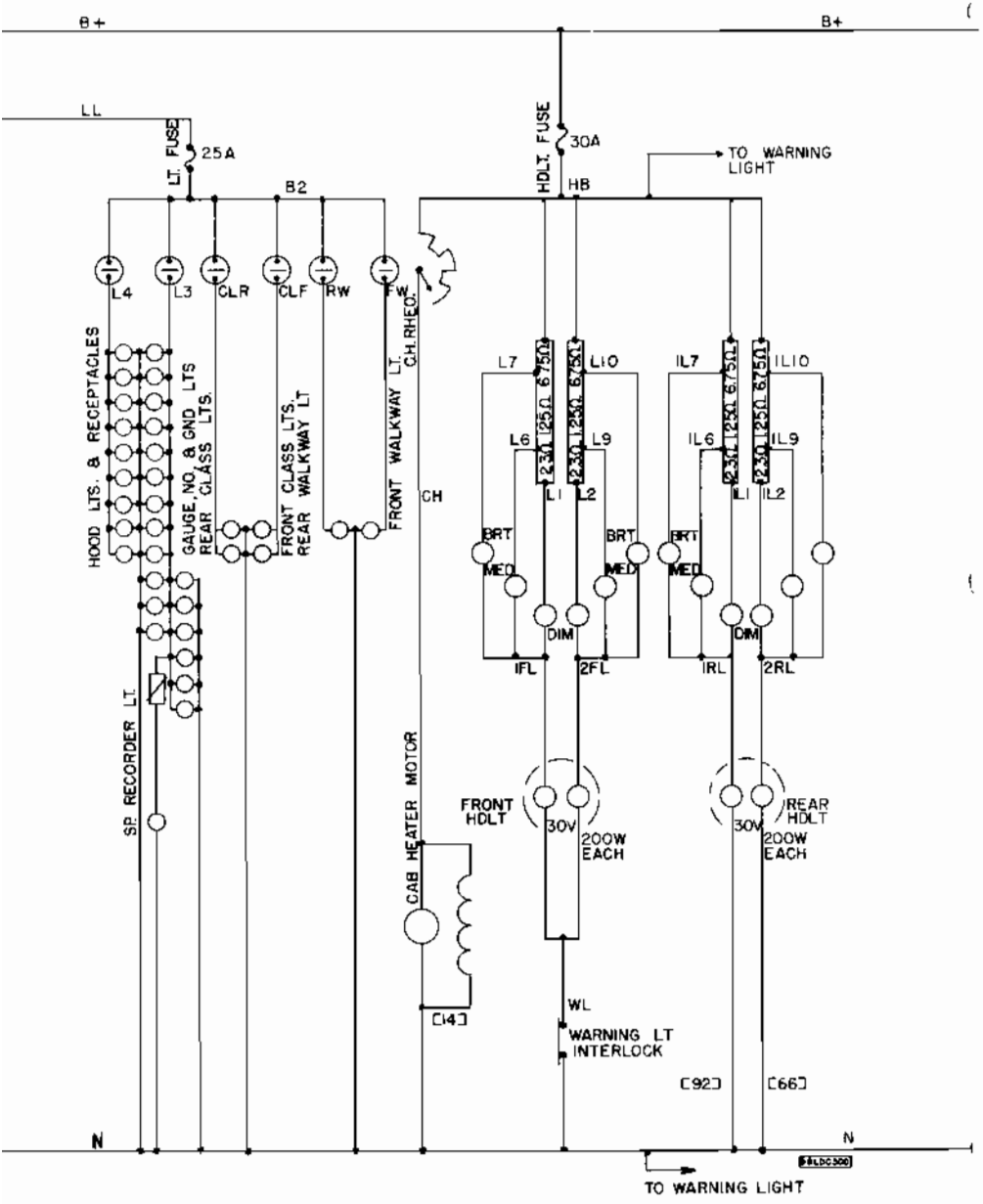


TRACTION MOTOR SECTION

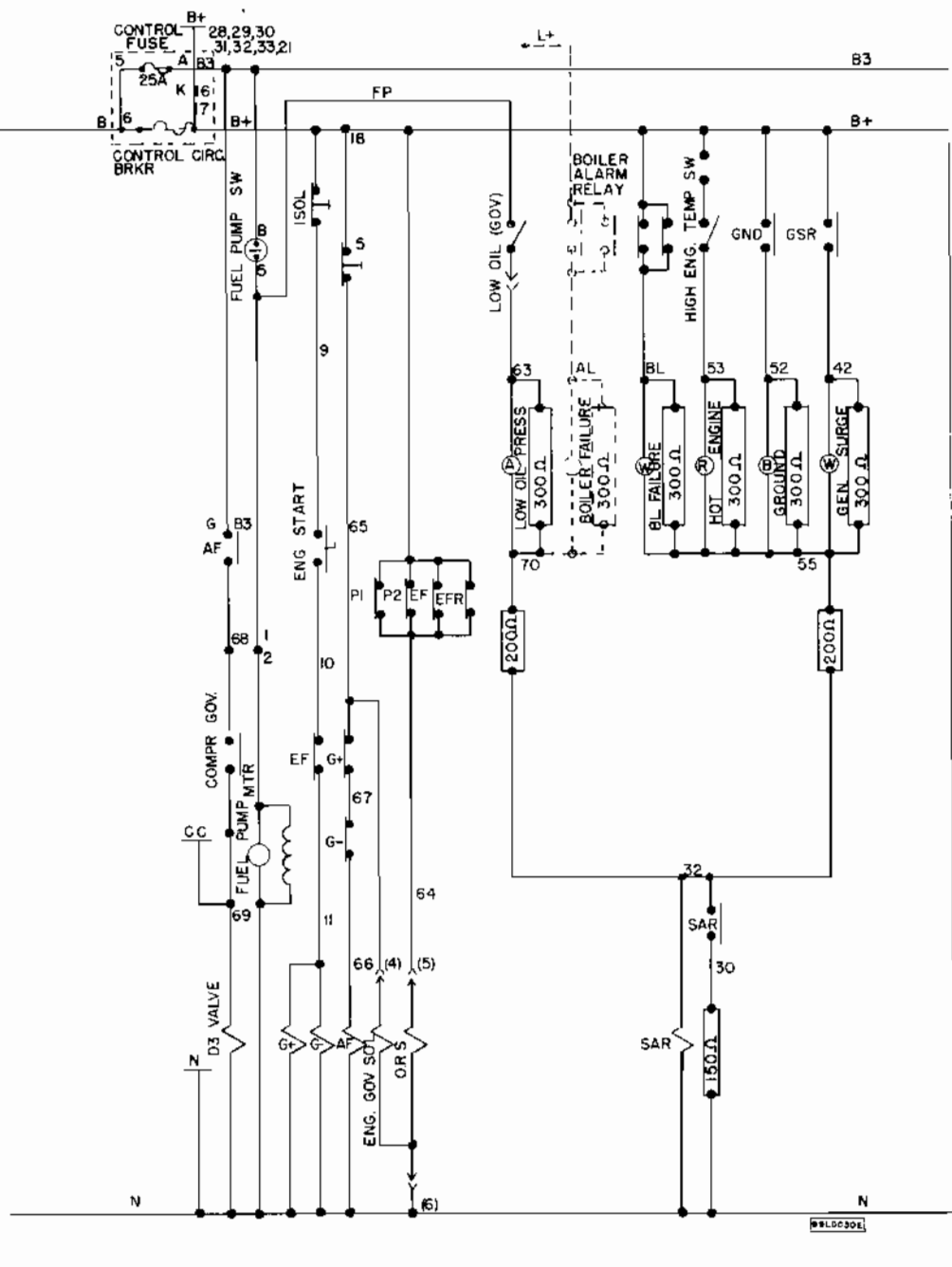


MAIN GENERATOR AND LOAD CONTROL SECTION

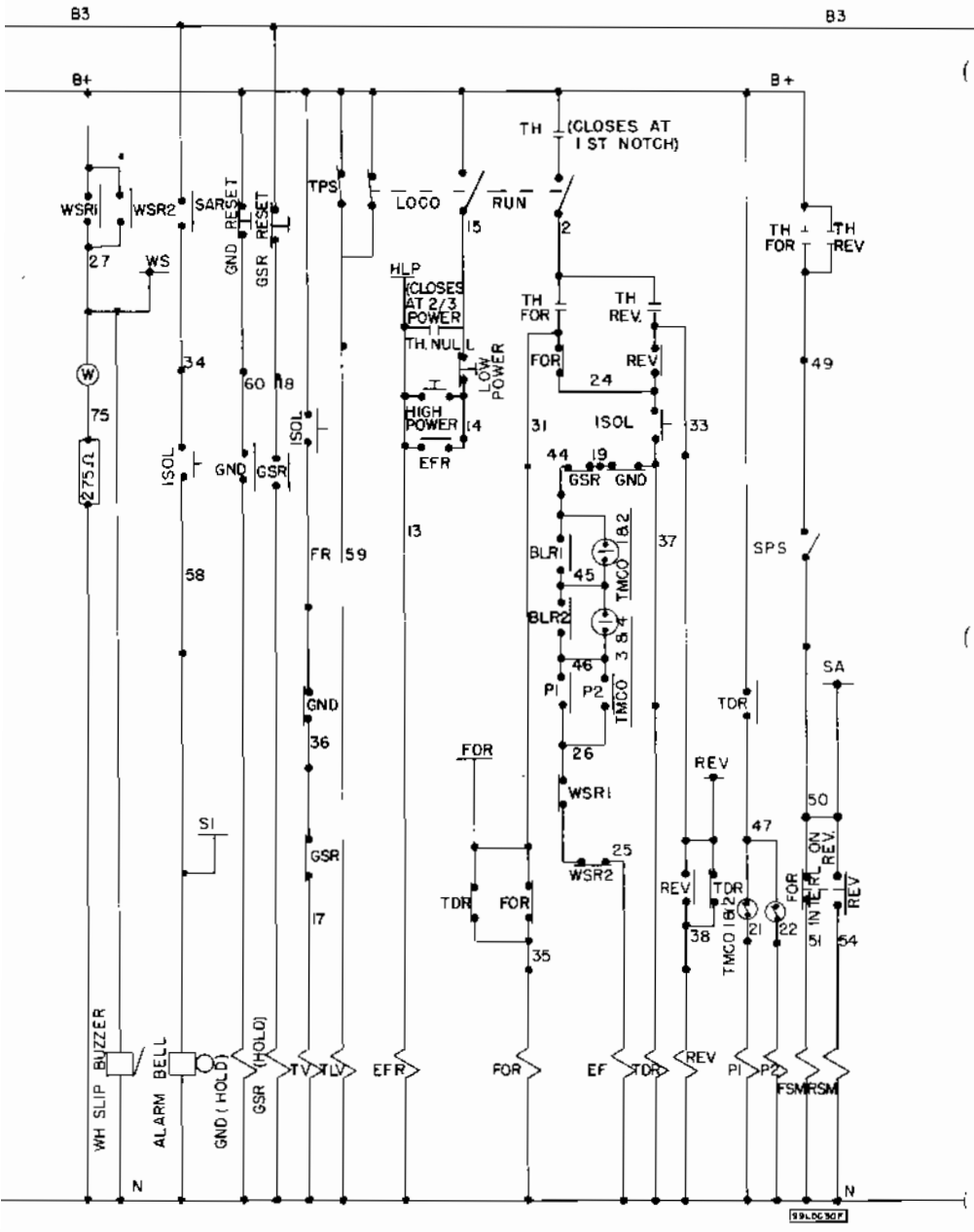
STORAGE BATTERY AND VOLTAGE REGULATOR SECTION



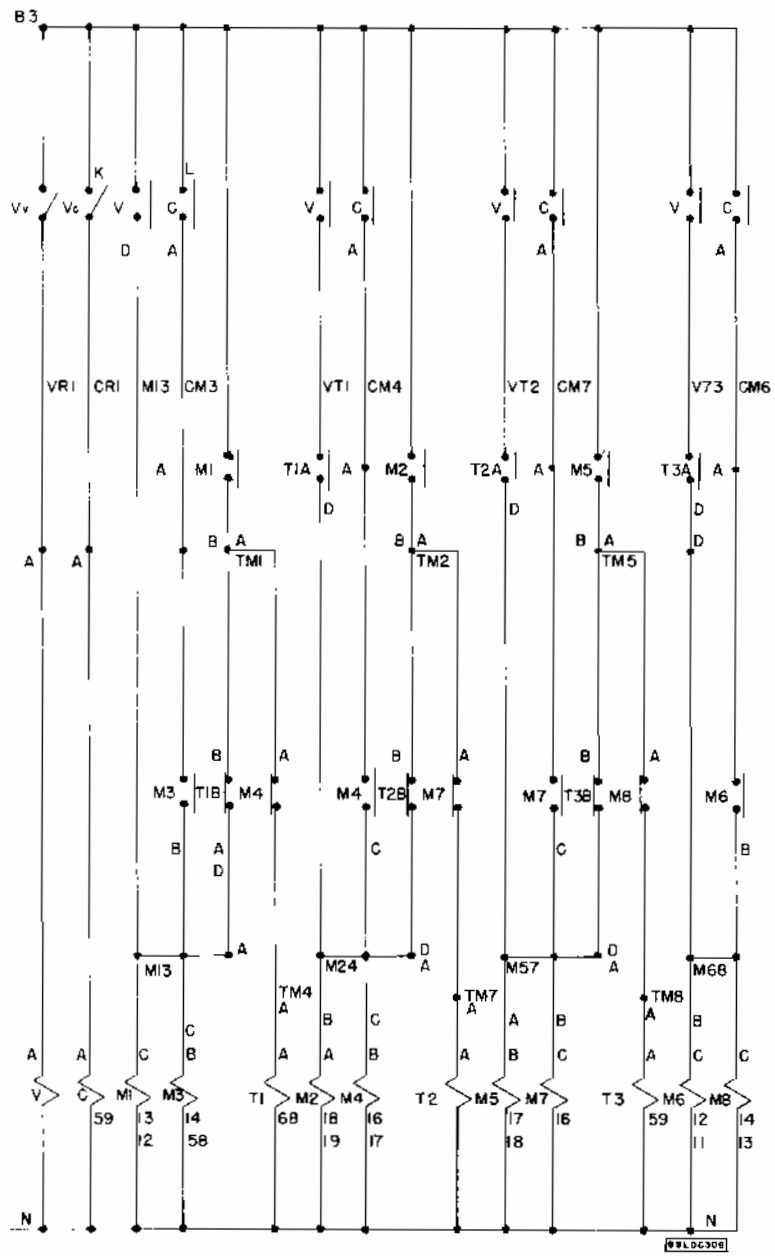
LIGHTING CIRCUIT SECTION



FUEL PUMP AND WARNING LIGHT SECTION



THROTTLE AND POWER CONTROL SECTION



FIELD SHUNTING SECTION

SECTION 137A. PASSENGER CAR LIGHTING

137A1. Passenger Car Lighting

The 1500 H.P. Freight, Passenger, and Transfer units designed for passenger service can be provided with a head and passenger car lighting system. This is comprised of a bracket mounted generator belt driven from the flywheel of the air compressor, a voltage regulator, a main disconnect switch, and suitable receptacles mounted at both ends of the locomotive. The voltage regulator is mounted on the generator bulkhead on the right hand side of the locomotive. The main safety disconnect switch is located on the left hand side of the locomotive in the machinery compartment. The electrical system is protected by two fuses located in the disconnect switch box. In case of failure of the train lighting, check that the fuses are intact and that the switch is closed.

Illus. A1 covers the 85 volt 12 K.W. passenger car lighting circuit. This circuit includes a voltage regulator, a reverse current relay and a field adjusting rheostat. This rheostat in the generator field circuit enables the operator to balance the load on the generators when two units are used in parallel. It also provides voltage adjustment for trains of varying length.

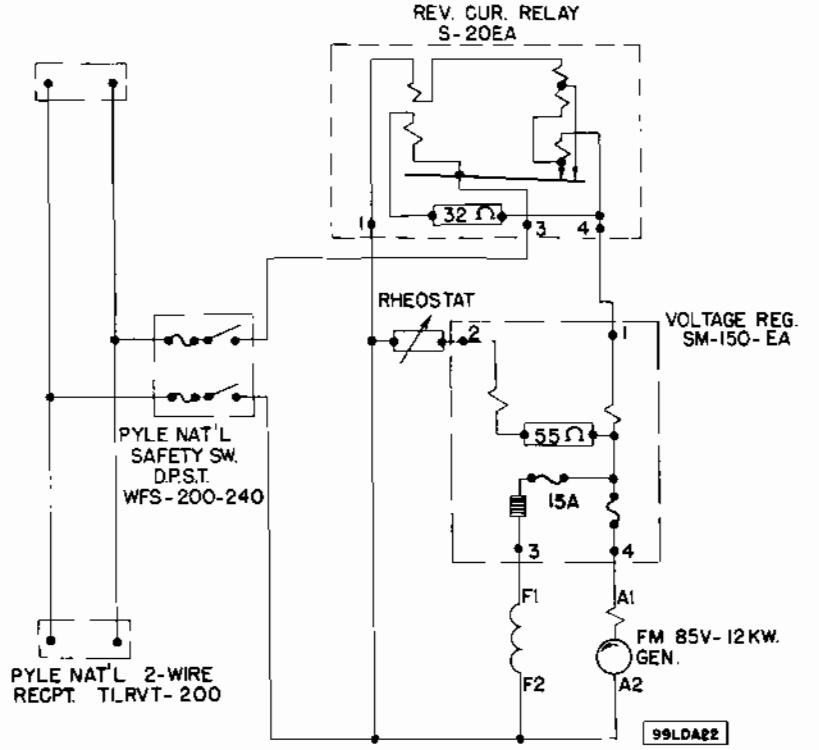
The main disconnect switch should be opened when making or breaking jumper connections in the train and when the locomotive is used for service other than passenger and train lighting is not needed.

A fuse is located in the voltage regulator cabinet. This fuse, as well as the two fuses in the main disconnect switch box, should be checked in case the generator fails to supply current.

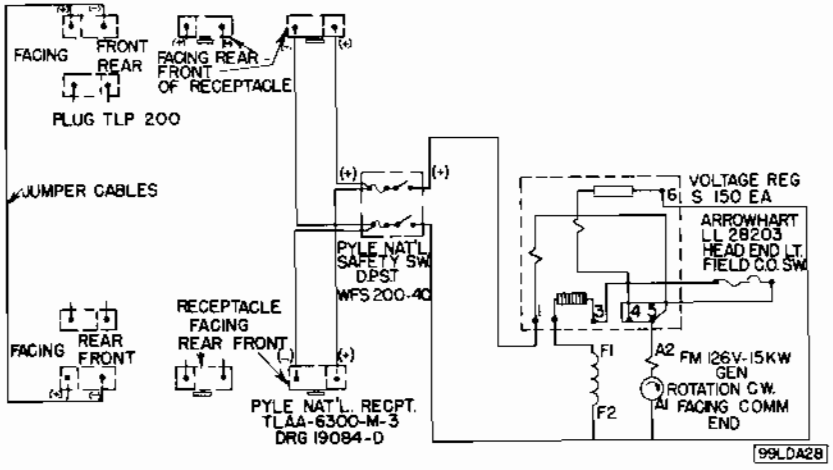
Illus. A2 covers the 125 volt 15K.W. head end passenger car lighting circuit. This consists mainly of a generator, a voltage regulator and a fused disconnect safety switch.

Adjustment for voltage drop is automatically provided thru the voltage regulator.. The voltage regulator provides constant voltage at varying generator speeds.

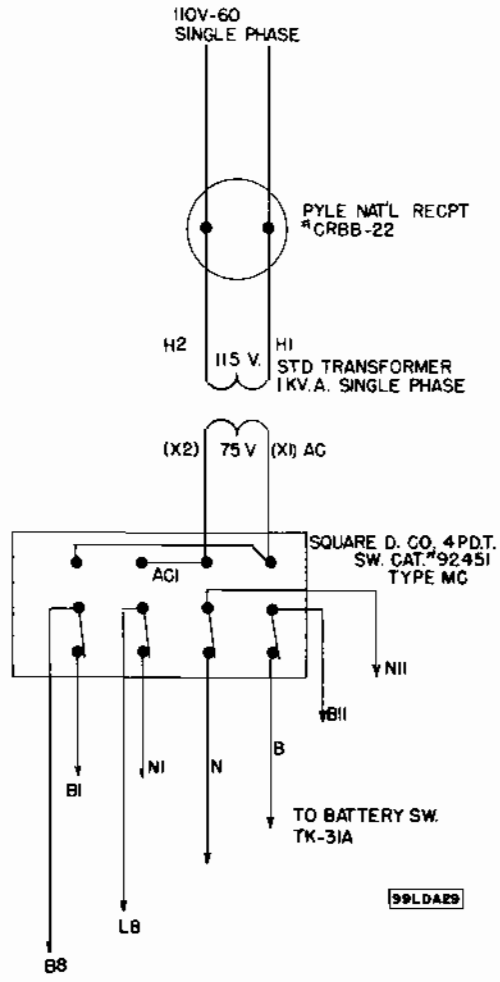
A head end lighting generator field cut-out switch is provided in the cab on the bulkhead. This is a circuit breaker type switch permitting interruption of the generator field circuit. It should be opened when making or breaking the electrical jumper connections in the train. It should also remain open along with the main disconnect switch when the locomotive is used for service where head end train lighting is not needed.



Illus. A1 Passenger Car Lighting Circuit—85 Volt 12 K.W.



Illus. A2 Passenger Car Lighting Circuit—125 Volt 15 K.W.



Illus. A3 Terminal Lighting Circuit (Optional Equipment)