CANADIAN LOCOMOTIVE COMPANY, Ltd.

KINGSTON ONTARIO

Engineers' Manual

DIESEL
ELECTRIC
LOCOMOTIVES

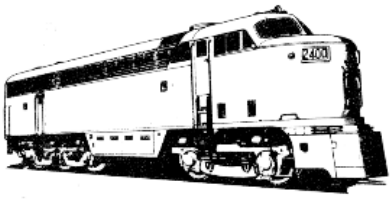
by

CANADIAN LOCOMOTIVE CO.
Limited

BULLETIN C2160

Enginemen's Manual for Operating
"Consolidation Line" Diesel Electric Locomotives
Manufactured by
Canadian Locomotive Company, Ltd.

Foreword . . . .
These instructions do not purport to cover all details or variations in equipment nor to provide for any diversities to be met in connection with installation, operation, or maintenance. Neither is the amount of material supplied by Canadian Locomotive Company, Ltd. 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 Canadian Locomotive Company, Ltd, Service Department, Kingston, Ontario.



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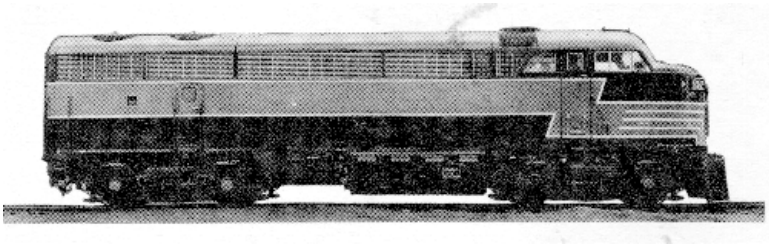
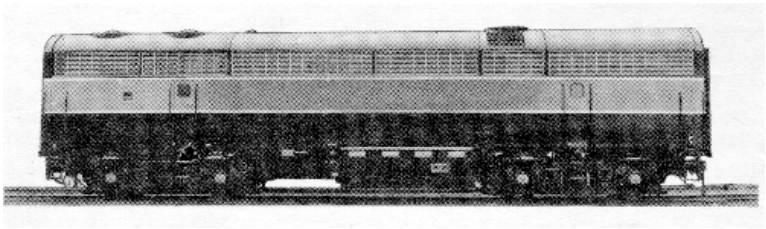
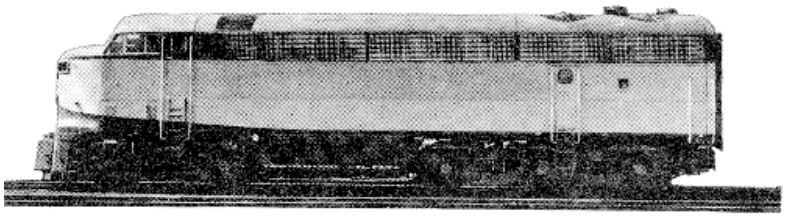


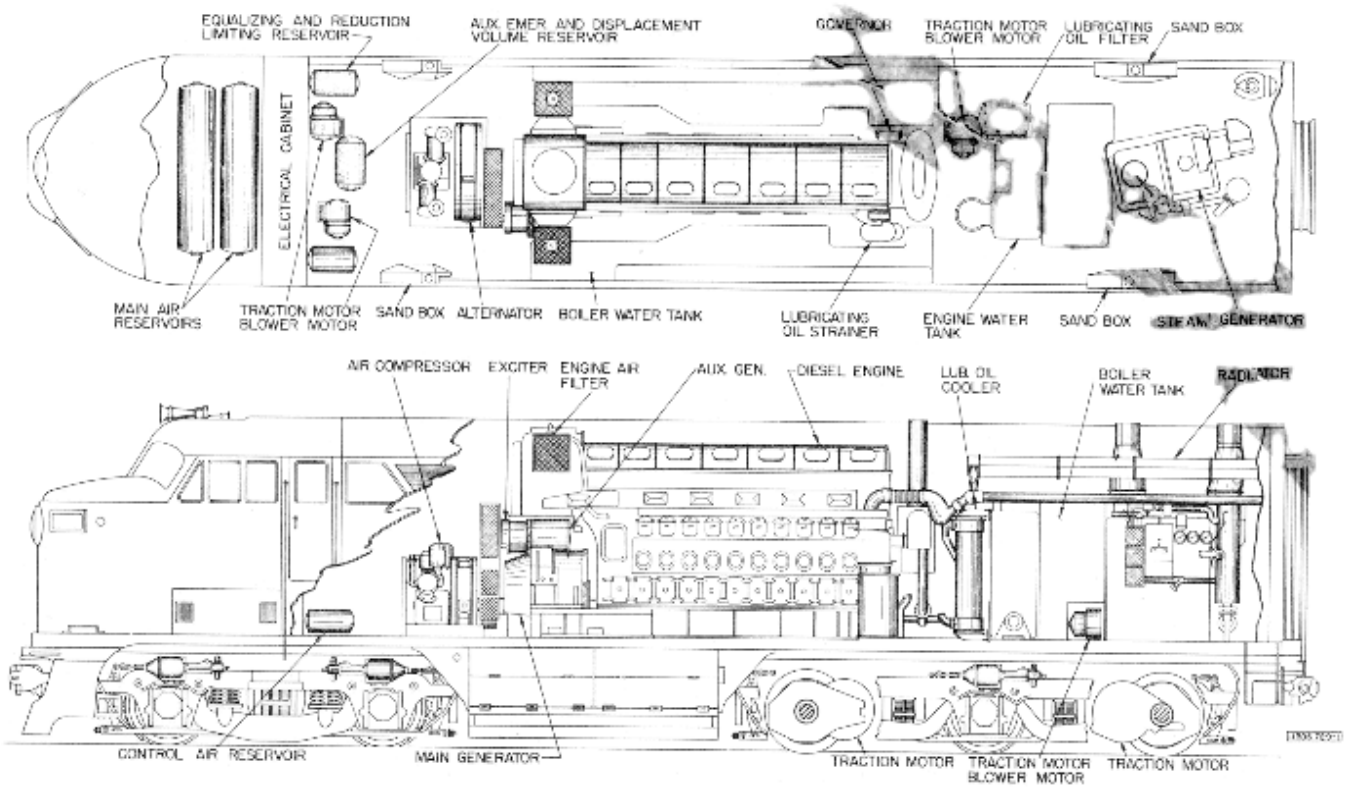
Road Freight "A" Unit



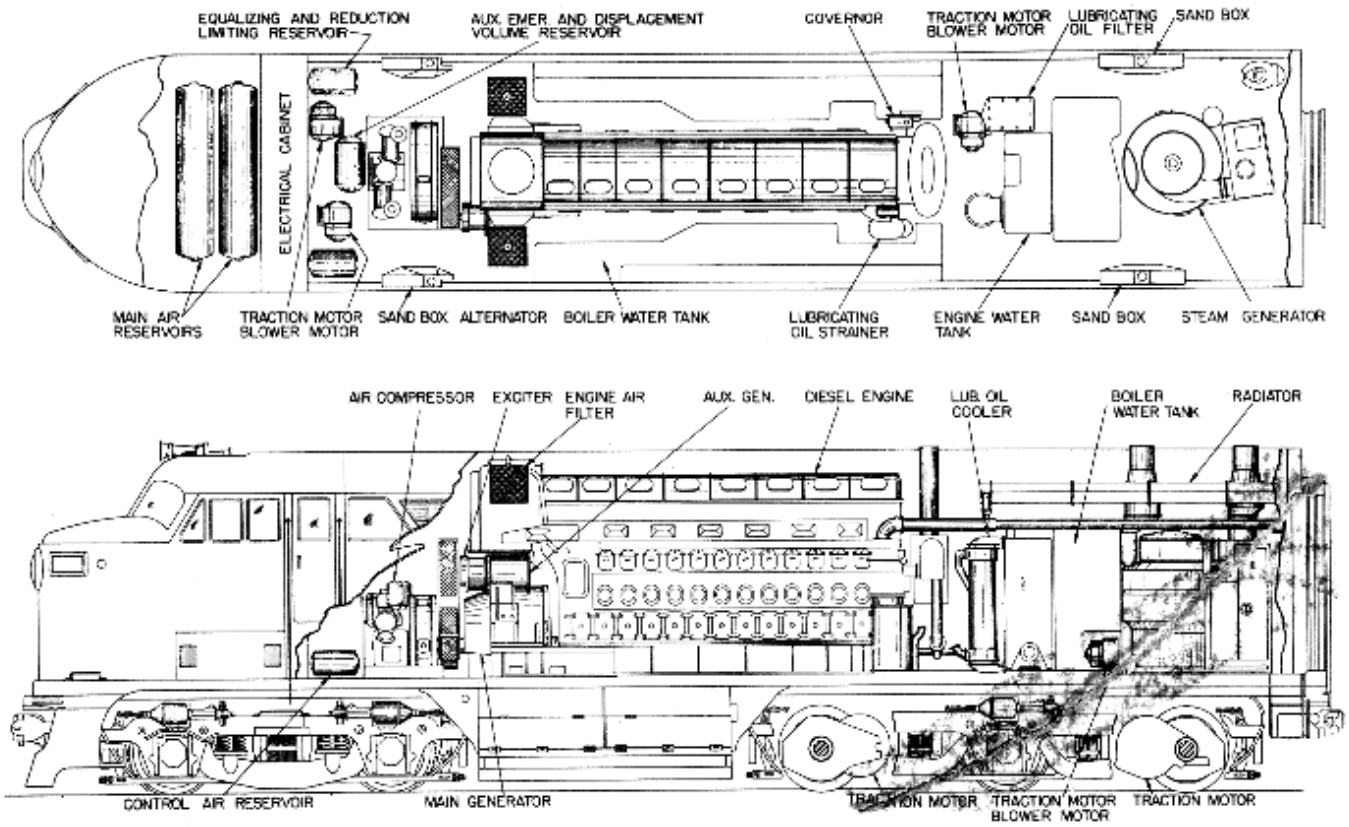
Road Freight "B" Unit



Road Passenger "A" Unit



Arrangement Diagram - 2000 H. P. Passenger Unit



Arrangement Diagram - 2400 H. P. Passenger unit

SECTION 201 GENERAL DESCRIPTION

GENERAL INFORMATION

General

This is a new type Canadian Locomotive Company road locomotive consisting of short uniformly-built units in which power plant size may be varied. Units can be operated in multiple with each other, or with certain units of other manufacture. Inter-unit control jumpers must match.

Trucks

Freight units use two 4-wheel trucks. Passenger units normally use a leading 4-wheel and rear 6-wheel truck, but may use a rear 4-wheel truck. All units are equipped with four driving axles and four traction motors. The middle axle of the 6-wheel truck used under passenger units is an idler.

Diesel Engine

A unit may be equipped with any one of three sizes of Fairbanks-Morse opposed piston 2-cycle diesel engines.

If 1600 hp, it has one 8-cylinder engine.
If 2000 hp, it has one 10-cylinder engine.
If 2400 hp, it has one 12-cylinder engine.

Engine idling speed is 300 rpm; full speed is 850 rpm on all three engines.

The governor is of the Woodward electro-hydraulic type, with the load regulator included in the governor.

Dynamic Braking

All units can be equipped with dynamic braking without sacrifice of water supply. Dynamic braking capacity on all units is 2000 hp at 880 amps.

Passenger Unit Boiler Water Capacity

All passenger units carry a boiler water capacity of from 700 to 1660 gallons depending upon railroad specification. Equipping units with dynamic braking does not affect water capacity. NOTE: All gallons referred to in this Manual are Imperial gallons.

Passenger Unit Steam Generators

Passenger units can be equipped with steam generators ranging in capacity from 2500 to 4500 lbs. per hour capacity, depending upon railroad specification.

Air Brake System

Both passenger and freight units are equipped with two main reservoirs, with a combined capacity of 56, 000 cu.in. on A-units and 29, 500 cu.in. on B-units. Maximum cooling is provided with 38 ft. 6 in. of copper finned pipe between the compressor and first main reservoir on A-units and a total of 5 4 ft. of finned pipe on B-units. The main reservoir equalizing line is taken off after the second main reservoir. With the extra amount of cooling provided, water will collect rapidly in the main reservoirs; and will not continue thru to the air brake system if main reservoir draining is not neglected.

Available Gear Ratios (All Wheel Diameters 42 in.

Gear Ratio	Max. MPH.	Continuous T. E.	MPH at Continuous T.E. 1600 HP	2000 HP	2400 HP
15:68	65	52, 500	9. 2	11.9	14.4
15:63	70	48,600	9.9	12.8	15. 5
17.62	80	42,200	11.4	14.7	17.8
19:60	90	36, 600	13. 2	17.0	20. 6
21:58	100	32,000	15. 1	19. 5	23.6
22:57	110	30,000	16. 1	20.8	25. 2

Model Designations and Weights Fully Loaded

Unit	Designation	Lbs. Total Wt.	Lbs. on Drivers
1600 hp Freight	CF 16-4	250,000	250,000
2000 hp Freight	CF 20-4	257,000	257,000
2400 hp Freight	CF 24-4	262,900	262, 900
1600 hp Combination CP 16-4 (Includes 700 gal. boiler water		258, 700	258,700
1600 hp Pass.	CP 16-5	281, 100	230, 100
2000 hp Pass.	CP 20-5	287, 300	236,000
2400 hp Pass.	CP 24-5	293,200	241, 500

Freight units include dynamic braking in weights. Subtract 3800 pounds for omission.

Passenger units include 1160 gallons boiler water in weights.

Dynamic braking 3800 pounds additional.

Traction Generator

1600 hp - Westinghouse Type 497-B.
2000 and 2400 hp - Westinghouse Type 498-A.

Traction Motors

Westinghouse Type 370.

Auxiliary Generators and Motors.

Direct Current:

Auxiliary Generator -Exciter	Westinghouse Type YG-54A
Dynamic Brake Blower Motor	Westinghouse Type Y-601A

Alternating Current:

Alternator	Fairbanks-Morse Type TGZO. Fr. IV
Cooling Fan Motors (Three on 1600 hp, Four on 2000 & 2400 hp)	Fairbanks-Morse Type QZA Frame 70130Y. Full Speed 1640 rpm, 16 hp each.
Traction Motor Blower Motor (Four)	Fairbanks-Morse Type QXZA. Frame L6095Z. Full speed 3340 rpm, 6 hp each.

Minimum Radius Curvature

273 ft. or 21 degrees.

Supplies

Fuel Oil	1000 Gallons (1430 gal. as extra)
Steam Generator Water (Passenger Units)	1170 Gallons (1670 gal. as extra)
Lubricating Oil	1600 hp - 262 gallons 2000 hp - 290 gallons 2400 hp - 320 gallons
Engine Cooling Water	1600 hp - 250 gallons 2000 hp - 270 gallons 2400 hp - 280 gallons
Sand	20 cu. ft.

Major Dimensions (ft. - in.

	Passenger	Freight
Wheel Base One Unit	43'5"	43'4"
Front Truck Wheel Base	9'4"	9'4"
Rear Truck Wheel Base	15'6"	9'4"
Overall Length (Inside Knuckles, (One Unit)	56'6"	56'6"
Overall Width	10'7-1/2"	10'7-1/2"
Overall Height Above Rail	15'0"	15'0"

GENERAL DESCRIPTION OF LOCOMOTIVE EQUIPMENT

Diesel Engine

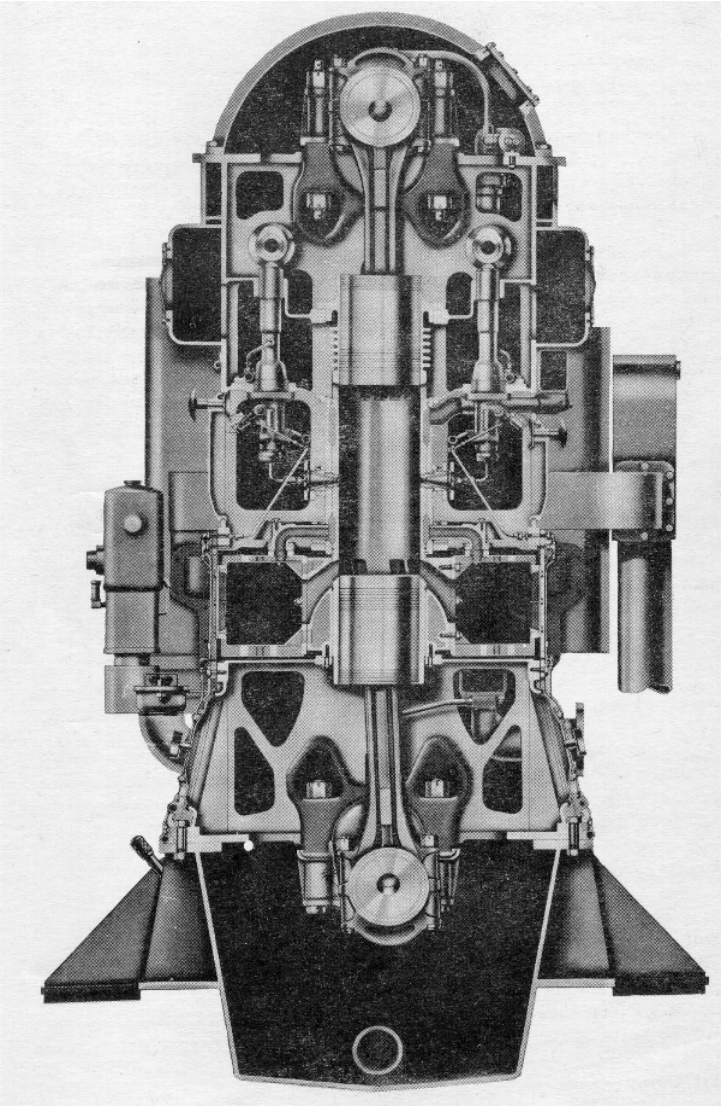
In the Fairbanks-Morse opposed piston engine, two pistons work vertically towards each other in the same cylinder. No valves or cylinder heads are used.

The upper and lower pistons drive separate crankshafts which are interconnected by a vertical drive shaft and gears with a suitable flexible coupling of coil spring design. The lower crankshaft leads the upper in timing by 12 degrees, which is known as the "Lower Crank Lead" and which causes the lower shaft to furnish 80% of the power developed.

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

The engine operates on the two-cycle principle. Two strokes of each piston through one revolution of the crankshafts complete a cycle. The cycle begins with movement of the pistons from their outer dead center. After the air from the rotary type blower is 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 fromthe compression of the air ignites the fuel. Combustion and the resulting expansion o f 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



Illus. 1. Cross-section of Engine

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 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.

Main Generator

The main generator is directly connected to the engine crankshaft through a flexible coupling, and furnishes power tothe traction motors. 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 (G+, G-) which close when the isolator is moved to the "Start" position.

Alternator

The alternator is mounted on an extension of the air compressor shaft replacing the compressor flywheel. The alternator furnishes a.c. power to the four traction motor blower motors and four radiator cooling fan motors (three fans on 1600 hp units)

Exciter-Auxiliary Generator

These machines are mounted on a common armature shaft atop the main generator and are driven by an 8 "V" belt assembly. The exciter furnishes main generator excitation and the auxiliary generator provides d. c. power for controls, battery charging, and lighting. The auxiliary generator is regulated for 72 volts at idling, and 75 volts at full engine speed, by the voltage regulator.

Air Compressor

The air-compressor is driven atengine speed througha 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.

Transition

Traction motors are permanently connected in series-parallel and do not require transition, but do use automatic field shunting in four steps. Shunting differs from transition in that no power circuits are completely opened.

Operating with a Unit Shut Down

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

Dynamic Braking

This locomotive is equipped with dynamic braking when specified by the railroad. When operating i n dynamic braking, the traction motors operate as generators. The current generated is dissipated in grids located in the roof hatch behind the operating cab. Part of the current operates the motor-driven grid cooling fan.

LOCOMOTIVE CONTROLS (See Illus. 2 on following page.

Controller

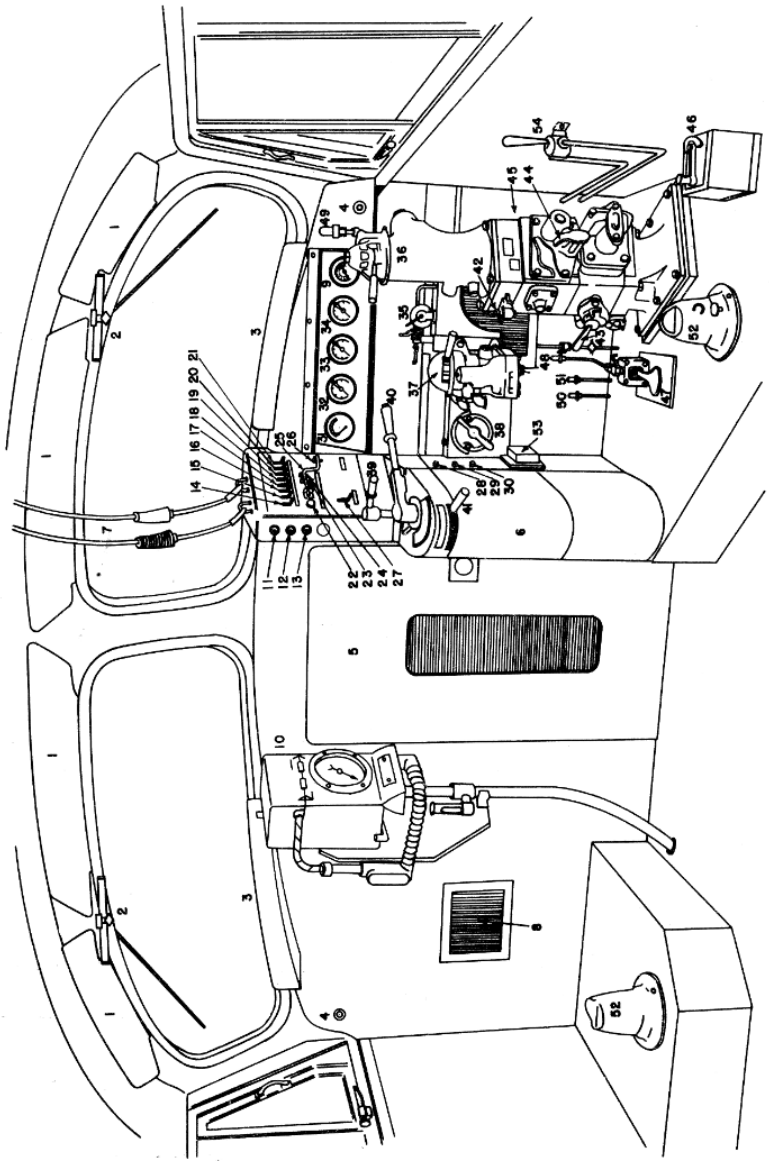
The throttle, reverse, and selector levers on the controller and the automatic and independent air brake valves control all locomotive operation. Breakers and switches must first be in proper position.

Throttle Lever

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

Reverse Lever

The reverse lever has three positions: "FORWARD", "OFF", and "REVERSE". NEVER MOVE REVERSE LEVER WHILE LOCOMOTIVE IS IN MOTION. Doing so may cause serious flashover of traction motors and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1. Sun Visors
2. Windshield Wipers
3. Defroster Openings
4. Windshield Wiper Valve
5. Door to Hood
6. Control Stand
7. Whistle Pull Cord
8. Cab Heater Openings
9. Electric Speedometer (if used)
10. Speed Recorder (if used)
11. Wheel Slip Warning
12. Power Off
13. Brake Warning
14. Headlight Bright
15. Headlight Dim
16. Snow Plow Headlight Bright
17. Snow Plow Headlight Dim
18. Number Light
19. Classification Light
20. Step Light
21. Cab Light
22. Attendant Call Button
23. Fuel Pump Breaker
24. Generator Field Breaker
25. Switch Lock for Engineer's Control Breakers
26. Engineer's Control Breaker
27. Train Order Light
28. Gauge Light Switch
29. Defroster Switch
30. Heater Switch
31. Load Ammeter
32. Main Reservoir and Equalizing Reservoir Gauge
33. Brake Pipe and Brake Cylinder Gauge
34. Application Pipe and Suppression Pipe Gauge
35. Bell Ringer Valve
36. Automatic Brake Valve
37. Independent Brake Valve
38. Rotair Valve
39. Selector Handle
40. Controller Handle 41. Reverser Lever
42. Full Release Selector Cock
43. Brake Valve Cut-out Cock
44. Application Valve Cut-out Cock
45. First Service Cock
46. Dynamic Brake Unit Switch
47. Safety Control Pedal
48. Safety Control Whistle
49. Safety Control Whistle (if Hinged Type Brake Valve
50. Cab Signal Whistle Handle used)
51. Overspeed Whistle
52. Seat Stands
53. Wheel Slip Buzzer
54. Sander Valve

Illus. 2. Cab Arrangement Diagram

generator causing considerable damage to electrical equipment.

Selector Lever

The selector lever is the top handle on the controller and is used to change traction motor circuits from motoring to dynamic braking and vice versa. When necessary, the selector is also used to control manual transition of traction motor circuits on trailing units of different model or manufacture. Positions are 4-3-2-1 OFF-BRAKE.

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 totrainline wires M and P in positions other than "OFF" or "BRAKE".

Lever Interlocking

Control stand levers are interlocked as follows:

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

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

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

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

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

Fuses

The only two fuses aboard are the 350 amp. auxiliary generator fuse and the 150 amp. external battery charging fuse. The latter is used only during shop battery charging. If the auxiliary generator fuse blows, the "alternator failure" alarm will sound because alternator excitation will be cut off.

To replace the auxiliary generator fuse, always first shut the engine down. Also never replace the external battery charging fuse under load.

Main Battery Switch

This is a double pole knife switch located behind a hinged door on the engineer's side of the electrical cabinet. It connects all control and lighting circuits to the battery and must be on in all units.

Other Switches in Electrical Cabinet

Also behind the hinged door and adjacent to the battery switch are the Traction Motor and Dynamic Brake Cutout switch, Ground Relay Cut-out switch and Standby Lighting Knife switch. These switches are described in following paragraphs.

Circuit Breakers

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

1. Engineer's Breaker Panel

In front of the controller is a panel containing two rows of breakers. The top row includes breakers for lights. The second row includes the CONTROL, FUEL PUMP, and GENERATOR FIELD breakers, and is fitted with a lever for locking the breakers in off position in a trailing cab. A signal button labeled "Attendant Call" operates the alarm bells in all units. Rheostats are provided for heater, defroster and gauge light control.

2. Cabinet Breaker Panel

This panel is located on the electrical cabinet and contains breakers as follows:

Breaker	Function	Must Be On In:
Alt. Field	Connects the alternator field to the auxiliary generator.	All units. "Alternator failure" alarm will sound if breaker trips.
Loco. Lights	Connects all lighting circuits to the main battery switch.	All units.
Heater and Defroster	Connects heater, de-froster and gauge lighting circuits to the main battery switch.	Both A units.
Control Cut-out	Connects all control circuits to the main battery switch.	All units.
Dynamic Brake (if used)	Connects the dynamic brake field loop ex citation circuit to the main battery switch.	Lead unit only.
Electro-Pneumatic Brake (if used)	Connects electro-pneu-matic braking circuits to the main battery switch.	Lead unit only.
Train Control (if used)	Connects train control circuits to the main battery switch.	Lead unit only.

Dynamic Brake Unit Switch (On units with dynamic braking

This switch is located behind the engineer's seat and has four positions for setting according to the number of units in the locomotive consist.

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

Traction Motor and Dynamic Brake Cut-out Switch

This is a knob-operated selector switch located behind the hinged door on the engineer's side of the electrical cabinet. NEVER CHANGE SWITCH POSITION UNLESS DIESEL ENGINE IS FIRST ISOLATED. Otherwise, generator flashover may occur. Switch positions and functions are as follows:

Position	Function
Normal	Normal operation of traction motors and dynamic brake.
TMCO No. 1	No. 1 truck traction motors cut-out (PI cannot en ergize) and generator output automatically reduced. Load ammeter will not function. Dynamic brake will not function.
TMCO No. 2	No. 2 truck traction motors cut-out (P2 cannot en ergize) and generator output automatically reduced. Dynamic brake will not function.
Dyn. Br. CO	Dynamic brake cut-out on unit without affecting other units. Operation in motoring not affected. (P1 relay is isolated in braking so that the Traction Motor field excitation circuit cannot energize.

In event of continued ground relay tripping or hot engine alarm, a pair of traction motors can be cut-out to reduce generator voltage and keep the engine on the line at reduced power.

Ground Relay Cut-out Switch

This is a breaker-type switch for emergency use, located behind the hinged door on the engineer's side of the electrical cabinet. It is normally sealed in the "on" position. Breaking the seal and throwing the switch to off cuts out the ground relay and alarm bells, but the ground alarm light will continue to burn. NEVER THROW SWITCH EXCEPT IN EMERGENCY, as cutting out ground relay protection endangers electrical equipment.

Standby Lighting Knife Switch

This is a double-throw double-pole knife switch located behind the hinged door on the engineer's side of the electrical cabinet. When switch is u p in normal position, the Locomotive Lights breaker is connected to the locomotive battery. When switch is down, breaker is connected to the a.c. standby lighting transformer for use with shop current. Switch must be in proper position to get lights on the locomotive.

ALWAYS SNAP OFF LOCOMOTIVE LIGHTS BREAKER BEFORE OPERATING SWITCH, to avoid a bad arc.

Sanders

Sanders are electro-pneumatically operated with sanding ahead of each truck in either direction. Control is either from the separate sanding valve on the right of the engineer; or by depressing the automatic brake valve handle below horizontal position against the bail; depending upon railroad specifications.

Operating the valve or depressing the bail operates the sander pressure switch. (Located on the right hand equipment rack in the nose. Do not confuse with the PC switch, located above on the same rack.) The sander pressure switch energizes the sand control trainline wire. This wire is connected in each unit to the "forward" and "reverse" sanding magnetvalves thru reverser interlock. The sanding magnet valves control sanding on either end of each truck.

Horn Shut-off Cock

A horn shut-off cock is located in the nose on the right bulkhead.

Locomotive Bell

The locomotive bell is located just behind the pilot on the engineer's side, with bell ringer valve located between the independent and automatic brake valves.

ENGINEER'S INSTRUMENTS

Black Lighting

Engineer's instruments are marked with a fluorescent lacquer which glows under "black" light illumination, enabling cab to be kept in darkness at night. Light intensity is adjustable through a rheostat located just ahead of the controller. Rheostat positions. are "OFF" and an adjustable "ON" range. The Heater and Defroster breaker on the cabinet down, breaker is connected to the a.c. standby lighting transformer for use with shop current. Switch must be in proper position to get lights on the locomotive.breaker panel mustbe "ON" for the rheostat to operate.

Load Ammeter and Brake Warning Light

The load ammeter indicates current to traction motors on the front truck, either in motoring or dynamic braking, with a separate scale for each on the dial.

The tonnage hauled must be limited to that which will allow the load ammeter pointer to remain in the green or continuous zone when operating on the ruling grade.

If the pointer goes into the overload 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 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 h a s indicated that the overload operation is safe.

In dynamic braking, operation within braking speed limits (See Sec. 2 10) is permissible up to 880 amperes where the red zone begins, approximately at w h i c h point the Dynamic Brake Warning Light will come on. Braking must then be reduced until the warning light goes out. Otherwise traction motors and braking grids will overheat, as braking current capacity is not designed for overload.

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

If load ammeter is inoperative (when leading unit is shut down or front trucktraction motors cut out), speed at fullthrottle must remain above the speed corresponding to the continuous limit on the load ammeter.This speed is shown on Page 2 of Section 201 as mph at continuous tractive effort.

Power Off Light

The "Power Off" light indicates tripping of the PC switch, opening of power contactors, and dropping of engine speed to idle.

The "Power Off °" light will come on whenever the following air brake applications occur:

Safety Control
Train Control (if used)
Locomotive Overspeed (if used)
"Emergency"

The PC switch operates the PCR relay which opens power and governor control circuits to the controller. The effect is s the same as if the throttle were returned to "IDLE" manually. Fuel pump operation is not affected.

The PC switch is an air pressure switch located at the top of the air brake equipment rack on the right in the nose. The PCR relay is located on the cab (low voltage) side of the electrical cabinet.

To reset the PC switch and extinguish the "Power Off" light,

1. Return throttle to "IDLE".
2. Lap automatic brake valve until applicationpipe pressure builds up to normal.

Wheel Slip Light

The wheel slip light indicates wheel slippage of one or more driving axles. To stop slippage, reduce throttle and apply sand AFTER SLIPPING STOPS. Power i s automatically reduced on unit affected when slipping occurs. Use sand whenever necessary to forestall wheel slippage.

Air Brake Gauges

Air brake gauges are as follows:

Main Reservoir and Equalizing Reservoir, duplex type.
Brake Pipe and Brake Cylinder, duplex type.
Straight Air, single-pointer type. (For electro-pneumatic brake when used.)
Application Pipe and Suppression Pipe, duplex type. (If used.)

Speed Recorder

The speed recorder is located on the left side of the cab facing the engineer, and includes a speedometer dial and recording tape. The drive

connection is on the left No. 1 journal. The locomotive overspeed switch is located in the recorder and operates as described under air brake equipment, Sec. 215. Newer units are equipped with an electric speedometer.

Control Air Gauge

This gauge is located on the electrical cabinet and indicates pressure of controlair to operate the power contactors, reverser, and cam switch. Normal reading is 80 pounds. A shut-off valve in the control air line is located in the left of the electrical cabinet on the engine room side.

Battery Ammeter

This meter is located on the electrical cabinet and indicates charging or discharge rate from the battery. With 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.

OTHER CAB EQUIPMENT

Cab Heaters

There are two hot water cab heaters, one each for engineer and fireman, with motor driven fans under control of the cab heater switches, providing air circulation. Water to the heaters may be shut off by a valve located on the left side of the engine. A small valve admits steam to the hot water lines, and is located overhead in the nose. The heaters are piped in parallel.

Special precautions:
1. Always keep shut-off valve open in cold weather, except when unit i s shut down and heaters are drained.
2. Never admit steam to heaters unless the engine is down, and then not without the water valve open. The heater elements are not designed to stand the temperature of live steam.

Emergency Fuel Trip

There are three emergency fueltrips on the locomotive, each connected to close the one emergency fuel cut-off valve at the left rear corner of the fuel tank when the ring is pulled. One trip is located in the

operating cab behind the fireman, and one on each side of the locomotive at the fuel tank. The cut-off valve shuts off fuel to the steam generator as well as the engine, and when pulled must be reset by hand.

ENGINE ROOM CONTROLS AND GAUGES

Engine Control Panel and Gauges

The engine control panel and gauges are located on the right side wall opposite the governor end of the engine. Included are:

1. Fuel pump breaker
2. Isolator lever
3. Engine stop button
4. Alarm lights
   Surge relay - white
   Ground relay - white
   Low oil pressure - yellow
   Alternator failure - blue
   Hot engine - red
   Steam generator off - green
   Stuck Starting Contactor - white
   (Provided only on railroad specification.)

5. Ground relay and sealed surge relay remote reset button:
6. Lube oil pressure gauge
7. Fuel oil pressure gauge
8. Fuel tank level gauge

The Lube oil pressure and Fuel oil pressure Gauges on later units are mounted on the engine water tank.

The engine water temperature gauge is located on the engine water outlet header.

Fuel Pump Breaker

This breaker on the engine controlpanel starts the fuel pump but not unless the engineer's fuel pump breaker is first closed. The breaker is of the double-throw type and also energizes the auxiliary generator field and exciter battery (4-pole field. If this breaker trips, engine will starve for fuel and alternator failure alarm will come on.

Isolator Lever

This lever has three positions:

Start - Handle upward, pulled to right, and upward against spring pressure.
Starting contactors G+ and G- are energized, connecting the main generator to the batteries to start the engine.

Idle - Handle upward.
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 cannot close. Power cannot be delivered on the unit either in motoring or dynamic braking. Other units are not affected. In this position the alternator failure alarm will not operate.

The engineer's throttle in stop position will not shut down on engine which has been isolated.

The engine stop pushbutton on the engine control panel is operative only with the isolator i n idle position. The emergency engine stop button on the engine is operative at any time.

Run - Handle downward
This places the engine under the engineer'.s controls, or "on the line".

Engine Stop Button

This button on the engine control panel will stop the engine, after i t is isolated, b y energizing the governor "D" solenoid. Control Cut-out breaker on electrical cabinet must be "ON" for this button to operate.

Alarm Lights

A description of alarm indications is included in Section 225 on "Alarms and Trouble Shooting".

Emergency Engine Stop Button

This is a large red pushbutton located on the engine above the governor. Its function is to manually trip the engine overspeed

safety mechanism to stop the engine in an emergency. Operation of this button is entirely independent of the governor or engine control panel stop pushbutton electrical circuits.

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. If an engine shuts down because of the overspeed tripping, alarm bells will ring in all units and a blue light will show on the engine control panel of the unit affected. Trip is set for approximately 950 rpm.

Fan and Shutter Controls

Fan and shutter controls are described in detail under the section on the

Engine Cooling System.

Control switches are sealed and are located in a box on the left side wall near the engine room side door.

The 30 lbs. air gauge below the control switch box indicates air pressure to the temperature control system; the plug to the left of the box is for a test gauge to indicate air pressure to the control switches as regulated by the thermostat in the engine outlet water header.

Fan contactors are located in the two boxes located one near each engine room side door on the floor.

Sander Relay Valve and Cut-out Cock

Front truck sander relay valves and cut-out cock are located on the right engine room side wall near the floor, opposite the main generator. Those for the rear truck are mounted near the rear Sand box on the right engine room side wall.

Hand Brake

The hand brake is located in the right rear of the unit and is connected to the right rear brake cylinder of the rear truck.

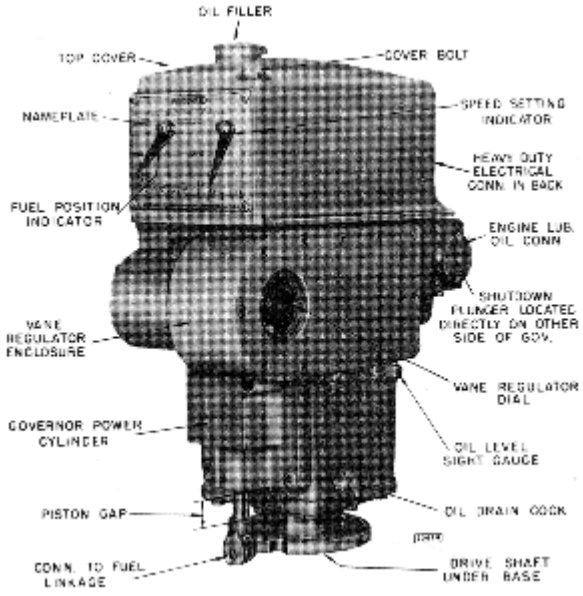
GOVERNOR

The engine governor is the Woodward Type PG with

1. Electro-hydraulic speed control.
2. Built-in engine low oil pressure shutdown protection.
3. Built-in load regulator, controlling resistance in exciter battery (4-pole) field.
4. Speed and Fuel indicator scales on governor housing.
5. Overriding solenoid used to send load regulator to minimum field during wheel slip.

Electro-hydraulic Speed Control

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



Illus. 3. Woodward Governor

shows solenoids energized at each throttle position:

Throttle Position	Solenoids Energized A	B	C	D	RPM Engine Speed
Stop				*	0
Idle					300
1					300
2	*				380
3			*		460
4	*		*		540
5		*	*	*	620
6	*	*	*	*	700
7		*	*		780
8	*	*	*		850

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 eachunit of the locomotive and the yellow "low oil" and blue "alternator failure" alarm lights will show on the engine control panel of the unit affected.

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

1. Push in button on governor. This will put out yellow low alarm light.
2. Isolate engine. This will stop alarm bells and putout blue alternator failure alarm light.

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

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 maybe 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.

Load Regulator

The load regulator, included in the governor housing, consists of a

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

Brush arm travel is from 7 o'clock at minimum field (marked "MIN" to 5 o'clock at maximum field (marked "MAX").

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

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

Indicator Scales on the Governor

On the outside of the governor housing are two pointers with scales. One is marked "Speed" and markings correspond to throttle position. The other is marked "Fuel" and indicates power piston position in 16ths of an inch. The lower the fuel scale r e a ding, the more fuel is being injected into the engine.

Over-riding Solenoid in Governor

The over-riding solenoid in the governor is energized by either wheel slip relay. It operates to send the load regulator to minimum field by control of oil flow.

Governor and Load Regulator Indications for Correct Loading
At full throttle a quick check maybe made for correct engine loading by observing the load regulator and the pointers on the

governor. Checking should be only at full throttle as variations at part throttle may cause confusion.

With throttle in run 8 position:

1. Governor speed pointer shouldbe at 8 to coincide withthe throttle.

2. Governor fuelpointer should be between 6 and 8. A reading higher than 8 indicates insufficient fuel to the engine. A reading lower than 6 indicates excessive fuel to the engine.

3. Load regulators in each unit should be between 9 and 3 o'clock.
   If arm stays at 7 o'clock, unit is at minimum field, indicating governor trouble.
   If arm stays at 5 o'clock, unit is at maximum field, indicating governor or electrical trouble.

If the observed readings do not agree with the above, report for correction. DO NOT ATTEMPT ANY ADJUSTMENTS ON THE ROAD.

Summary of Correct Governor-Load Regulator Settings

1. Load Regulator Timing: 7 sec. minimum-maximum
   14: sec. maximum-minimum

2. Governor Power Piston Gap:
   3/8" full load. Corresponding engine fuel pump rack readings are 8 CS, 8 OCS, 16 total.
   $\frac{60"}{64}$ idle.

3. Locomotive Start: In minimum field, i. e. load regulator in minimum field with throttle in idle. Maximum field start is also possible, but is restricted to certain suburban locomotive applications.

SECTION 204. LOCOMOTIVE OPERATION

PRELIMINARY

Outside Check of Units

Before boarding locomotive, check for:

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

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

3. Trainline air cut-out cocks open between units. Electrical jumper cables in position.

4. Condensation in main reservoirs. Reservoirs are located under operating cab with drain cocks on fireman's side.

IMPORTANT NOTE: With the added cooling of main reservoir air on these units, water willcollect rapidly in the main reservoirs and will not continue thru to the air brake system AS LONG AS RESERVOIRS ARE FREQUENTLY DRAINED. Emergency drain plugs are provided on the control, application control, and auxiliary emergency and displacement volume reservoirs.

Interior Check on Each Unit

1. Check supplies before starting engine.

   a) Engine lubricating oil - bayonet gauge on right side of engine, sub-base.
   b) Governor oil - sight glass on governor.
   c) Air compressor lubricating oil-bayonet gauge in compressor crankcase.
   d) Engine water level - sight glass on engine water tank.
   e) Steam generator water level.
   f) Sand - four sand boxes in engine room aisles.

2. Check for leaks in piping systems.

3. Check air compressor oil pressure. Should run from 5 to 20 lbs. idle to full engine speed.

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

	Trailing A-Unit	B-Unit	Leading Unit
Main Battery Switch	On	On	On
Throttle Handle	Idle	Idle	Idle
Selector Handle	Off	---	1 or 4
Reverse Handle	Removed	Off	Off
Rotair Valve	Pass. Lap or Freight Lap	---	Pass. or Freight
Controlled Emergency Cock, D-24		Set same as leading A unit rotair	
Control Valve	---		---
Automatic Brake Valve	Cut out	---	Cut in
Engineer's Switch Panel			
Control breaker Off	Off	On	
Fuel Pump Breaker	Off	Off	On
Generator Field Breaker	Off	Off	On
Cabinet Breaker Panel			
Alternator Field Breaker	On	On	On
Locomotive Lights Breaker	On	On	On
Heater and Defroster Breaker	On	---	On
Control Cutout Breaker	On	On	On
Dynamic Brake Breaker (if used)	Off	---	On
Electro-pneumatic Brake Breaker (if used)	Off	---	On
Train Control Breaker (if used)	Off	---	On
Control Air Pressure, Lbs.	80	80	80
Battery Ammeter	Charge	Charge	Charge
Traction Motor Cutout Switch	As desired	As desired	As desired
Ground Relay Cutout Switch	Sealed "on"	Sealed "on"	Sealed "on"
Dynamic Brake Unit Switch	Set for no. of units in locomotive.	---	Set for no. of units in locomotive.

To Start Engine and Put on Line

1. Snap "ON" fuel pump breaker at engineer's breaker panel to be used.

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

3. Snap "ON" fuel pump breaker at engine control panel and note that fuel oil pressure builds up to 12-18 lbs.

4. Pull isolator to right, and upward against spring pressure to "START" position. Hold until engine fires and lube oil pressure reaches 7-9 lbs. The engine should start turning promptly and firing should occur within a f e w revolutions. If engine fails to fire, release isolator and repeat. If failure again occurs, investigate for cause as continued unsuccessful attempts will run down the batteries.

5. To put engine on the line, turn isolator to "Run" position. NOTE: ENGINE WILL NOT DELIVER POWER IF STARTING CONTACTORS STICK CLOSED.

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

STARTING AND ACCELERATING

Before moving locomotive

1. Check that main reservoir pressure i s being maintained at 130-140 lbs.

2. Set independent brake. Release hand brake.

3. Move reverse lever to desired position.

4. Move selector lever to:

   a) Position 1 when locomotive consists entirely of "C"-Line" units.

   b) Position required for operation of trailing units when locomotive includes units of differentmodel ormanufacture.

To move locomotive

1. Place foot on safety control pedal.
2. Release independent brake.
3. Open throttle as required.

Pumping up train line after coupling to train

1. Snap "OFF" generator field breaker.
2. Move reverse lever to neutral.
3. Open throttle as needed but not beyond 6th notch.

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 one not c h at a time until locomotive moves. Bunching slack is normally unnecessary. If slack is bunched, be careful to avoid damage to knuckles and drawbars. Going beyond the 5th notch should not b e necessary to start. If so, look for sticking brakes, or coupler damage may result.

   c) The power required to start the train may move the load ammeter pointer into the red zone. This is permissible on starting and i s recommended for good performance where conditions permit. However, ammeter needle must steadily return to the green 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.
(2) Slack action, depending upon how many cars have tightlock couplers and length of train.
(3) Rail conditions.

c) Maximum load meter a m p e r a g e in the red zone is permissible on starting and acceleration provided the pointer steadily returns to the green (continuous) zone.

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 trainbrakes. Throttle mustbe in "IDLE" when locomotive stops.

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, will result in serious damage.

VISUAL INSPECTION DURING STOPS

If time permits during stops, make visual inspection of under part of locomotive to detect any signs of trouble. Watch especially for hot journals, hot motor axle bearings, and hot armature bearings.

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

REVERSING

Bring locomotive to a dead stop before moving reverse handle for opposite locomotive movement. Applying power in reverse direction, before locomotive stops, may cause serious damage to traction motors.

PASSING OVER RAILROAD CROSSING

When approaching a railroad crossover, throttle should be moved to notch 3 or below and kept in that position until all locomotive units have passed over the crossing. This will minimize the possibility of traction motor flashovers because of brushes being jolted off the commutator.

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 generator field switch, move reverse handle to "OFF", and open throttle to 4th notch for about ten minutes. This will allow the water to be dried off the traction motors.

CHANGING ENDS

Before leaving cab:

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

2. Make 20 lb. brake pipe reduction, close brake pipe cutout cock, move rotair valve t o "LAP", and remove brake handles.

3. Snap "OFF" Control, Generator Field, and Fuel Pump breakers at engineer's breaker panel. Snap "OFF" Dynamic Brake, Electro-pneumatic Brake, and Train Control breakers o n electrical cabinet. Engines will run long enough for a man to reach the other cab.

New leading cab:

1. Snap "ON" Fuel Pump, Control, and Generator Field breakers a t engineer's breaker panel. Snap "ON" Dynamic Brake, Electro-pneumatic Brake, and Train Control breakers on electrical cabinet.

2. Check for correct position of Dynamic Brake Unit Switch behind engineer's seat.

3. Insert brake handles, move rotair valve t o "PASS" o r "FRT" as required, apply full independent brake, and open brake pipe cutout cock.

4. Insert reverse handle and make air brake tests.

OPERATING WITH LEADING UNIT SHUT DOWN

Snap "OFF" Control and Fuel Pump breakers at lead unit engineer's breaker panel and "ON" in trailing unit. Avoid having both ends on at same time as battery equalizing currents may be enough to damage control wiring.

FREEZING WEATHER PRECAUTIONS

If the engine is to be shutdown during freezing weather, standby steam must be connected or the cooling water system drained. See "Cooling System", Sec. 218.

HEAVY KNOCKING OR OTHER UNUSUAL ENGINE SOUNDS

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

TO RERAIL A UNIT

The locomotive can be rerailed, if not more than one pair of wheels are off the rails, by spiking down a rerailing frog in the usual manner and cutting out the motors on the derailed wheels. 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 their gear cases. Use the remaining two motors and proceed very 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

SECTION 210. DYNAMIC BRAKING

Operation of Controls

1. Check that the dynamic brake unit switch behind the engineer's seat is set for the number of units in the locomotive.

2. Check that the dynamic brake circuit breaker on the panel behind engineer is in "ON" position. This breaker controls the field loop excitation circuit.

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

   The dynamic brake retards the train similarly to a strong independent brake, so the same care must be used in controlling slack.

4. Place throttle in "Idle". Wait at least ten seconds, to allow plenty of time for the power contactors (P1 and P2) to open, and the engine speed to come down to idle.

5. Move selector lever to "OFF". (Reverse lever mustbe in forward or reverse.) This will:

   a) Throw the cam switch from "motoring" to "braking" position.

   b) Double traction motor blower speed through action of the pole changer which is connected mechanically to the cam switch.

6. Power contactor P1 closes to connect the traction motor fields to the main generator, but excitation is not applied. If train speed is high, residual magnetism in the generator and exciter fields may cause sufficient braking effort to bunch slack. The load ammeter will indicate a reading, which is a measure of the braking effort being produced.

7. After a few seconds, move selector until it latches in the FIRST braking position. Here the diesel engine speed is increased from 300 to 380 rpm (second notch).

8. AFTER SLACK IS BUNCHED, move the selector lever to the right to give the desired amount of braking. Do not allow the ammeter pointer to go into the red area of the braking band on the scale. Excitation is applied just beyond the first braking position, when a controller closes

the field loop contactor, FL.

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

10. DO NOT APPLY THE DYNAMIC BRAKE BEYOND FIRST BRAKING POSITION AT 50 MPH OR OVER.

11. The automatic air may be used at any time along with the dynamic brake. An interlock on the D-24 Control Valve of each unit keeps the automatic brake from applying on the unit when the dynamic brake is inuse. The independent brake is always available. KEEP INDEPENDENT AIR ALWAYS RELEASED IN DYNAMIC BRAKING, or wheels may slide.

    Note that if a unit is isolated, so that its dynamic brake is inoperative, air brakes on the unit will still not apply while the rest of the locomotive is in dynamic braking. This is because the dynamic brake interlock remains energized on a unit, even if it is isolated, as long as the engineer is operating in dynamic braking. Dynamic brake interlocks on all units are energized by the engineer's selector handle.

12. A brake-valve initiated emergency air brake application will automatically nullify the dynamic brake and allow locomotive brakes to apply. The selector handle must be returned to the "OFF" position to recapture the dynamic brake.

13. As the speed decreases braking effort builds up to a maximum near the locomotive continuous speed and then decreases at a sharp rate. However, there is still considerable braking left at 8 mph and often this is more effective than the independent brake.

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

14. At low speeds, dynamic braking effortdecreases sharply. Around 5 mph the dynamic brake maybe released by moving the selector lever to No. 1 position and applying the independent brake to keep slack from running out.

Manipulating Dynamic Brake on Level Track

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

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

Manipulating Dynamic Brake on Grades

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

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

A similar procedure should be used when the grade includes stretches where the speed is restricted because of curves, yards, track conditions, etc. By the use of heavier air applications, the speed can be

reduced to meet the restriction. After passing a restricted area, release the air and allow the train to come up to the normal speed for the grade where the pointer will again reach the top of the white area. This method will accomplish smooth train handling and, in some respects, act as a graduated release after slowdowns.

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

SECTION 215. 24-RL AIR BRAKE EQUIPMENT

AUTOMATIC BRAKE VALVE

The six handle positions are:	Release	Lap
(left to right on the quadrant)	Running	Service
	First Service	Emergency

Release Position gives controlled full release with the large capacity feed valve providing a high rate of air flow to the brake pipe at feed valve pressure without overcharging. A warning port operates to inform the engineman of the handle position.

Running Position gives air flow to the brake pipe at the same rate as provided by older feed valves. This position is used to release the brakes; when the brakes are charged and ready for use; and when the brakes are not being operated.

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

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

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

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

Cocks on the brake stand are:

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

2. Application Valve Cut-out cock on the service application portion normally sealed in the "In" position. "Out" position cuts out the safety control, overspeed, and traincontrol 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.

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

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

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

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

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

5. Shifter Lever, on the left side of the rotary valve seat portion. Used only with electro-pneumatic brake installation.

   "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 a t 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 canbe 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: Independent brake valve Controlled emergency Split-reduction (if used) Suppression timing (if used)

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

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

"PASS LAP" - 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 the PC switch, and the "power off" light to come on.

A 4 seconds, time delay is provided during which a warning whistle sounds , 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 cut-out cock at the top of the righthand equipment rack in the nose.

SAFETY CONTROL

Releasing pressure on the foot pedal and the hinged brake valve handle at the same time (one or the other must be kept depressed while running) will cause a warning whistle to blow. Within four seconds, the pedal must be again depressed and the brake valve lapped, or an automatic full service application will occur, tripping the PC switch and causing the "power off" light to come on.

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

If unit is equipped with the rigid type brake valve handle the safety control feature is initiated by the foot pedal only. The safety control feature can be cut out by closing the sealed 3/8" cut-out cock in the line to the foot pedal.

BRAKE CYLINDER CUT-OUT COCKS

The brakes on any truck can be cut out by closing the brake cylinder cut-out 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 charging from the brake pipe. Use only when locomotive is hauled dead in a train.

2. Retarded Recharge Cock

Position should correspond to that of A-unit rotair valve.

"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.

B-UNIT CONTROLLED EMERGENCY CUT-OUT COCK

Position must correspond to that of the rotair valve in the leading "A" unit.

"F" position cuts in controlled emergency brake cylinder pressure development feature.
"L" position must not be used.
"P" position cuts out controlled emergency brake cylinder pressure development feature.

SECTION 216. FUEL OIL SYSTEM

DESCRIPTION

The fuel system employs equipment as follows, listed according to the flow of the fuel from the tank to the engine. Refer to the piping diagram on the following page and to the drain and fill diagram in Section 231.

1. 1000-gallon supply tank underneath locomotive.
   Sight glasses on tank and remote air operated level gauge at engine control panel.

2. Emergency fuel cut-off valve, located at left rear corner of 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 on front end of engine water tank.

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.

7. Fuel pressure gauge, mounted on engine water tank and indicating pressure supplied to engine fuel header.

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

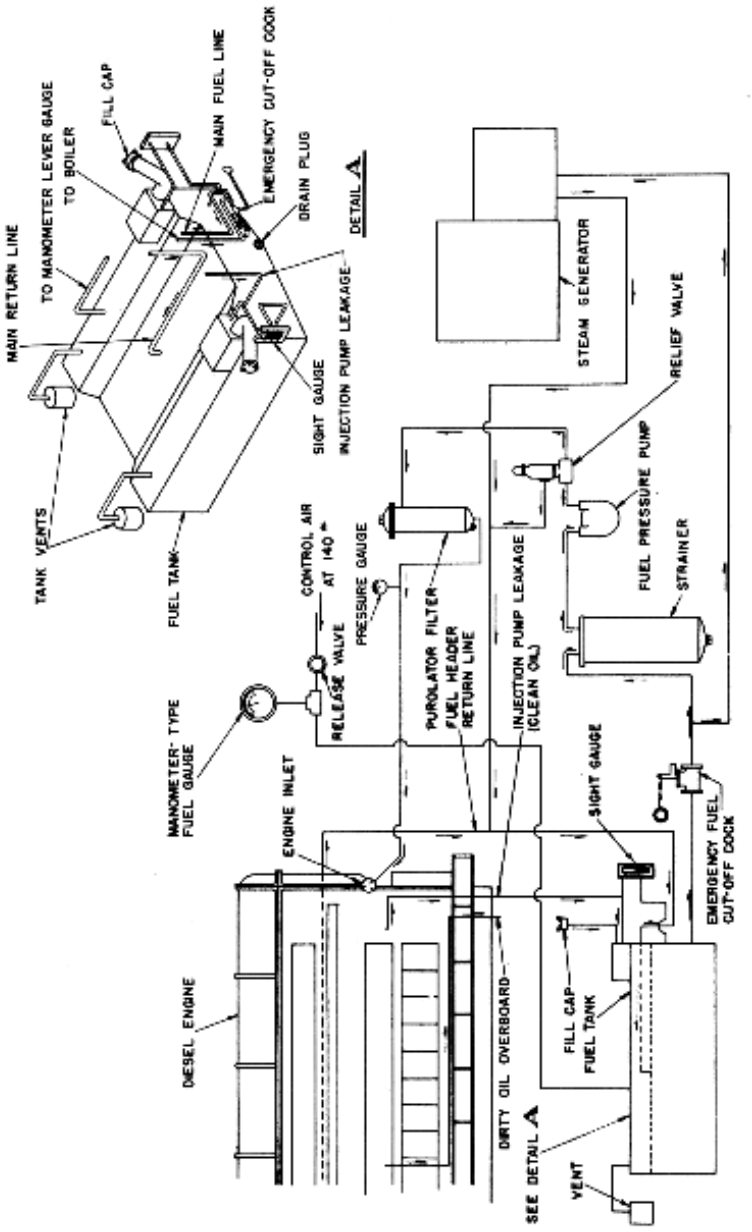
9. *Engine fuel pumps and nozzles*.

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



Illus. 1. Fuel Oil Piping

rate of 200 gallons per minute. Sight gauges near 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.

Vents

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

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 mustbe reset byhand. The valve is located at the left rear corner of the fuel tank below the left side filler pipe, and shuts off fuel to the steam generator as well as the engine.

STEAM GENERATOR FUEL SUPPLY

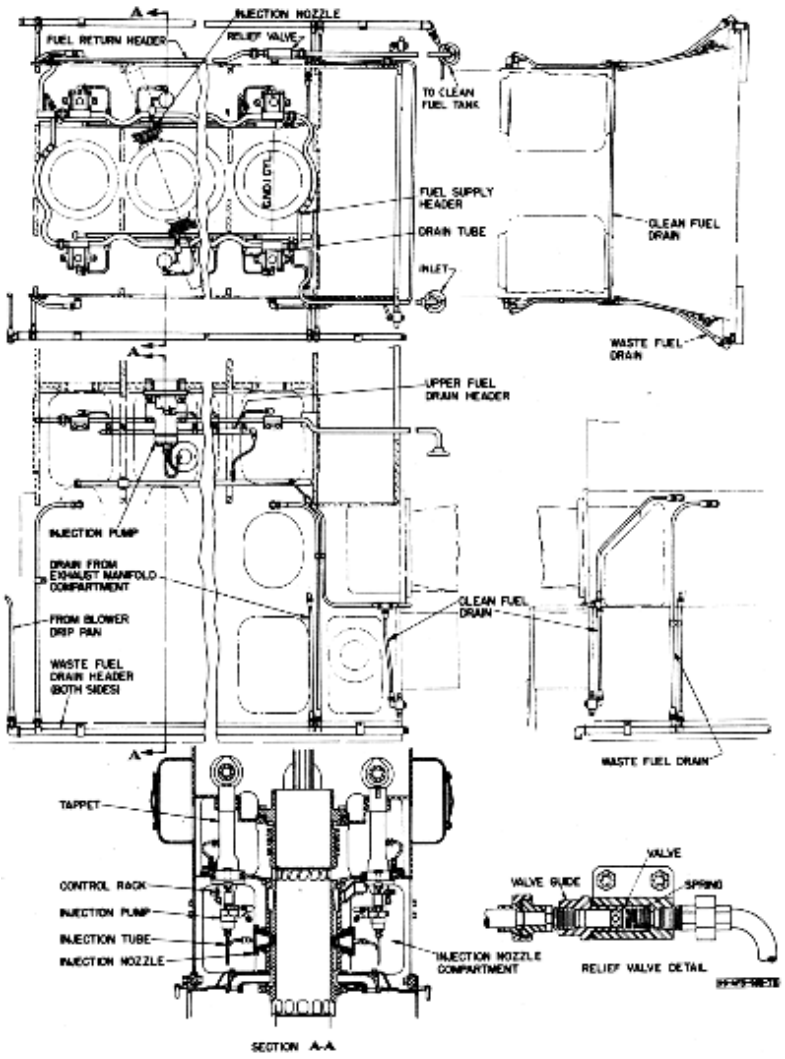
An auxiliary line is tapped into the main suction line between the emergency cut-off valve and the fuel pump, to supply the steam generator on passenger units.

ENGINE FUEL HEADERS

The fuel supply headers on each side of the engine are connected to each injection pump. More fuel is pumped thru the injection system than is needed by the pumps, and a pressure of about 15 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 con nections collecting in the



Illus. 2. Engine Fuel Injection System

injection nozzle compartments is piped to a drain to the ground at the left rear corner of the fuel tank.

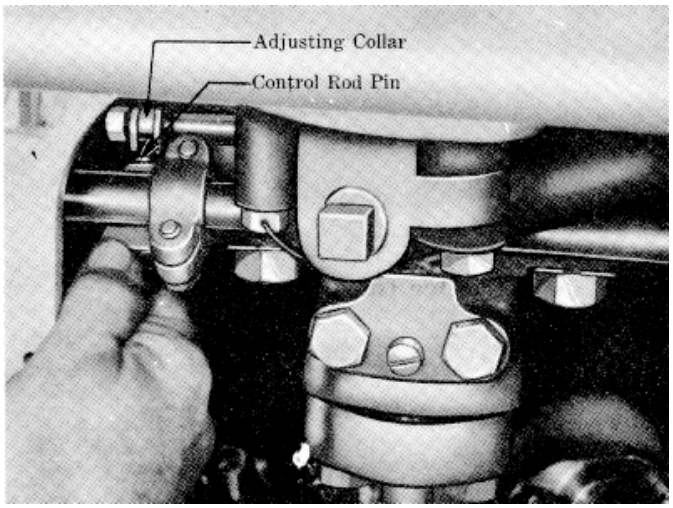
FUEL PRESSURE

Fuel should be clean tp avoid trouble in the system. The fuel pressure should be approximately 25 lbs. at idle and 16 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.
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.

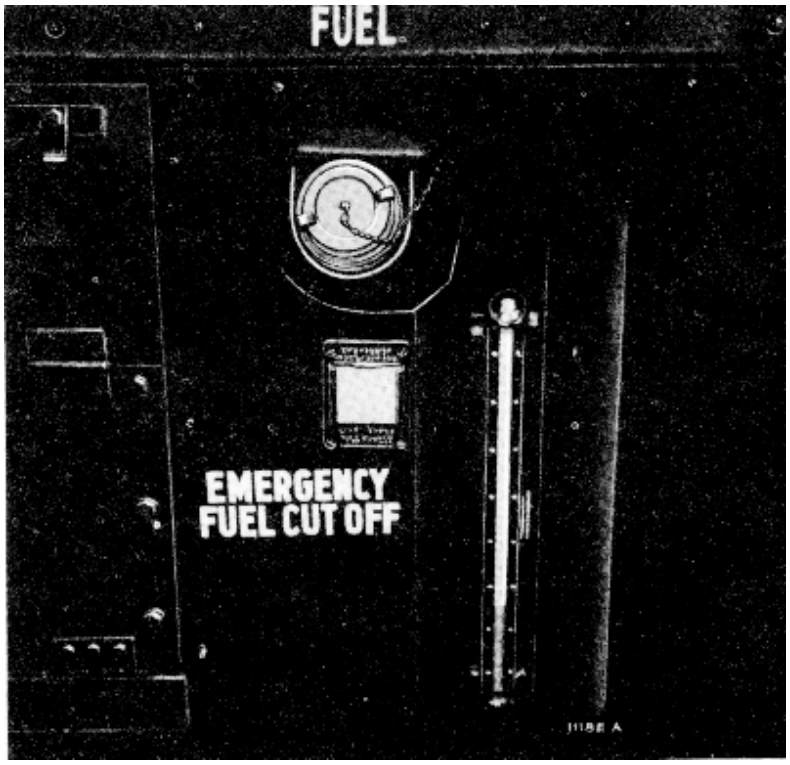


Illus. 3. Fuel Injection Pump Cut-out

No more than four pumps should be cut out at one time on a ten or twelve cylinder engine (Two pumps on an 8-cylinder engine), 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. 4. Fuel Tank

SECTION 217. LUBRICATING OIL SYSTEM

GENERAL

The lubricating oil system serves a dual purpose byfurnishing oil to the engine for cooling the pistons and lubricating the various bearings and wearing parts under pump pressure. Refer to the piping diagram on the following page and to the drain and fill diagram in Section 231.

FLOW OF LUBE OIL

The engine driven lubricating oil pump draws oil from the engine crankcase through a coarse strainer, and pumps it through the 6-element filter to the oil cooler. Here, the oil is circulated around water cooled tubes and then piped through a fine strainer to the engine oil headers. Flowcontinues through the engineparts and back to the crankcase.

RELIEF VALVES AND BY-PASSES

At idling speed all oil is designed to flow through the 6-element filter. At higher engine speeds a relief valve will open at 20-25 lbs. to allow part of the oil to flow through an external by-pass around the 6-element filters.

Plugging of the oil cooler or strainer will open an internal bypass in the pump and cause the engine to shut down from low oil pressure if sufficient drop occurs. The pump relief valve is set at 70 lbs. and is not adjustable.

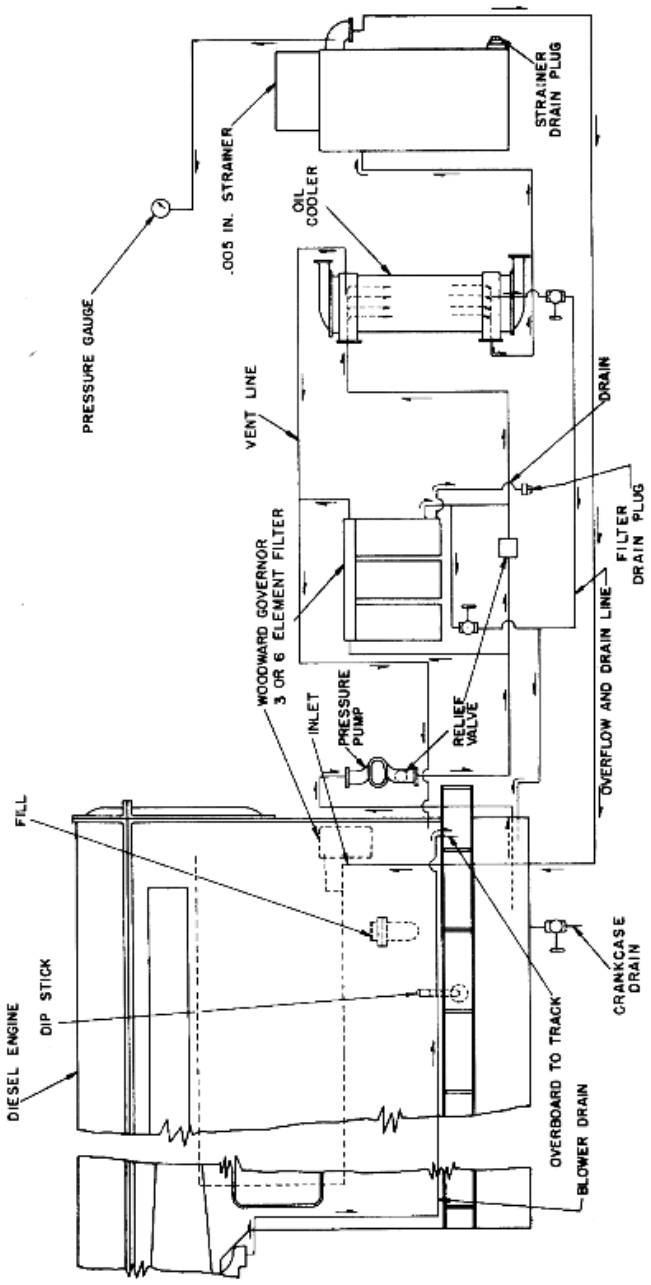
LOW OIL PRESSURE PROTECTION

An oil line from the lower engine lubricating oil header to the engine governor provides connection to the low oil pressure shutdown feature located in the governor. Refer to Sec. 201, Page 22 for operation. There are no separate pressure switches.

CHECKING OIL LEVEL AND FILLING SYSTEM

Measuring Oil Level

Oil level is measured at the dip stick located in the engine subbase on the left side of the engine. The lubricating oil level should be checked at the start of every run, and should be between the "Full Engine" and "Add Oil" marks.



Illus. 1. Lubricating Oil Piping

If the engine is running when the level is checked, read the side of the gauge marked "Engine Running". Readside marked "Engine Stopped" when engine is not running. Use the following procedure:

1. Unscrew bayonet gauge, remove and wipe clean of oil.

2. Insert to full thrust but do not screw into pipe.

3. Withdraw and read proper side.

4. Replace in pipe and screw down snug.

Filling System

The engine is supplied with lubricating oil by filling the crankcase through the filler pipe on one of the lower crankcase doors on the engine.

1. Initial Fill

   When the system i s being filled for the first time, oil should be added until the level reaches the "Full Engine" mark on the "Engine Stopped" side of the dip stick. After the engine has been run and the oil distributed through the system, oil should again be added until the level reaches 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 reaches the "Full Engine" mark on the dip stick,

DRAINING SYSTEM AND CHANGING OIL

The system is drained from the bottom of the engine crankcase through the drain pipe at the pump end of the engine. The drain is equipped with a valve and pipe plug at the end, and is located just ahead of the rear truck.
To change lubricating oil, proceed as follows:

1. Open drain valves at oil filter and cooler in engine room. Filter and cooler will drain into the crankcase.

2. Remove pipe plug in end of system drain pipe on outside of locomotive.

3. Open crankcase drain valve on outside of locomotive.

4. When oil flow stops, close crankcase and filter and cooler drain valves and replace the pipe plug in the end of the drain pipe.

5. Renew filter elements and clean strainer.

6. Refill system to "Full Engine" mark on the "Engine Stopped" side of the dip stick.

7. Start engine, allowing oil to circulate and fill system.

8. Stop engine. Allow oil to settle in crankcase and take level reading on bayonet gauge. Level should be at the "Full Engine" mark on "Engine Stopped" side of the dip stick.

9. If necessary, add enough lubricating oil to bring the oil level up to "Full Engine" mark.

DRAINING OIL FILTER

To service the 6-element oil filter, a drain valve is provided to drain the filter into the crankcase. A plugged opening is also provided at the rear of the filter draining into a waste hose. Drain valve is located by the filter.

CAUSES OF LOW LUBRICATING OIL PRESSURE

1. Dirty strainer.

2. Insufficient oil.

3. Oil diluted by fuel oil or water.

4. Line broken.

5. Pump defective.

6. Cooling water above 195° F.

SECTION 218. COOLING SYSTEM

GENERAL DESCRIPTION

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

Water is drawn from the engine water tank by the enginedrivenpump, circulating water through the engine coolingpassages to two parallel banks of radiators in the cooling hatch. After being cooled, the water passes through the lubricating oil cooler to the engine.

Air for cooling the radiators enters through shutters on the sides of the locomotive unit. The air is drawn through the radiators and expelled through openings in the roof by four alternating current-motor-driven fans mounted at the top of the cooling hatch. (Three fans for 1600 hp units.)

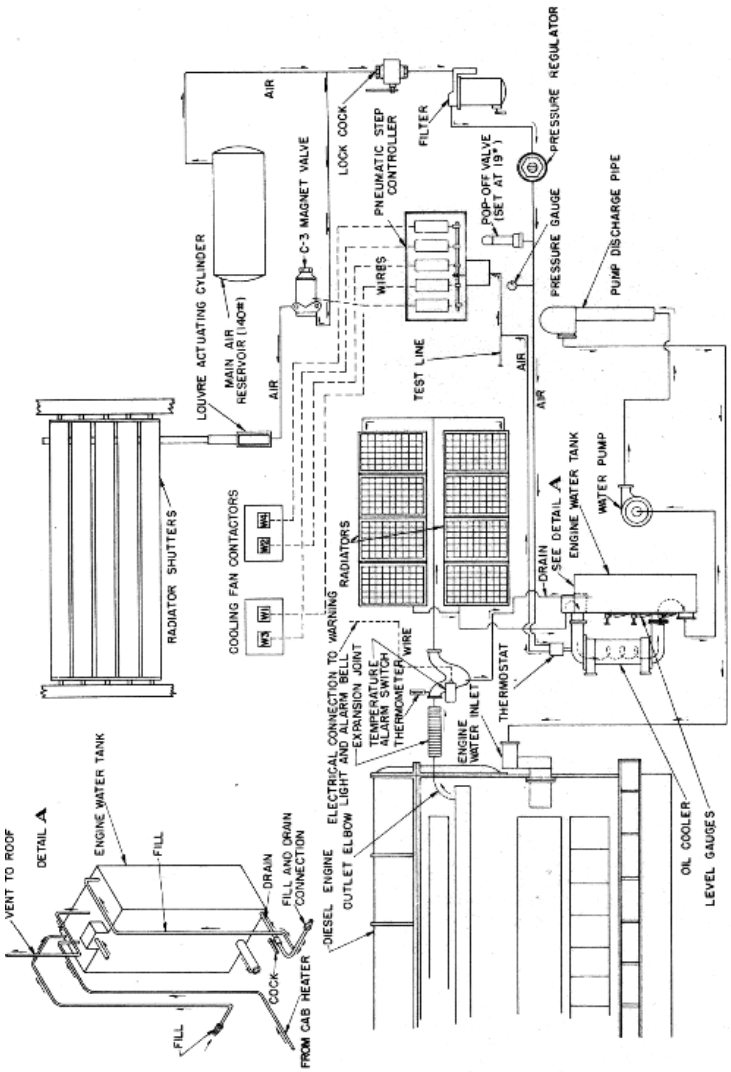
TEMPERATURE CONTROL

The fan motors are electrically connected to the alternator by contactors in the lower cabinets located near the engine room side doors. The fan contactors are energized by electric contacts in the pneumatic step controller located in the upper cabinet by the left engine room side door. An additional contact operates the shutter magnet valve, controlling air at main reservoir pressure to the two shutter operating cylinders. There is a shut-off cock in the air line to the magnet valve.

The pneumatic step controller is operated by a 0-17 lb. range in temperature control air pressure regulated byathermostat located in the water inlet line to the oil cooler. This air pressure rotates a camshaft to make the electric contacts close in sequence.

Air pressure to the thermostat is 17 lbs. and is indicated by the air gauge below the step controller. This pressure is regulated by a reducing valve in the line, connected to the main (80 lb.) control air system. A relief valve is set at 19 lbs. to protect the temperature control, and a drip well and filter is installed ahead of the pressure regulator.

Refer to the piping diagram on the following page and to the drain and fill diagram in Section 231;.



Illus. 1. Cooling Arrangement Note: 1600 hp units use only 6 radiator sections and three fans

OPERATION OF TEMPERATURE CONTROL SYSTEM

The thermostat in the engine waterline controls the air pressure to the air-operated pneumatic step controller. The thermostat is direct acting, so that the outlet air pressure rises as the engine water temperature rises. Main line pressure to the thermostat is set by the reducing valve to 17 lbs. Branch line pressure out of the thermostat varies directly as the water temperature. The thermostat is adjustable on temperature control setting. The following describes operation on the 150-162 degree setting which is presently used.

Up to 150° F. temperature of the water out of the engine, air pressure out of the thermostat varies from 0 to 3 lbs. At 3 lbs. , contact TSS energizes the shutter magnet valve to open the shutters. At 152° F. the thermostat increases the air pressure to 5 lbs. to rotate the controller which closes contact TS1 which energizes No. 1 fan contactor. Similarly at 154° (7 lbs.) 158° (11 lbs.), and 162° (15 lbs.) Nos. 2, 3, and 4 fans are started by contacts TS2, 3 and 4 in the controller.

Note: 1600 hp units use only three fans, three contactors, and four controller contacts. Fan No.2 and fan contactor 2 are omitted, and contact TS2 controls fan contactor No 4.

As the water temperature lowers, the branch line air pressure out of the thermostat decreases and the reverse sequence occurs; the controller rotates back, the contacts open, and the fans stop in succession. There is a differential of approximately 1-1/2 lbs. .of air (1-1/2 degrees) on each contact. When the pressure reduces to 1-1/2 lbs. , contact TSS opens to de-energize the shuttermagnet valve and close the shutters.

A plugged connection is provided in the air line from the thermostat to the controller for installation of anair gauge fortesting.

HOT ENGINE ALARM SWITCH

This switch is located on the engine water outlet pipe.If the water outlet temperature exceeds 195°.F. the switch closes to light the hot engine alarm light (only on unit affected) and ring the alarm bells on all units. If alarm comes on, check for cause and take the engine off the line if necessary.
Causes may be:

1. Steam valves open into engine water system or cab heaters.

2. Shutters stuck or closed. Magnet valve may be dirty or shut-off cock closed.

3. Fans not running. Check for:

   a) Leakage in 17 lb. control air lines.
   b) Defective step controller. If necessary, rotate by hand to limit of travel so that all contacts are closed.
   c) Defective thermostat.

4. Water low.

5. Defective water pump.

6. Restricted water circulation.

7. Scale deposits in water system causing poor heat transfer.

FILLING COOLING SYSTEM

1. Water level is designed to be below radiators when the engine is shut down, with the same level maintained winter or summer. Two 16" overlapping sight glasses on the engine water tank indicate water level. A low-level red line indicates minimum level on the lower sight glass, and an engine should never b e operated with water below this mark.

2. Filling is through a filler pipe with a corrugated male coupling located one on each side of the locomotive, or through the roof filler-vent pipe in emergency. When filling from the side, water should be run into the system until it starts to run out the opposite filler pipe. System capacity is 250 gal. (1600 hp), 270 gal. (2000 hp) or 280 gal. (2400 hp). Be sure the drain valve at the bottom of the engine water tank is closed before filling.

3. If the system is filled with the engine running and then the engine is shut down, water will overflow until the radiators drain.

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

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

DRAINING COOLING SYSTEM

1. Open drain valve at bottom of engine water tank. This valve opens into the left side filler pipe and will drain the radiators, oil cooler, and engine water tank.

2. Open valve at pump end of engine and remove pipe plug in each exhaust manifold to drain engine exhaust manifold water jackets.

3. Remove drain plug from the water pump.

4. To drain cab heaters, open cab heater drain valves located in the engine room on each side opposite the main generator.

ADDING WATER TREATMENT

Water treatment is added to the system through a plug in the top of the engine water tank on the left side.

COLD WEATHER PRECAUTIONS

When an engine is shut down in freezing weather, the cooling system must be drained or steam supplied through the standby lines. To admit steam to the cooling system:

1. Open valve in steamline to engine water tank. Valve is located on floor just ahead of the left engine room side door. This valve also admits steam to the engine water jacket.

2. Open valve in steamline to the cab heaters. Valve is located overhead in the nose. Always have water on at the same time as live steam alone will melt the heater elements.

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

When an engine is shut down, standby steam should also be admitted to the steam generator water tanks and sanitary water tank (if equipped).

Standby steam is admitted to the unit thru a 1" line into the main steam line at the left rear of the car body.

SECTION 218A WINTERIZED 1600 H. P. C -LINE UNITS

The purpose of the winterization program is to maintain an efficient engine room temperature during cold weather operation and to reduce the posibility of snow sifting into the engine room through the carbody filters.

PROCEDURE FOR COLD WEATHER OPERATION

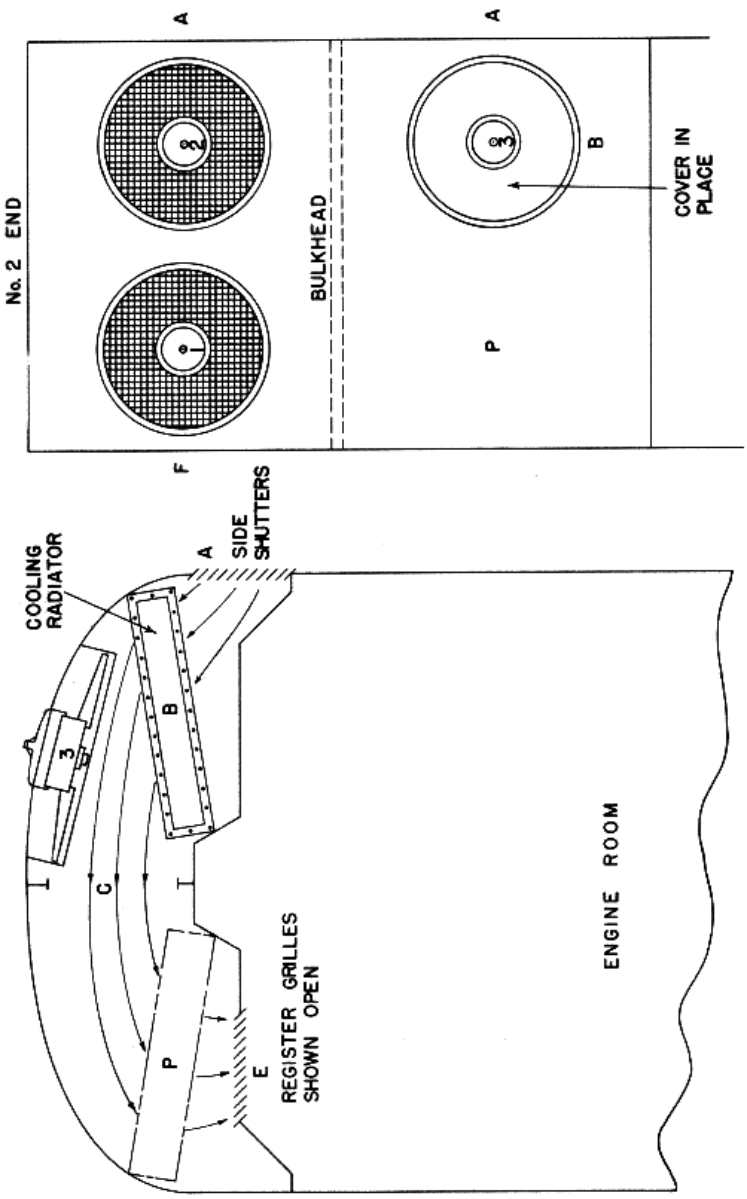
1. Close the generator fan exhaust ports in the duct under the main generator. There are two closure plates, each one being held in the open position by means of a lock-bolt. The lock-bolts are located on the side of the duct facing the front end of the unit.
2. Put the covers on the carbody air intake filters.
3. Install the cover plate on the roof of the cooling hatch over No. 3 fan.
4. Cut-out radiator fan No. 3 by operating No. 3 fan cut-out switch, located in the AC contactor box near the left hand engine room door. The switch is marked "SUMMER" and "WINTER". The "WINTER" position makes No. 3 radiator fan motor inoperative.
5. Open the register grilles in the engine cooling hatch pan in the engine room.

OPERATION

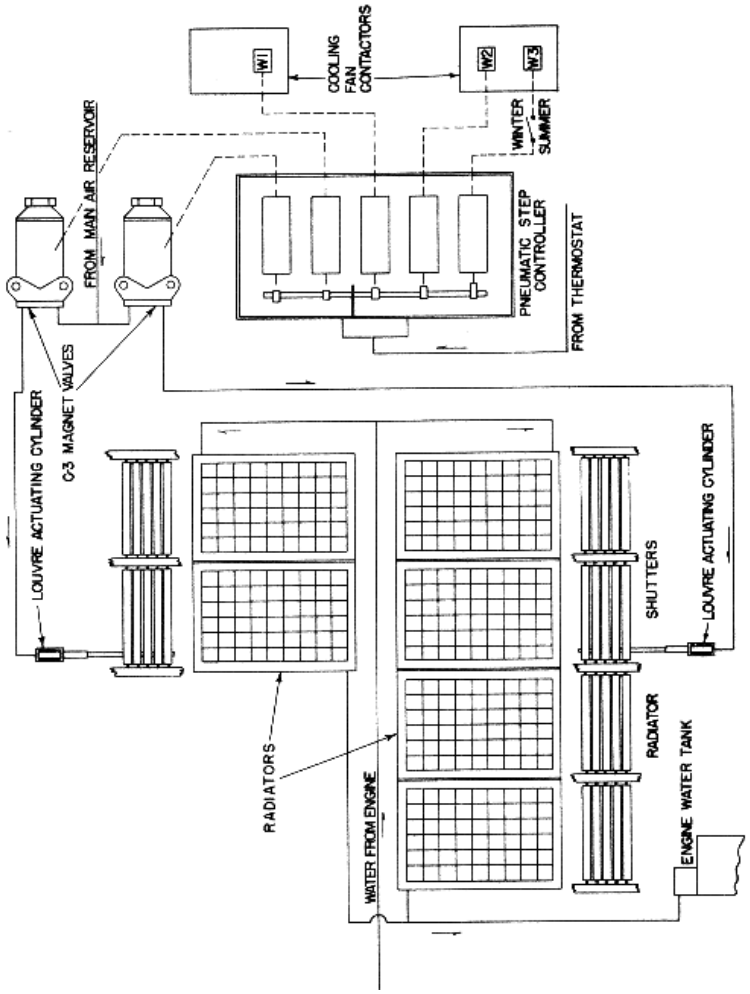
The carbody filters are covered on both sides of the unit. Air for the diesel engine is drawn directly from outside the unit by means of ducts running to the blower intake. The main generator fan exhaust duct is closed to allow the warmed air to remain in the engine room and to reduce the amount of air required by the engine room equipment. The only equipment now requiring supplies of air are the four traction motor blowers and this air is supplied through the engine water cooling hatch.

At a temperature of 165 degrees in the engine water outlet, the thermostat operates the step controller to energize a magnet valve which admits air to the louvre actuating cylinder on the left hand side of the cooling hatch, opening the shutters at A on Illus. 1.

The vacuum in the engine room created by the demands of the traction motor blowers tends to draw air in through radiator B, Through the opening in the longitudinal bulkhead C, through the register grilles at E and down into the



Illus. 1. Winterized C-Line Cooling Hatch



Illus. 2. Winterized C-Line Cooling Arrangement

engine room. register grilles at E and down into the engine room. Thus all air entering the engine room is warmed as it passes through the hot radiator section.

At a temperature of 170 degrees, the step controller energizes a second magnet valve to open the cooling hatch shutters at F. At 173 degrees, the step controller closes AC contactor W 1 to start radiator fan No. 1. At 175 degrees, radiator fan No. 2 starts with the closing of AC contactor W2.

During operation in warmer weather, fan motor No. 3 starts at 177 degrees. This temperature sequence of operationof the shutters and fan motors remains the same winter and summer, with the exception of fan motor No. 3 which is cut-out during cold weather operation.

PROCEDURE FOR WARM WEATHER OPERATION

1. Remove the covers from the carbody air intake filters.

2. Open the generator fan exhaust ports in the duct under the main generator by swinging the closure plates to the open position and securing in place with the lock-bolts.

3. Remove the cover plate from No. 3 fan on the roof of the cooling hatch.

4. Close the register grilles in the engine coolinghatch pan.

5. Cut-in No. 3 radiator fan by operating the fan cut-out switch to "Summer" position.

SECTION 225. ALARMS AND TROUBLE SHOOTING

SUMMARY

Trouble Cause	Cab Alarm Light	EC Panel Alarm Light	Eng. Stops	Eng. To Idle	Power Off	Unit Not Fully Loading
Low Oil Pressure	-	Yellow, Blue	Yes	-	Yes	-
Eng. Overspeed Tripped	-	Blue	Yes	-	Yes	-
Ground Relay Tripped	-	White	-	Yes	Yes	-
Surge Relay Tripped	-	White	-	Yes	Yes	-
Ground Relay Tripped - 5th or 6th Throttle	-	White, Blue	Yes	-	Yes	-
Surge Relay Tripped - 5th or 6th Throttle	-	White, Blue	Yes	-	Yes	-
PC Switch Tripped	Power Off	-	-	Yes	Yes	-
Throttle in "Stop"	-	Blue	Yes	-	Yes	-
Aux. Gen. Fuse Blown or Alt. Field Brkr. Tripped	-	Blue	-	Yes	Yes	-
Aux. Gen. Fuse Blown etc. , 5th or 6th Throttle	-	Blue	Yes	-	Yes	-
Wheel Slip	Wheel Slip	-	-	-	-	Yes
Wheel Slip Relay or Contactor Stuck	--	-	-	-		Yes

Trouble Cause	Cab Alarm Light	EC Panel Alarm Light	Eng. Stops	Eng. To Idle	Power Off	Unit Not Fully Loading
Pair Traction Motors Cut-out	-	-	-	-	-	Yes
V-Belts Slipping on Exciter	-	-	-	-	-	Yes
Low Fuel Pressure	-	-	-	-	-	Yes
Engine Isolated	-	-	-	Yes	Yes	-
Starting Contactor Stuck	-	-	-	-	Yes	-
Jumper Cable Loose	-	-	-	Yes	Yes	-
Emergency Fuel Cut-off	-	Blue	Yes	-	Yes	–
Control Cut-out Brkr. Tripped	-	Blue	Yes	-	Yes	-
Fuel Pump Brkr. Tripped	-	Blue	Yes	-	Yes	-
Engineer's Control Brkr. Trip Engineer's Gen.	-	-	-	Yes	Yes	-
Fld. Brkr. Trip	-	-	-	-	Yes	-
Low Control Air Pressure	-	-	-	-	Yes	-
Faulty Interlocks or Contacts	-	-	-	-	Yes	Yes
Governor or Load Regulator out of Adjustment (DO ADJUST ON ROAD.)	-	-	-	-	-	Yes NOT

ALARMS

Listed below is each alarm, how it affects the unit, and steps necessary for correction. In each case alarm bells will ring in all units but lights will show only on the engine control panel of the unit affected.

Light	Alarm	Action	To Correct Condition
White	Ground relay tripped	Motoring - automatically isolates engine by de-energizing contactors TV and EF. Dynamic braking - cuts out brake on unit affected only, by de-energizing power contactor P1. Also brings engine to idle by de-energizing contactor TV.	1. RETURN ISOLATOR TO IDLE. 2. Reset relay by pressing reset button on engine control panel. This will put out light and stop bells. 3. Put engine back on line, EXCEPT WHEN DYNAMIC BRAKE IS APPLIED. 4. If relay repeatedly trips, a) RETURN ISOLATOR TO IDLE. b) Cut out a pair of traction motors by turning selector in electrical cabinet. c) Return engine to line. If relay again trips, a) RETURN ISOLATOR TO IDLE. b) Cut out other pair of traction motors with selector knob. c) Return engine to line. 5. If relay still trips, leave engine isolated.
White and Blue	Ground relay tripped 5th or 6th throttle	Stops engine. Contactors TV and EF are de-energized, and "D" solenoid in governor shuts engine down.	1. RETURN ISOLATOR TO IDLE. This will put out blue light. 2. Press relay reset button. This will

Light	Alarm	Action	To Correct Condition
			put out white light and stop bells. Check that engine overspeed has not tripped. 3. Thru 5, same as section above.
White	Surge relay tripped	Motoring - same as ground relay. Dynamic braking - same as ground relay.	(Surge relay tripping indicates a flashover on the main generator) 1. RETURN ISOLATOR TO IDLE. This will put out alarm light and stop bells. 2. Unit should be left isolated until generator is inspected and cleaned by maintenance forces. 3. In emergency, as during single-unit operation, relay can be reset by breaking seal on reset switch and opening and closing switch. PROCEED AT HALF THROTTLE OR LESS. Follow railroad instructions.
White and Blue	Surge relay tripped 5th or 6th throttle	Same as ground relay.	Same as in preceding section, except engine should be started first and then left isolated.
Blue	Alterna- for failure	Takes engine off line by de-energizing contactors TV and EF (TV and P1 in	1. RETURN ISOLATOR TO IDLE. This will put out light and stop bells. braking) 2. Check overspeed trip, PC switch, and

Light	Alarm	Action	To Correct Condition
			all fuel pump breakers.
		"D" solenoid in governor shuts engine down if NVR trips while throttle is in 5th or 6th position.	3. Check auxiliary generator fuse. SHUT DOWN ENGINE TO REPLACE.
			4. Check Alternator Field breaker on electrical cabinet.
		Alarm comes on also if engine stops from overspeed trip, lack of fuel, etc. while on	5. Put engine back on line, EXCEPT WHEN DYNAMIC BRAKE IS APPLIED. line.
Blue & Yellow	Low Oil Pressure	Stops engine.	See description in section under Governor.
Red	Hot Engine (Water over 195° on gauge.)	Alarm only.	1. Check that steam admission valves are closed to engine, engine water tank, and cab heaters. 2. Check engine water level. 3. Check shutters and shutter air shut-off cock. 4. Check temperature switch control air, which should be at least 13 lbs. on gauge to the left of the cabinet. 5. Check Pneumatic Step Controller. If necessary turn by hand to limit of travel so all contacts are closed. 6. Check fan contactors. All should be closed. 7. If condition cannot be corrected, isolate

Light	Alarm	Action	To Correct Condition
			engine, cut out a pair of traction motors, and return engine to line. This will cut engine loading 50%. If alarm again comes on, leave engine off line.
Green	Steam Gener-ator Off		See Section on Steam Generator.

LOCOMOTIVE TROUBLE SHOOTING

Little or No Fuel Pressure When Fuel Pump Switch is on at Engine Control Panel.

1. Fuel pump fails to run, or stops:

   a) Main battery switch not closed.
   b) Breakers feeding fuel pump motor circuit tripped.

      (1) 50A. main control breaker on electrical cabinet tripped, or same breaker on leading unit.
      (2) 15A. fuel pump breaker at engineer's position tripped.
      (3) Fuel pump breaker on engine control panel tripped.

   c) 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 cut-off tripped.
   c) Leaks in pump suction line.
   d) Clogged suction strainer.
   e) Worn pump packing rings.
   f) Pump relief valve sticking.
   g) Clogged pressure filter.

Engine Fails to Rotate When Isolator is Pushed to Start Position

1. Weak battery. f engine room lights go very dim or out, generator is receiving starting current but battery is too weak to rotate generator.

2. Starting contactors not closing. Check "Out" interlock on EF contactor, which must be closed to complete circuit from Control Cut-out breaker to starting contactor coils.

Engine Rotates but Fails to Fire

1. Overspeed tripped.
2. Low oil shut-down button on governor not reset.
3. No fuel pressure.

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.

Load Ammeter Shows No Current when Throttle is Notched Out with Locomotive Not Tending to Move

1. Diesel engine isolated.
2. Control and generator field breakers not "ON" at engineer's control stand.
3. Reverse handle not in "FORWARD" position.
4. Control air pressure less than 70 lbs. (Should be 80 lbs. on gauge in cab.)
5. Ground relay tripped.
6. Surge relay tripped.
7. No A. C. voltage relay tripped.
8. Starting contactor G+ or G- stuck closed.

9. PC switch (in nose open, indicated by "Power Off" light burning. Reset if necessary by lapping automatic brake valve until application pipe pressure builds up to normal.

Locomotive Tends to Move, but Load Ammeter Shows No Current

1. Front truck traction motors isolated.

2. Load ammeter defective.

Unit Loading Only Partially or Not at All

1. Diesel engine isolated.

2. Pair of traction motors cut out.

3. Starting contactor G+ or G- stuck closed. Pry open with a flagstaff if necessary.

4. Low control air pressure.

5. Low fuel pressure.

6. If a trailing unit, loose jumper cable between units.

Loss of Power on All Units. "Power Off" Light Does Not Burn. All fuel pumps stopped.

1. Lead unit control cut-out breaker tripped.

2. Engineer's fuel pump breaker tripped.

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

1. Engineer's control breaker tripped.

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

1. Engineer's generator field breaker tripped.

SEQUENCE CHART
UNITS WITH DYNAMIC BRAKING
FOR ENGINE GOVERNOR SOLENOID SEQUENCE SEE SEC.201 R22

OPERATION	MOTOR CONNECTION	SELECTOR	THROTTLE	ISOLATOR	CAM SWITCH	CONTACTORS: P1	P2	M1, M2	M3, M4	M5, M6	M7, M8	GF	G+ G-	FPC	EF	TV	FL	DBM	RELAYS: PCR	BR	TDR	V+ V-	CR	C	T1	T2	T3
SHUT DOWN	ENGINEER'S FUEL PUMP SWITCH OPEN	OFF	IDLE	ISOL	B																						
ENGINE START	ENGINEER'S FUEL PUMP SWITCH CLOSED	OFF	IDLE	START	B								●	●													
IDLING	ENGINEER'S FUEL PUMP SWITCH CLOSED	OFF	IDLE	ISOL	B									●													
IDLING	ENGINEER'S FUEL PUMP & CONTROL SWITCHES CLOSED	OFF	IDLE	ISOL	B									●					●					●			
IDLING	ENGINEER'S FUEL PUMP CONTROL & GEN. FIELD SWITCHES CLOSED	OFF	IDLE	ISOL	B									●					●					●			
IDLING	SAME AS ABOVE	OFF	IDLE	RUN	B									●		●			●					●			
IDLING	SAME AS ABOVE & REVERSER IN FORWARD OR REVERSE	OFF	IDLE	RUN	B	●								●		●			●	●	●						
IDLING	SAME AS ABOVE	1 TO 4	IDLE	RUN	M	●								●		●			●								
MOTORING FORWARD SHUNTING	FULL FIELD	1 TO 4	1 TO 8	RUN	M	●	●					●		●		●			●		●			●			
	FIRST SHUNT	1 TO 4	8	RUN	M	●	●	●				●		●	●	●			●		●	●		●			
	SECOND SHUNT	1 TO 4	8	RUN	M	●	●	●	●			●		●	●	●			●		●	●		●	●		
	THIRD SHUNT	1 TO 4	8	RUN	M	●	●	●	●	●		●		●	●	●			●		●	●		●	●	●	
	FOURTH SHUNT	1 TO 4	8	RUN	M	●	●	●	●	●	●	●		●	●	●			●		●	●		●		●	●
MOTORING BACKWARD SHUNTING	THIRD SHUNT	1 TO 4	8	RUN	M	●	●	●	●	●	●	●		●	●	●			●		●		●	●			●
	SECOND SHUNT	1 TO 4	8	RUN	M	●	●	●	●	●		●		●	●	●			●		●		●	●	●		●
	FIRST SHUNT	1 TO 4	8	RUN	M	●	●	●	●			●		●	●	●			●		●		●	●	●		
	FULL FIELD	1 TO 4	8	RUN	M	●	●	●				●		●	●	●			●		●		●	●			
IDLING		1 TO 4	IDLE	RUN	M									●		●			●					●			
DYNAMIC BRAKING		OFF	IDLE	RUN	B	●								●		●			●	●	●			●			
		BRAKE	IDLE	RUN	B	●								●	●	●	●	●	●		●			●			
		OFF	IDLE	RUN	B	●								●		●			●	●	●			●			
MOTORING ONE TRUCK CUT OUT	NO. 1 TRUCK CUT OUT	1 TO 4	1-8	RUN	M		●					●		●	●	●			●		●			●			
	NO. 2 TRUCK CUT OUT	1 TO 4	1-8	RUN	M	●						●		●	●	●			●		●			●			

SECTION 231. LOCATION OF DRAINS, FILLER PIPES AND STANDBY STEAM INLETS

The diagrams on pages 2 and 3 of this section indicate the various drains, filler pipes and standby steam inlets as used on these locomotives.

SECTION 232. ELECTRICAL CONTROL SYSTEM DESCRIPTION OF PARTS

General

Wiring diagrams differ for each locomotive order because of variations in specifications and details of construction. Therefore, reference should be made to the wiring diagrams which cover specifically the locomotives being operated or maintained. These diagrams are furnished to the railroad when the locomotives are delivered. In addition, typical schematic w i r i n g diagrams are included in this publication, beginning on Page 10 for the "A" unit.

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

*Indicates used only on units equipped for dynamic braking.

Symbol	Device	Function
A	Load Ammeter	Indicates current to traction motors on front truck. This is one-half generator current.
ACL, ACN	Standby Lighting Switch	Two-pole knife selector switch for connecting lights to locomotive battery or transformer on shop power connection.
AV, BV, CV, DV	Solenoids in Electro-Hydraulic Governor (See also ORS & TV)	Control engine governor action. Energized from lead unit throttle.
BA	Battery Ammeter	This meter is located on the electrical cabinet and indicates charging or discharge rate from the battery.

Symbol	Device	Function
BC	Battery Charging Contactor	Connects the auxiliary generator to the battery and the low-voltage control circuits. (Except the al ternator field which is taken directly off the aux. gen. after the charging fuse.)
B L 1-BL4	Traction Motor Blower Motors	Drive blower fans for Traction Motor cooling
* BR	Braking Relay	Throws cam switch to "Motoring" when throttle selector is moved from "Off" to "1".
BW	Brake Warning	Informs engineer when BWR is energized on any unit. Trainlined thru BW wire.
BWR	Brake Warning Relay	Voltage relay connected across one set of braking resistor grids to indicate when current is excessive. Set to pick up at 880 amps. Thru the braking grids or 770 volts on the relay.
C	Traction motor field shunting pilot relay, backward sequence.	Opens shunting contactors two at a time. De - energized by opening of CR, or by returning throttle to idle.
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. Closed by main reservoir air pressure at 130 lbs. ; open at 140 lbs.
CR	Current Relay	Energized by main generator current to operate backward shunting sequence. Set at 1900 amps. On 2400 hp units, and .1700 amps. On other units.

Symbol	Devic e	Function
*CSB, CSM	Magnet valves, contacts & interlocks on the Cam switch. "CSB" indicates those normally closed in braking. CSM indicates those in motoring.	Changes main power and control circuits from motoring to dynamic braking and vice versa. CSB is energized in "OFF" and "BRAKE" on throttle selector, thru "B" wire. The Cam Switch is electro-pneu matically operated thru magnet valves CSB and CSM.
*CSP	Cam Switch Pressure Switch	Air pressure switch to prevent Cam Switch from throwing to "Motoring" unless ample control air pressure is built up. Set at 70 lbs.
*DB l-DB 21	Contacts on Dynamic Brake Controller	Control resistance in dynamic brake field loop excitation circuit.
*DBM	Dynamic Brake Interlock	Releases or prevents an automatic service (not emergency) or electro-pneumatic straight air brake application on the locomotive while the dynamic brake is in operation.
*DBN	Dynamic Brake Nullifying Switch (PCR interlock replaces DBN on some units)	Impulse type pressure switch on air brake equipment rack. Operates to nullify dynamic brake in event of brake-valve initiated emergency application, but not on a train initiated emergency application.
*DBNR	Dynamic Brake Nullifying Relay	Nullifies dynamic brake when energized by DBN. Selector handle must be returned to OFF to reset.
EF	Exciter Field Contactor	Energizes exciter battery (4-pole) field controlling exciter and hence main generator output. Motoring: Closes when throttle is in Notch 1 or above.

Symbol	Device	Function
		Dynamic Braking: Closes with throttle selector in "BRAKE". Energized from BG wire.
EFR	Exciter Field Reduced Contactor	Inserts 40-ohm resistance in exciter field when de-energized by either wheel slip relay. Also energizes governor ORS to send load regulator to minimum field.
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 engine control panel of unit affected.
F 1- F4	Cooling Fan Motors	Drive fans for cooling the engine water in the radiators
*FL	Field Loop Contactor	Controls dynamic brake field loop excitation circuit. Energized on leading unit only when the selector is just beyond the first braking position and the reverse handle is in "FORWARD" or "REVERSE".
For, Rev	Magnet Valves, contacts and interlocks on the Reverser. "For" indicates those normally closed in "forward". "Rev" indicates those normally closed in "reverse".	Change direction of current thru traction motor fields. Operate in propulsion and sanding control circuits. The Reverser is electro-pneumatically operated thru magnet valves "For" and "Rev".
FPC	Fuel Pump Contactor	Connects fuel pump to the Control Cut-out breaker. Utilized to energize each fuel pump from its own battery.
FSM, RSM	Forward & Reverse Sanding Magnet Valves	Control forward and reverse sand ing. Energized by SPS thru reverser interlocks.

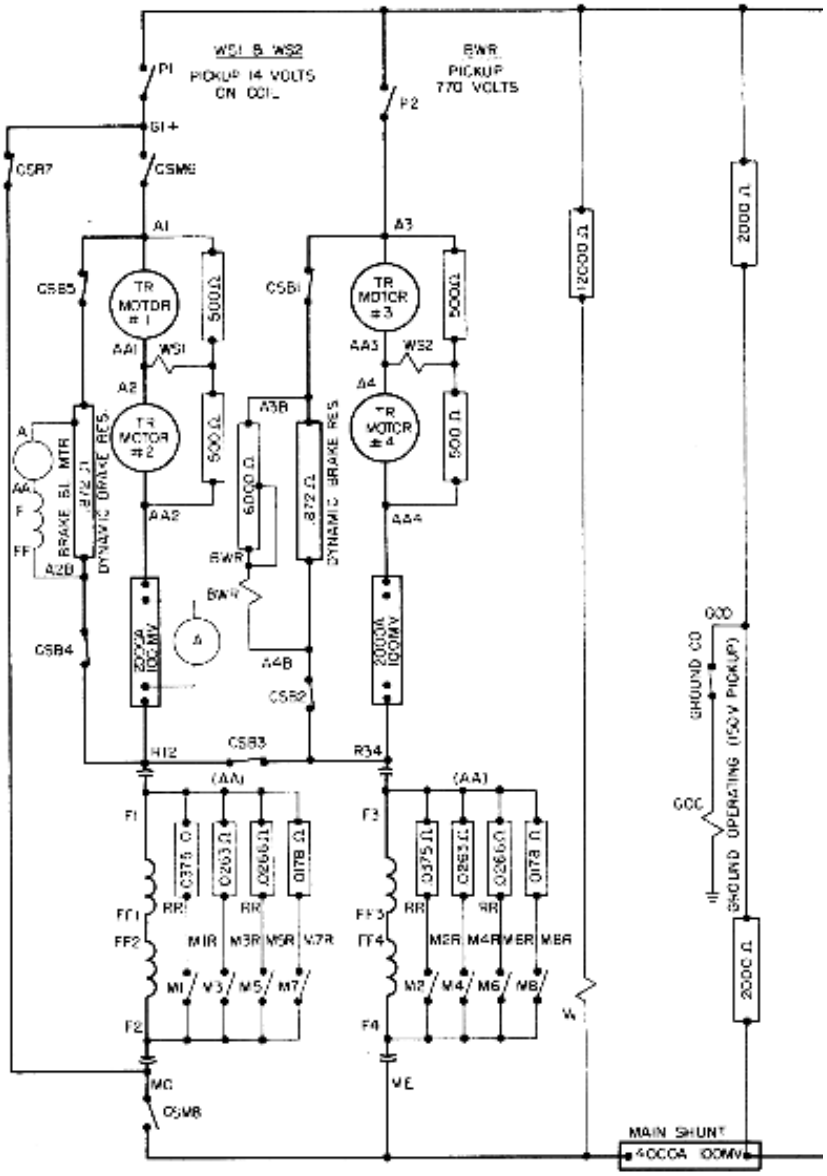
Symbol	Device	Function
G+, G-	Engine Starting Contactors	Connect main generator to battery for starting the engine. Energized from Isolator thru "EF open" in terlock.
* GF	Generator Field Contactor	Limits generator field current during dynamic braking. Energized in motoring through throttle
GR	Ground Relay (Remote reset button on engine control panel.	Energized in event of a ground in the main power circuits. Alarm bells ring on all units, and white light lights on engine control panel of unit affected. Motoring De-energizes TV to bring engine speed to idle and de-energizes EF to remove power. If relay trips while throttle is in 5th or 6th position, "DV" governor solenoid shuts engine down. Dynamic Braking De-energizes P1 to drop braking on unit affected. De-energizes TV to bring engine speed to idle.
GRCO	Ground Relay Cut-out Switch	De-energizes Ground Relay holding coil
GSR	Generator Surge Relay	Designed to energize in event of a main generator flashover. Set to operate at 160 amps. in main generator field. Functions are identical to the ground relay, except that GSR uses a separate sealed reset switch.
HCS	Hostler Control Switch	Controller for B-units.
ISOL	Isolator	Starts engine and puts engine on or off line. Positions are "Start", "Isol", & "Run". Complete description in Sec. 201.

Symbol	Device	Function
LOS	Low Oil Switch (in Governor	Shuts engine down if engine lubricating oil pressure falls too low for engine speed being maintained.
Ml-M8	Traction Motor Field Shunting Contactor	Shunt traction motor fields to in crease motor speed. Controlled by Vv and CR.
NVR	No-A. C. -Voltage Relay	De-energizes if alternator voltage falls below approximately 100 volts. Alarm bells ring on all units and blue light lights on engine control panel of unit affected. Motoring De-energizes TV to bring engine speed to idle. De-energizes EF to remove power. If relay opens while throttle is in 5th or 6th posi tion, "DV" governor solenoid shuts engine down. Dynamic Braking De-energizes Pl to drop braking on unit. De-energizes TV to bring engine speed to idle.
ORS	Overriding Solenoid (in governor	Operates to send the load regulator to minimum field during wheel slip Energized by EFR.
OSM	Overspeed Magnet Valve	Gives automatic service application on air brakes when de-energized. This may be caused by: 1. Overspeed Switch opening at maximum locomotive speed. 2. Low battery voltage, Control Cut-out breaker tripping, or Engineer's Control Breaker tripping.
Oversp. Switch	Overspeed Switch (in Chicago- Pneumatic Speed Recorder	Opens to de-energize OSM if maximum locomotive speed is exceeded.

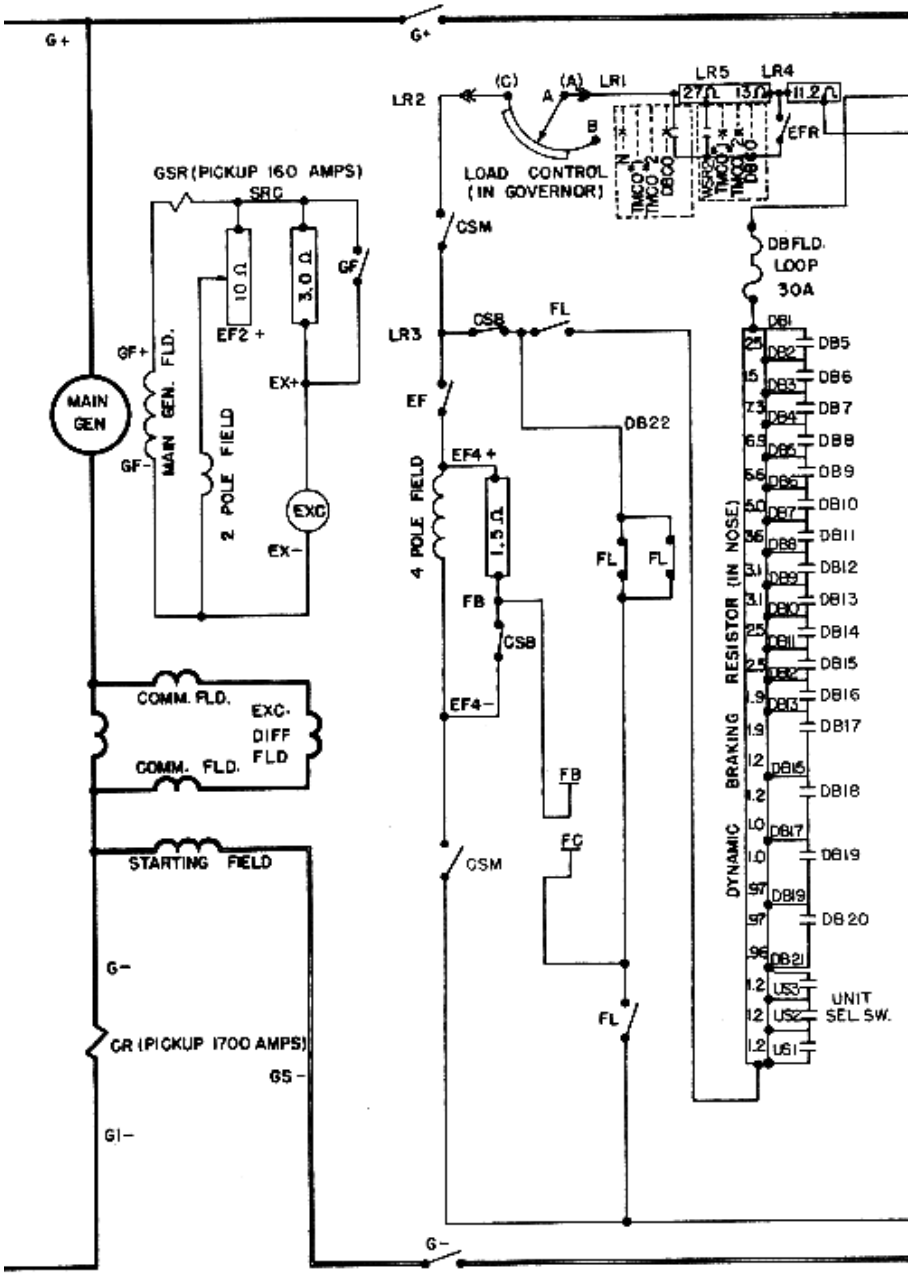
Symbol	Device	Function
P1, P2	Power Contactors	Connect traction motors to the main generator. In dynamic braking, P1 connects the traction motor fields (in series) with the main generator.
PCR	Pneumatic Control Relay	Opens throttle control circuits when deenergized by opening of PCs. This drops power on all units and brings all engines to idle speed.
PCs	Pneumatic Control Switch	Air pressure switch located at top of right-hand nose equipment rack. Opens in event of brake-valve initiated emergency, safety control, overspeed, or train control air brake application. When open deenergizes PCR.
Pole Ch.	Pole Changer	Connected mechanically to Cam Switch. When Cam Switch is in braking position, the Pole Changer changes the traction motor blower motors from 4-pole to 2-pole operation to double blower speed. This furnishes necessary air to traction motors at low engine RPM.
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 re-versing.
SMV	Shutter Magnet Valve	Controls main reservoir air to the two shutter operating cylinders. Energized by switch TSS.
SPS	Sanding Pressure Switch	Energizes FSM or RSM and train line wire SP (No. 12) closed by engineer's sander switch or brake valve bail.
SR	Signal Relay	Energizes alarm bells.

TDR	Time Delay Relay	Delays opening of power contactors (Pl and P2) until after excitation is removed, reducing contact tip burning.
T1, T2, T3	Traction motor field shunting time delay relays	Control timing of sequence in field shunting circuits.
T IA, TZA, T3A	Contacts of T1, T2, T3 for forward shunting sequence	In first three forward shunting steps, prevent shunting contactors from de-energizing for specified time after energizing; and prevent next step of shunting from picking up until after time delay has expired.
TIB, T2B, T3B	Contacts of T1, T2, T3 for backward shunting sequence	In first three backward shunting steps, prevent shunting contactors from energizing for specified time after de-energizing; also prevent a shunting step from dropping until the time delay has elapsed after the previous step.
TMCO	Traction Motor Cut-out Switch	Cuts out traction motors on either truck by de-energizing contactor P1 or P2. This will also make the dynamic brake inoperative on unit affected only. Also inserts resist ance in exciter battery field to reduce main generator output. Dynamic Brake cut-out de-energizes Pl on unit affected. Operation in motoring is not affected.
TSS, TS1-TS4	Temperature Control Switches	Energize Shutter Magnet Valve (SMV) and cooling fan contactors (W1-W4). Operated by air pres sure controlled from a thermostat" in engine water outlet manifold.
TV	Throttle Contactor	Brings engine speed to idle by deenergizing AV, BV, and CV solenoids in the governor.

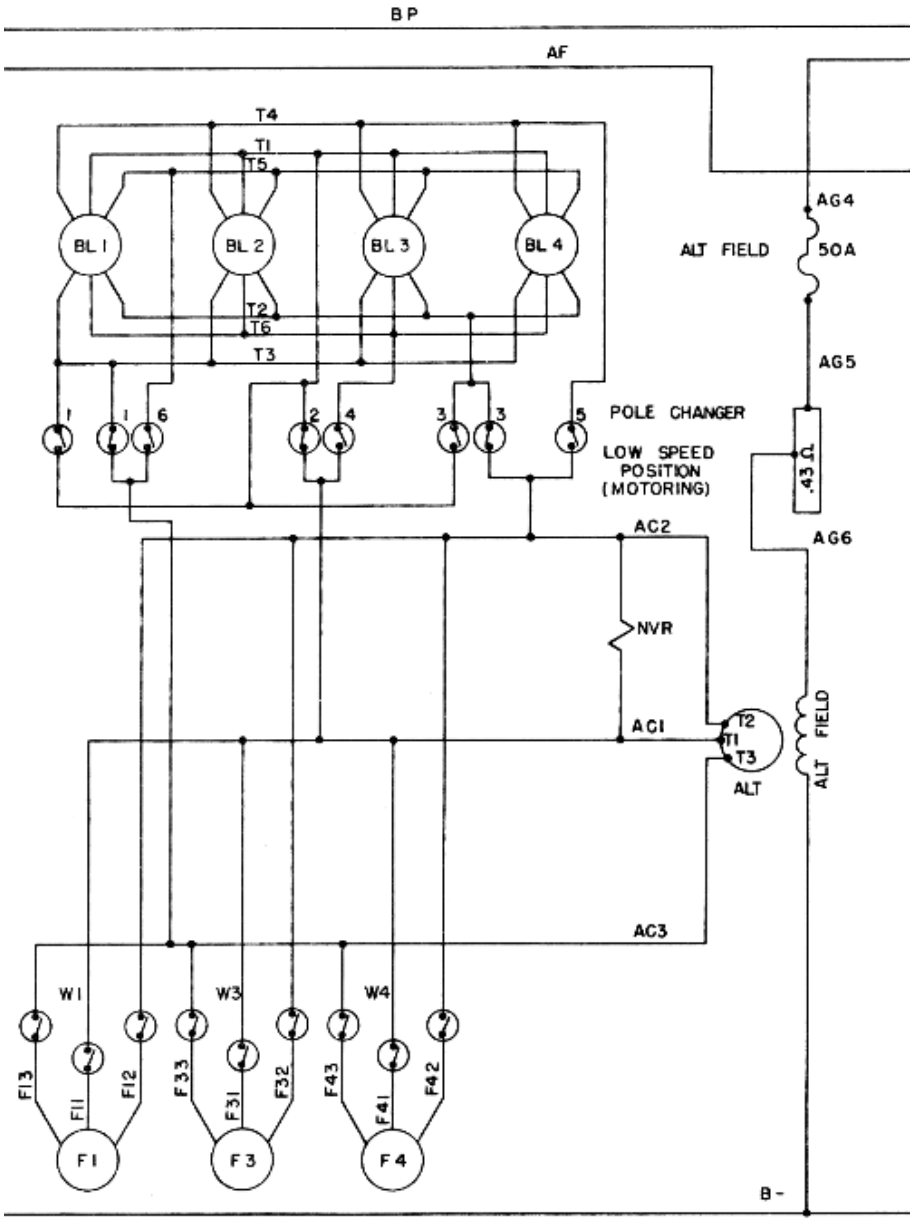
		Engine stops if TV is energized with throttle in 5th or 6th position, since governor DV solenoid will shut down engine.
US1 US3	Unit Selector Switch	Sets resistance in dynamic braking field loop control circuit according to number of units in locomotive. Settings are designed so loop con trol current remains the same regardless of number of units in locomotive.
V	Traction motor field shunting pilot relay, for ward sequence	Closes field shunting contactors M1 to M8. Energized by Vv.
Vv	Traction motor field shunting voltage relay, forward sequence	Controls forward field shunting sequence according to generator volt age. Operates pilot relay V.
VR	Voltage Regulator	Regulates auxiliary generator volt age. Correct settings are 72 volts idling, 75 volts full speed.
W1, W4	Radiator Fan Motor Contactors	Connect radiator cooling fan motors to alternator. Energized by TS1-TS4
WS 1, WS2	Wheel Slip Relays	Sound buzzer and light warning light at engineer's station when wheels slip on any unit; also automatically reduce power on unit affected by deenergizing contactor EFR.



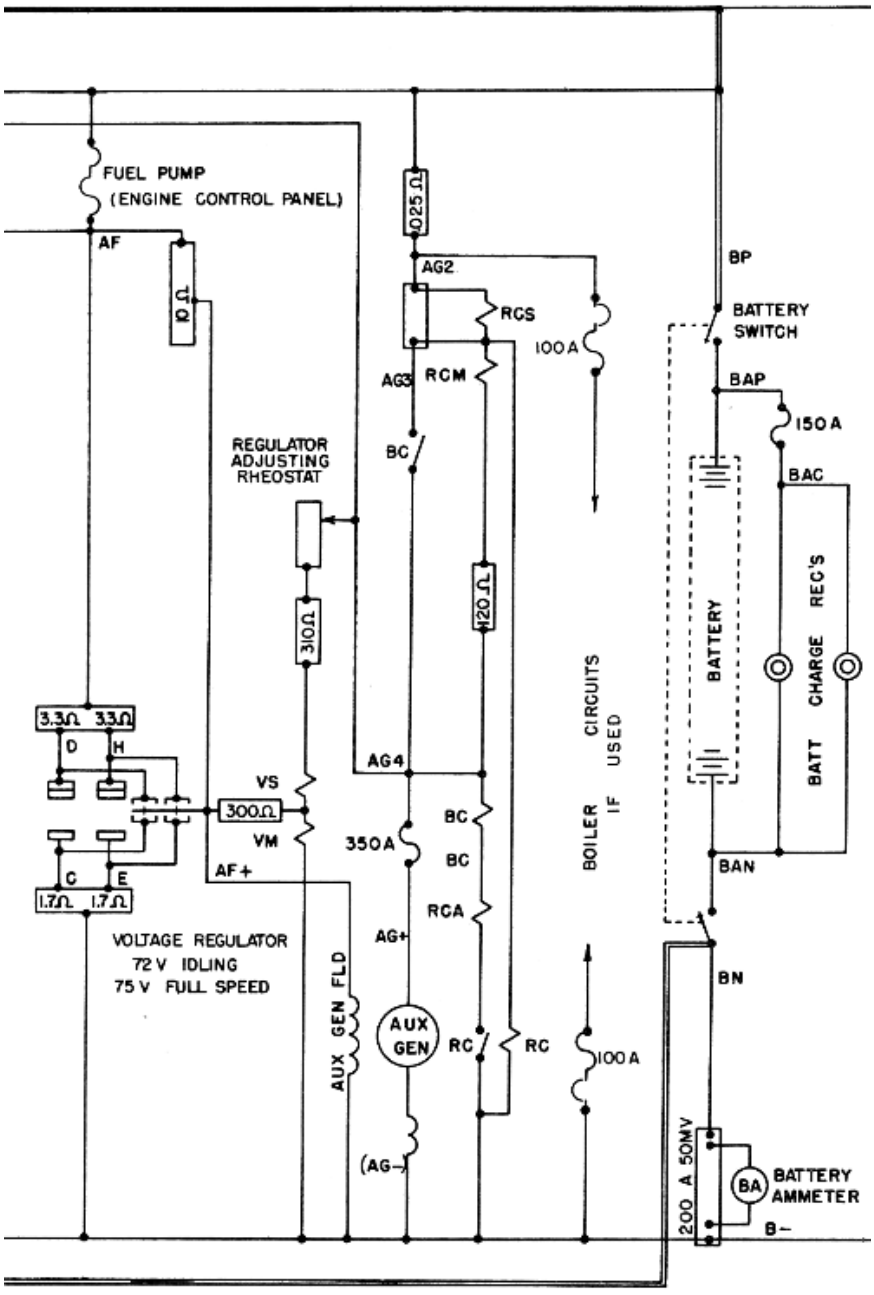
Traction Motor Power Circuits
("A" Units With Dynamic Braking)



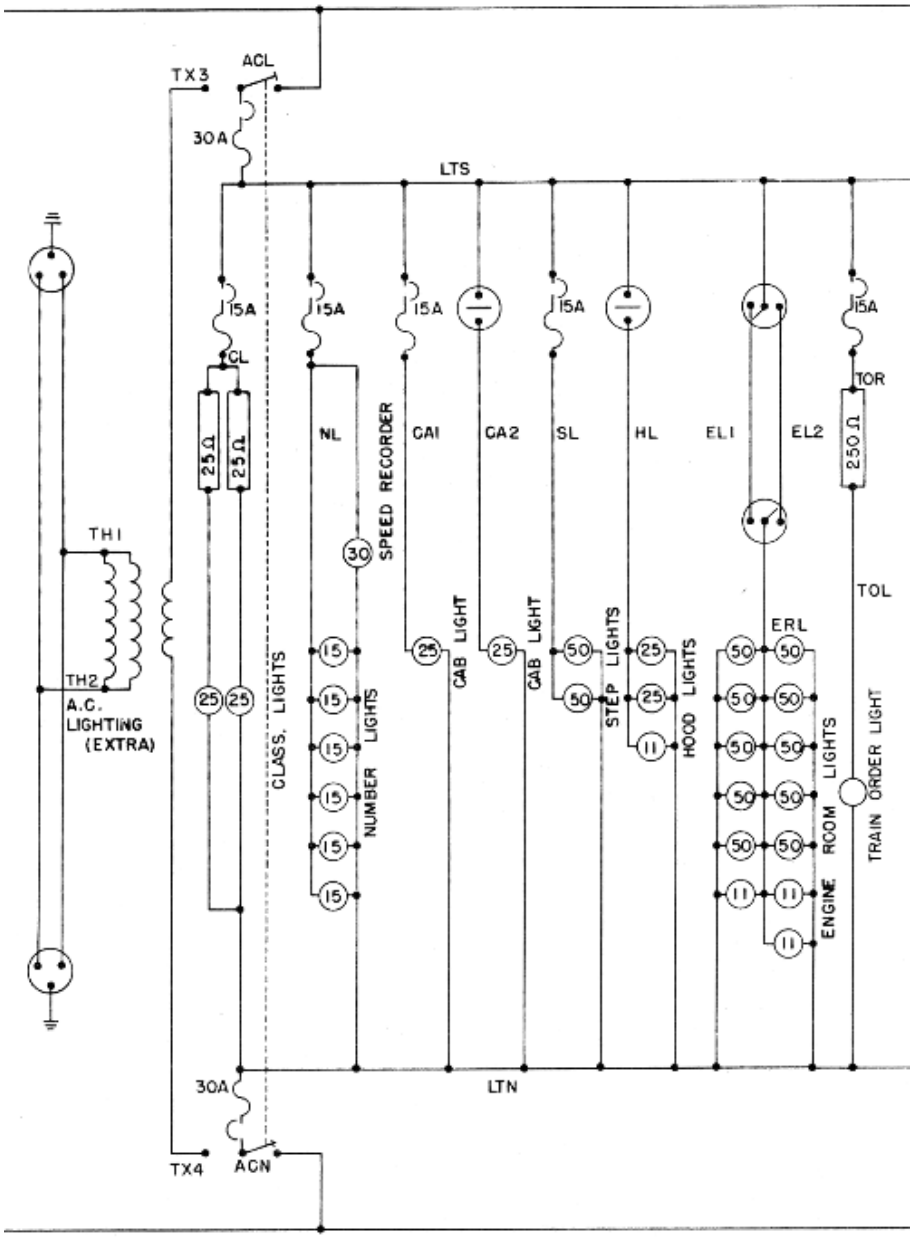
Main Generator and Exciter - Power and Control Circuits ("A" Units With Dynamic Braking



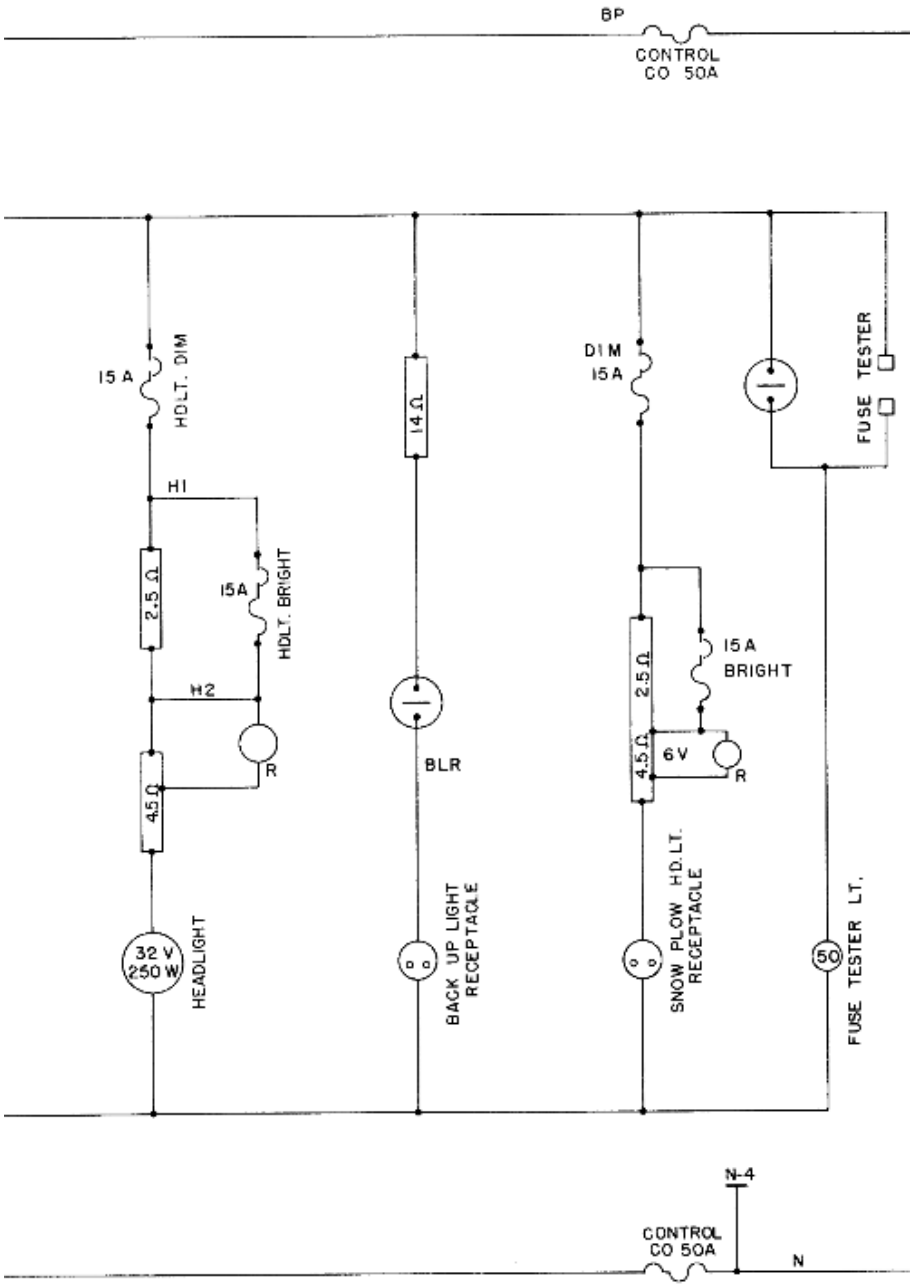
Alternator, Radiator Fans, and Traction Motor Blowers –
"A" Units with Dynamic Braking - Note: 2000 & 2400 H. P.
Units Use Additional Radiator Fan F2, Not Shown



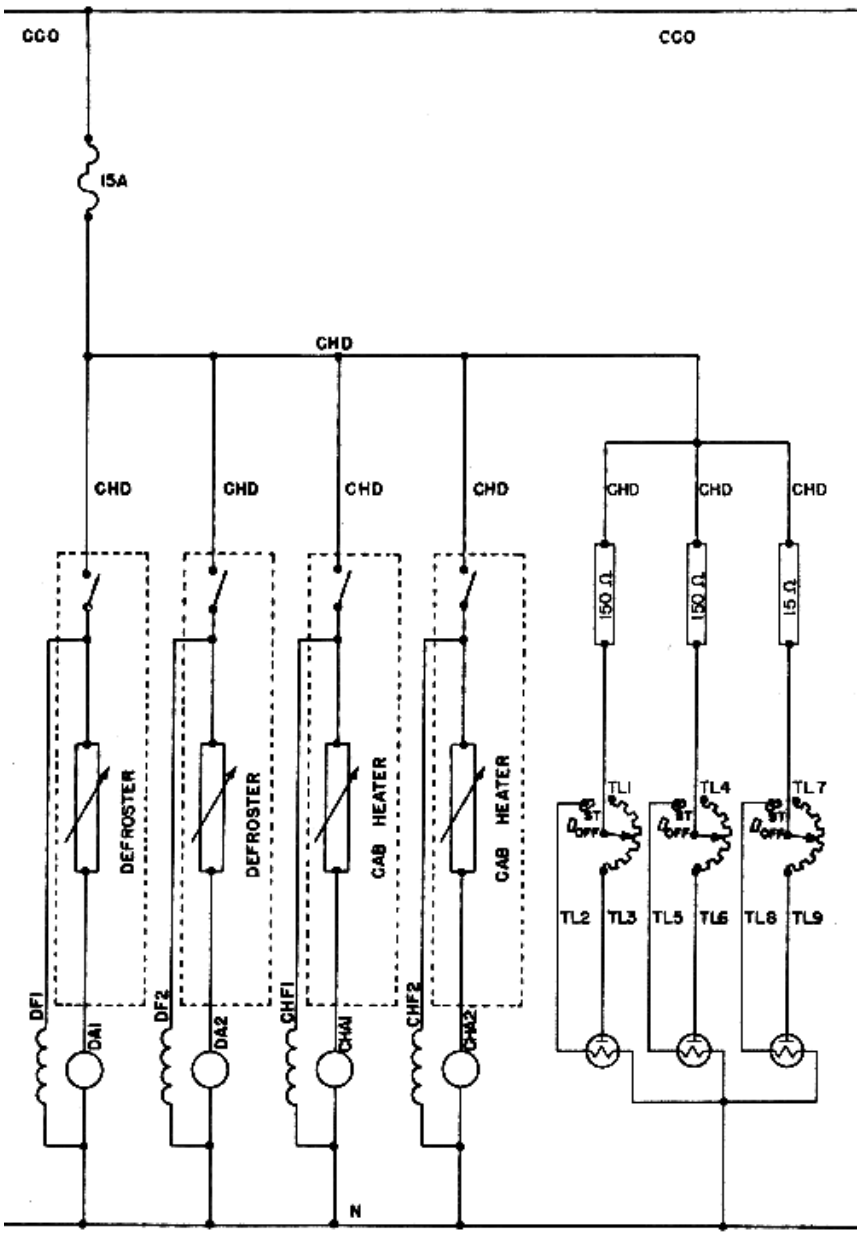
Voltage Regulator, Auxiliary Generator, Boiler Control and Battery
("A" Units - Boiler Control Not Used on Freight Units)



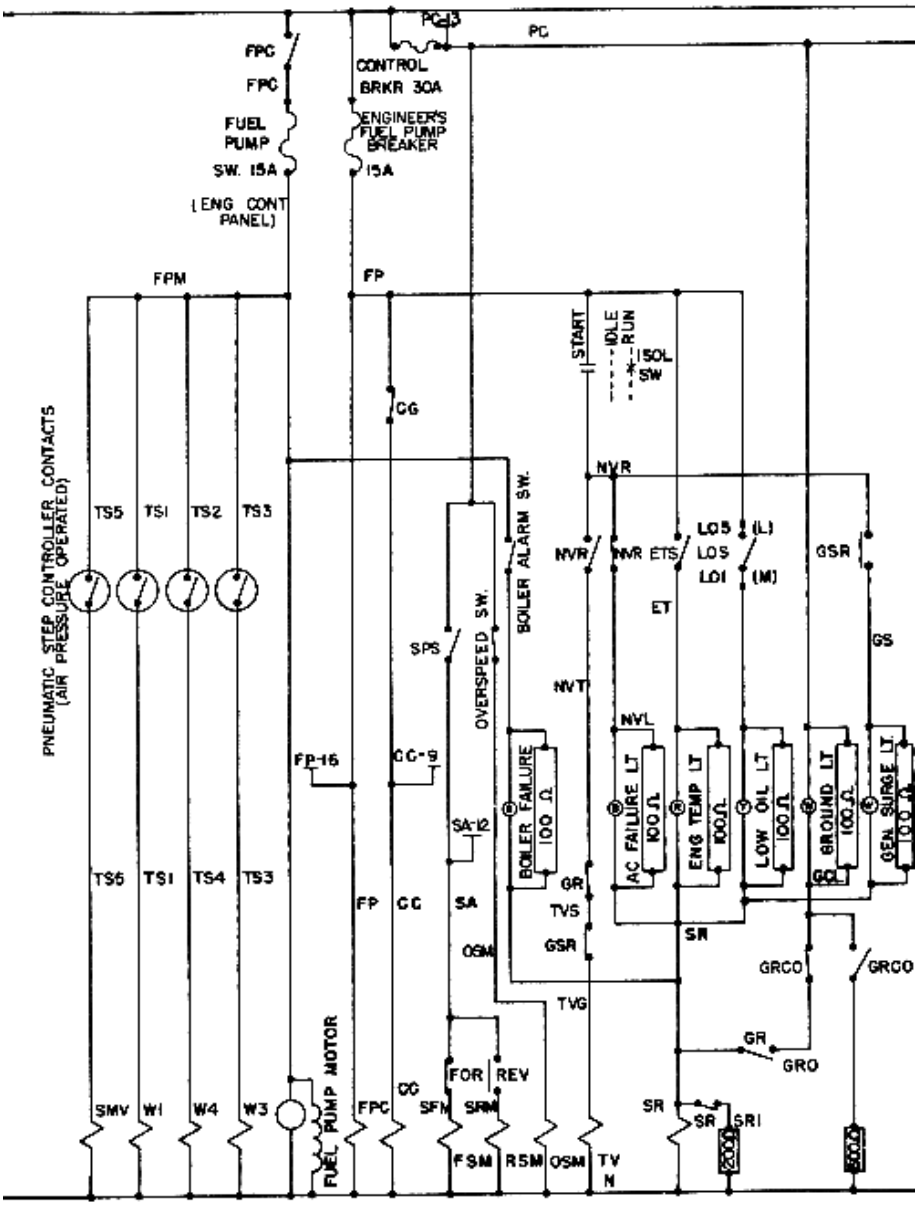
Lighting Circuits - "A" Units



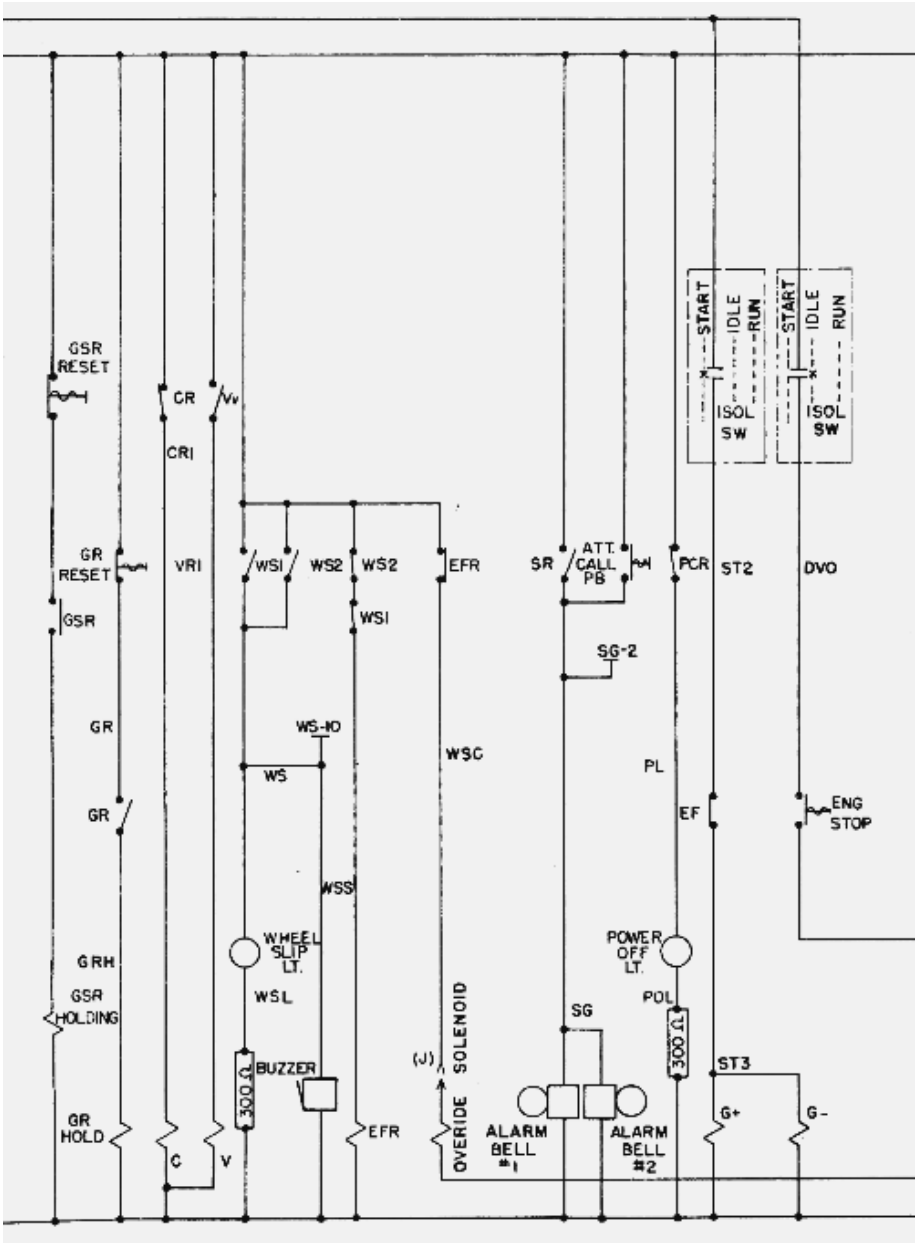
Headlight, Snow Plow Lights, Fuse Tester ("A" Units With Dynamic Braking)



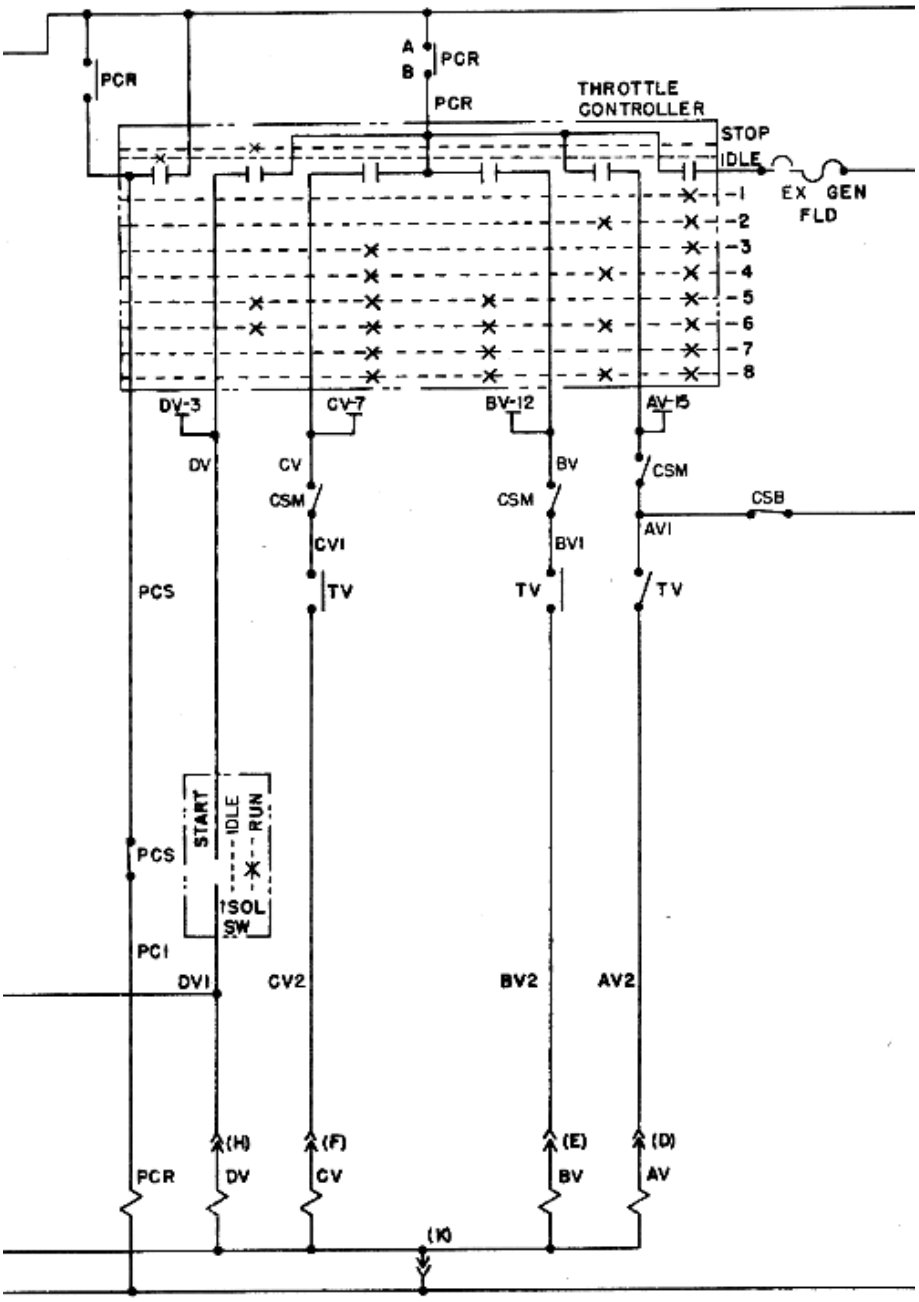
Defroster, Heater and Gauge Lighting Circuits ("A" Units)



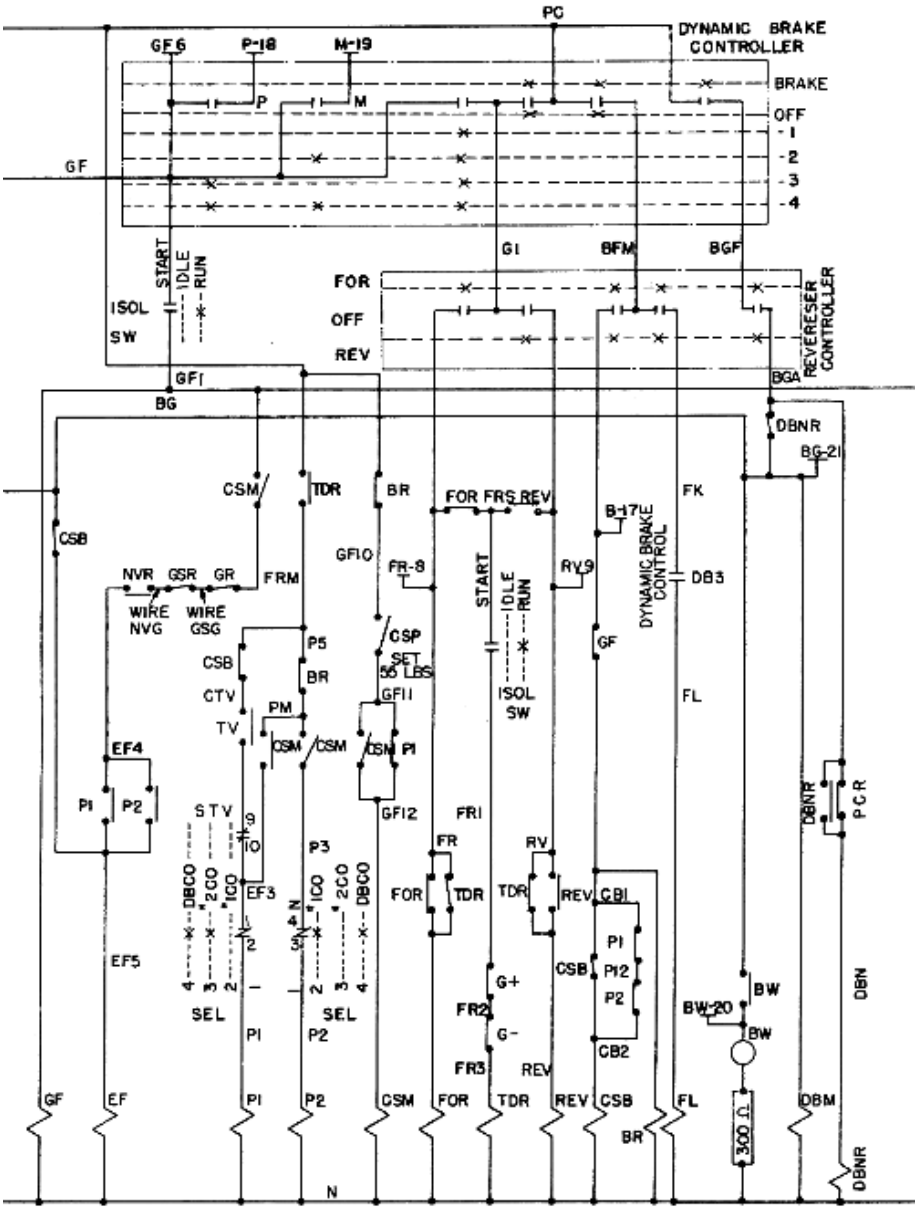
Fan Shutter Control, Fuel Pump, Compressor Synchronizing, Sanding, Overspeed, Engine - Idle and Alarm Circuits - "A" Units.
N o t e: 2000 & 2400 H. P. U n i t s Use Additional Fan Contactor W2 (Not Shown)



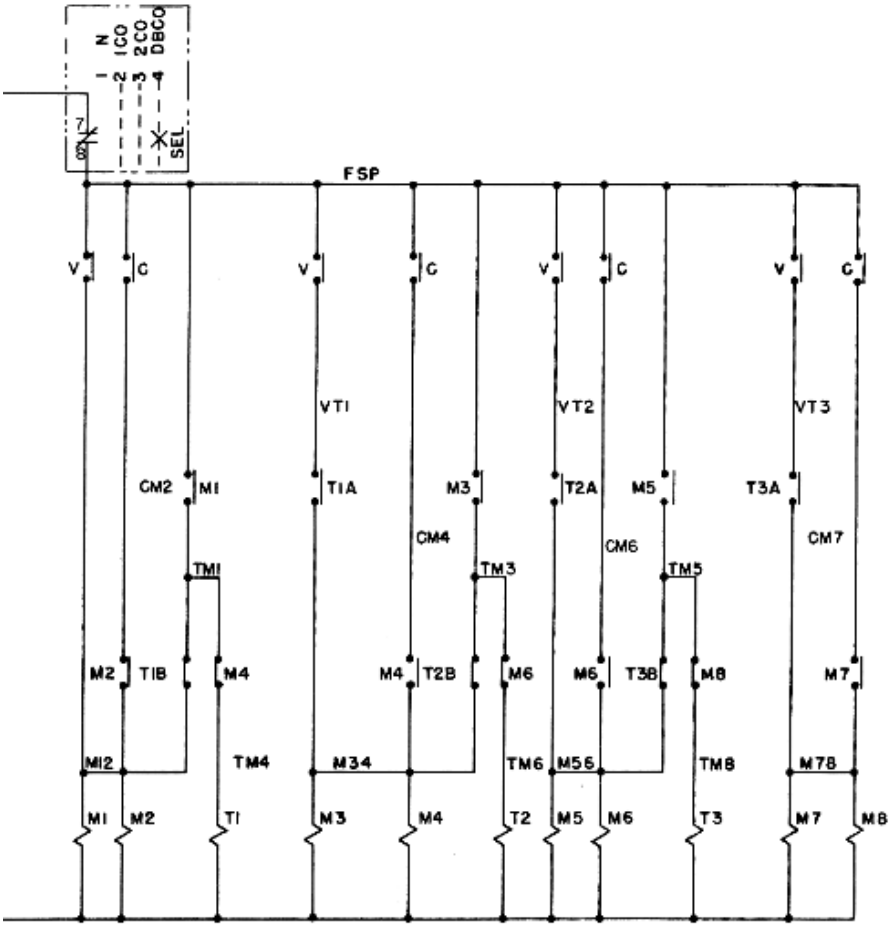
Ground Relay, PCR, Wheel Slip, Shunting Control, Alarm Bell,
and Engine Start-Stop Circuits - "A" Units



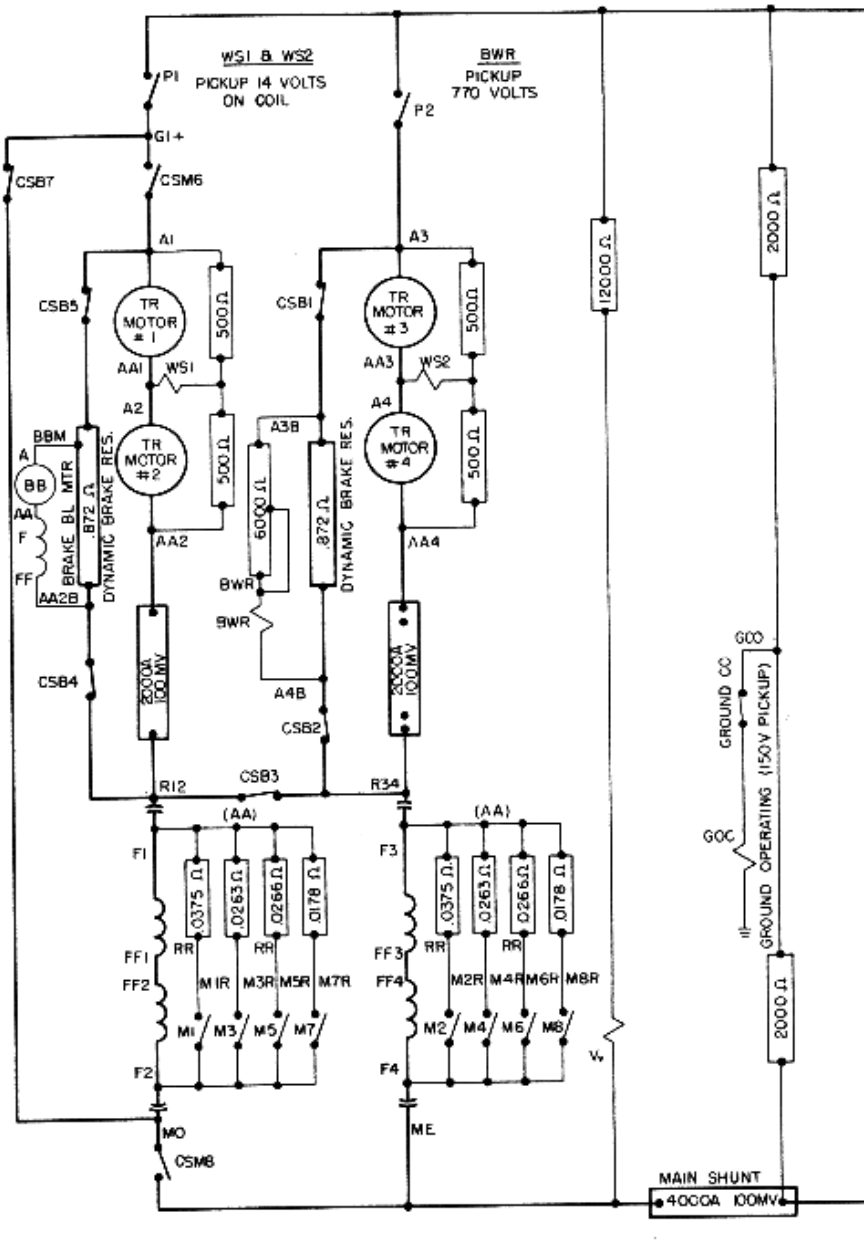
Throttle Control Circuits - "A" Units with Dynamic Braking



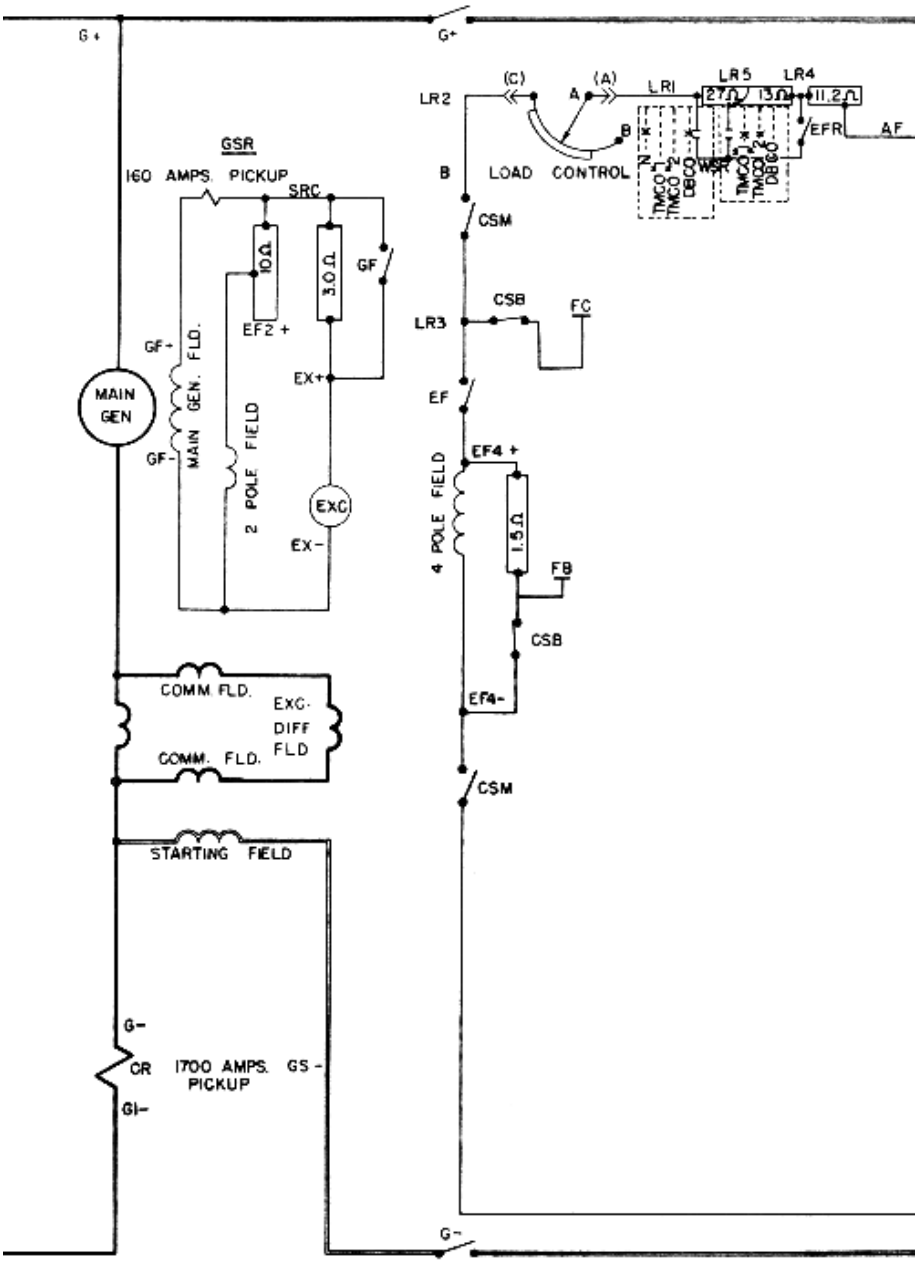
Propulsion Control Circuits - "A" Units with Dynamic Braking



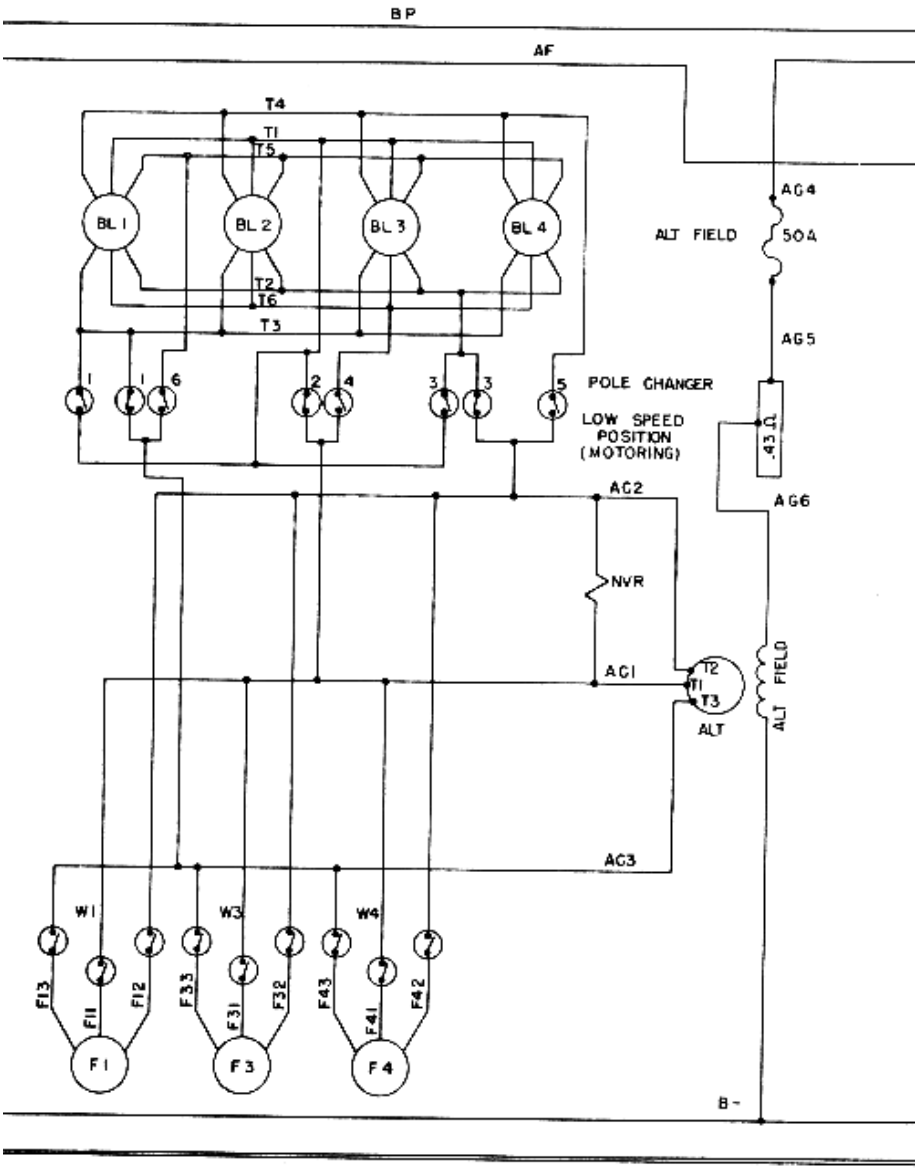
Traction Motor Field Shunting Control Circuits - "A" Units



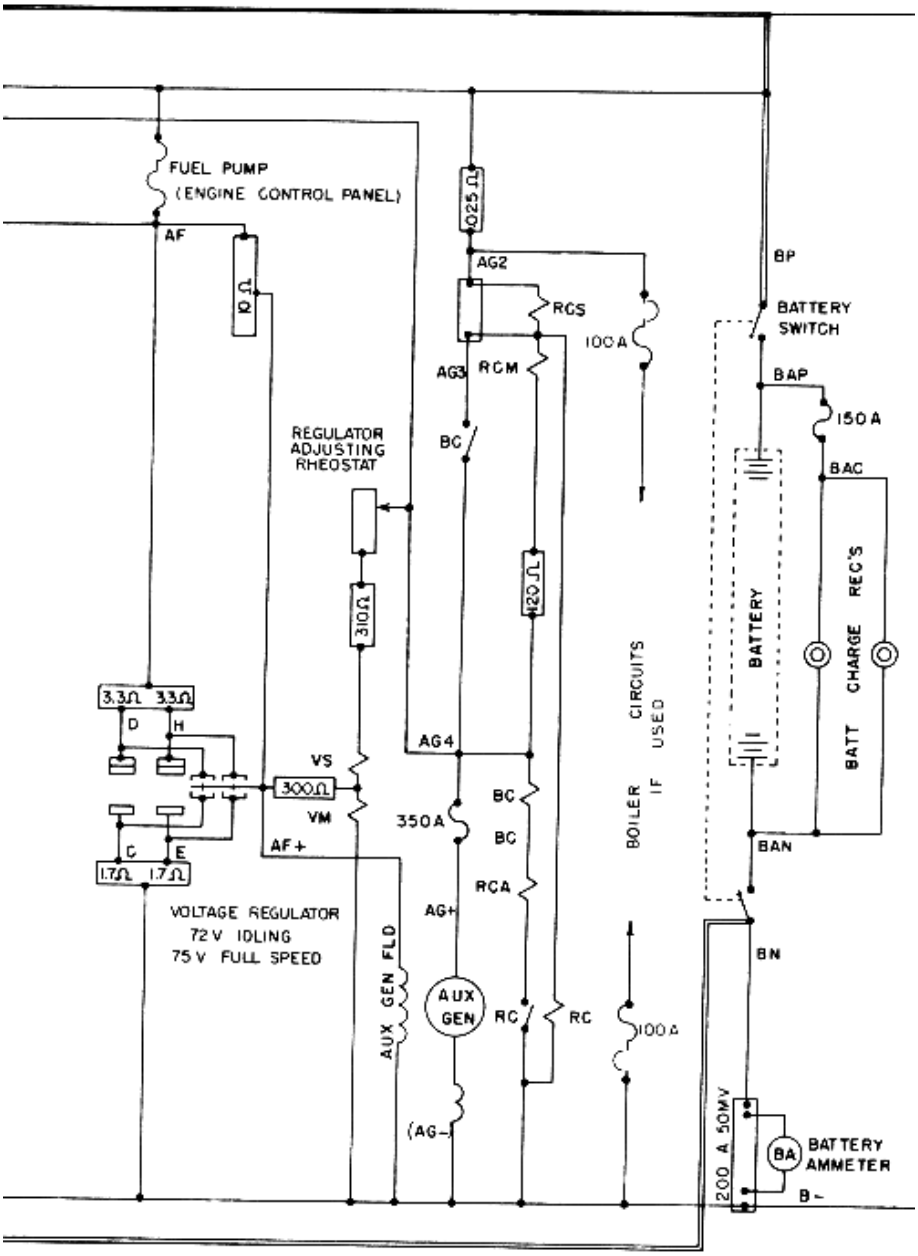
Traction Motor Power Circuits - "B "Units with Dynamic Braking



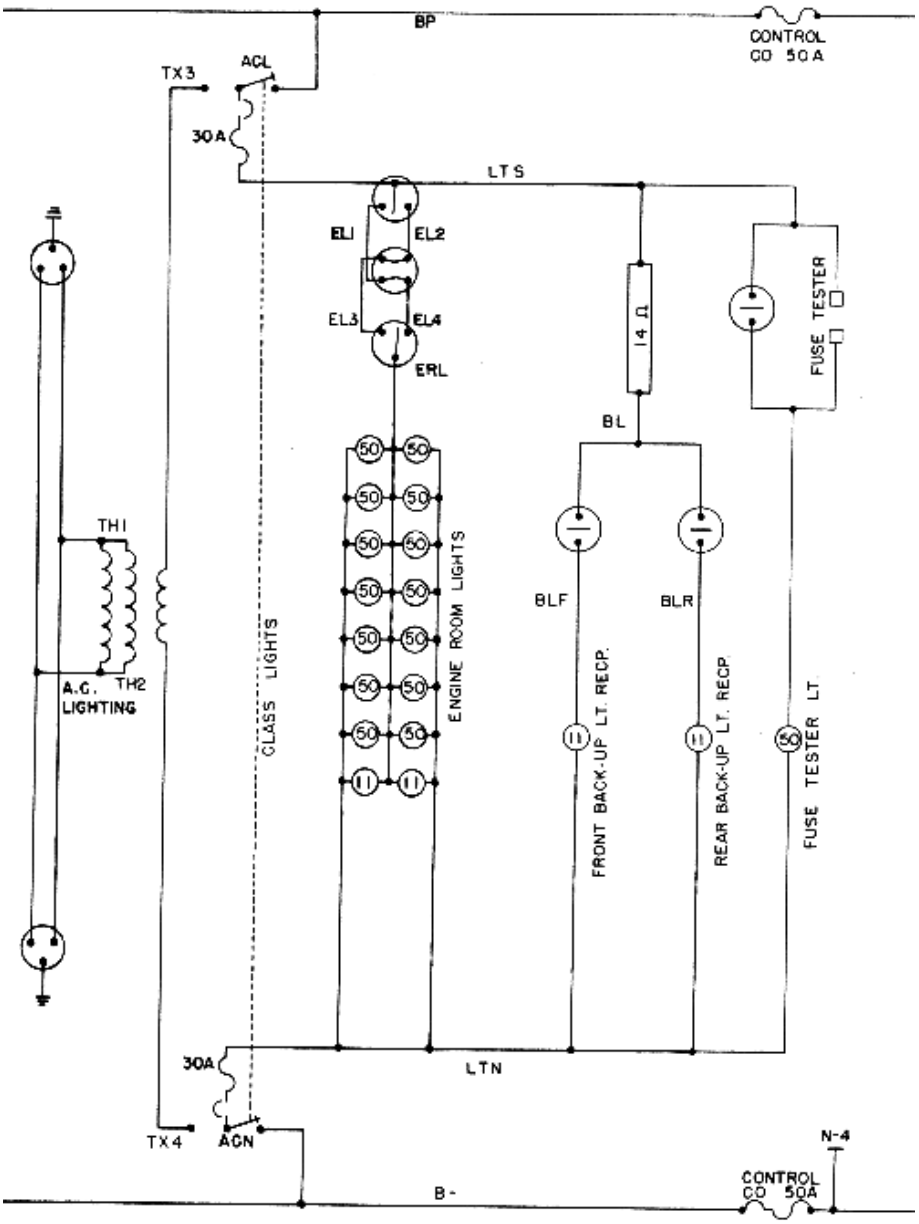
Main Generator and Exciter - Power and Control Circuits "B" Units with Dynamic Braking



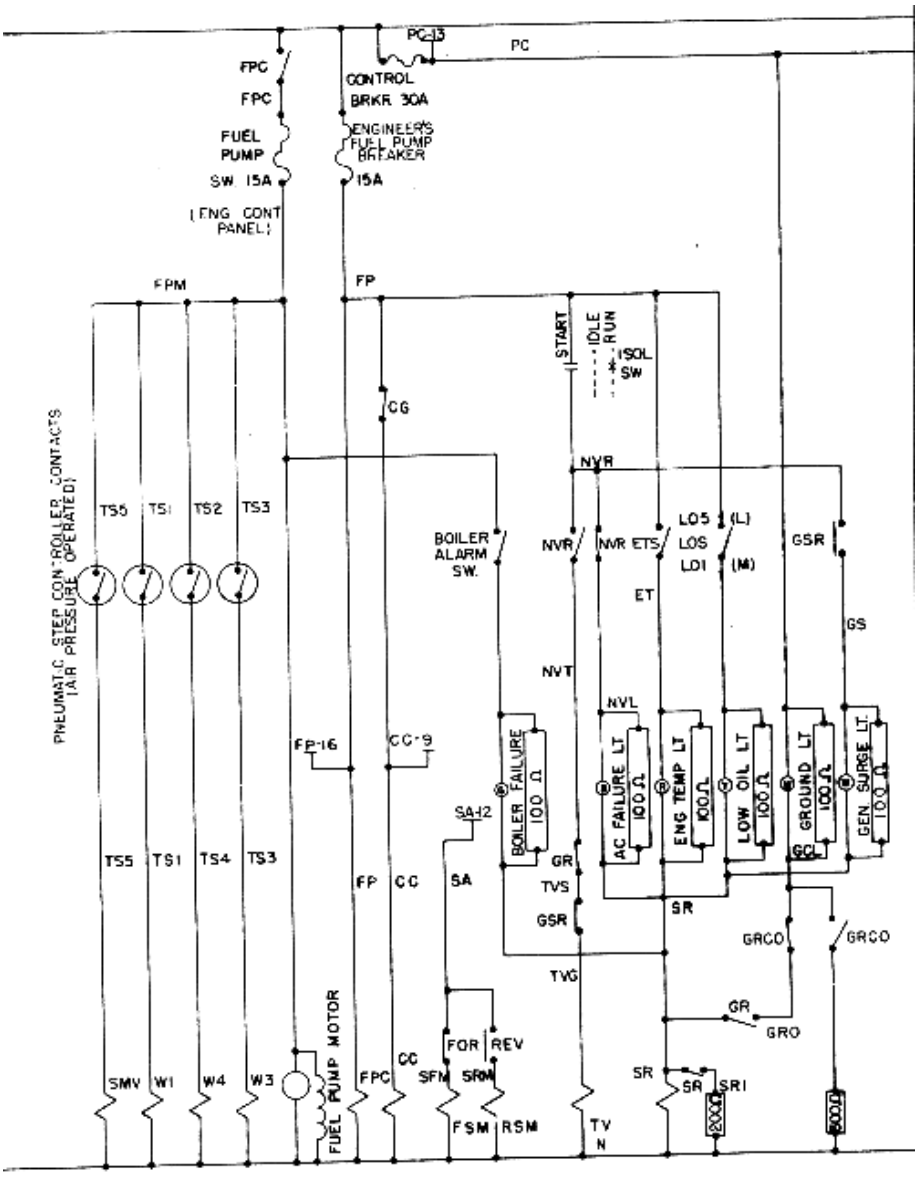
Alternator Radiator Fans and Traction Motor Blowers "B" Units with Dynamic Braking - Note: 1600 H. P. Units Use Only Three Radiator Fans



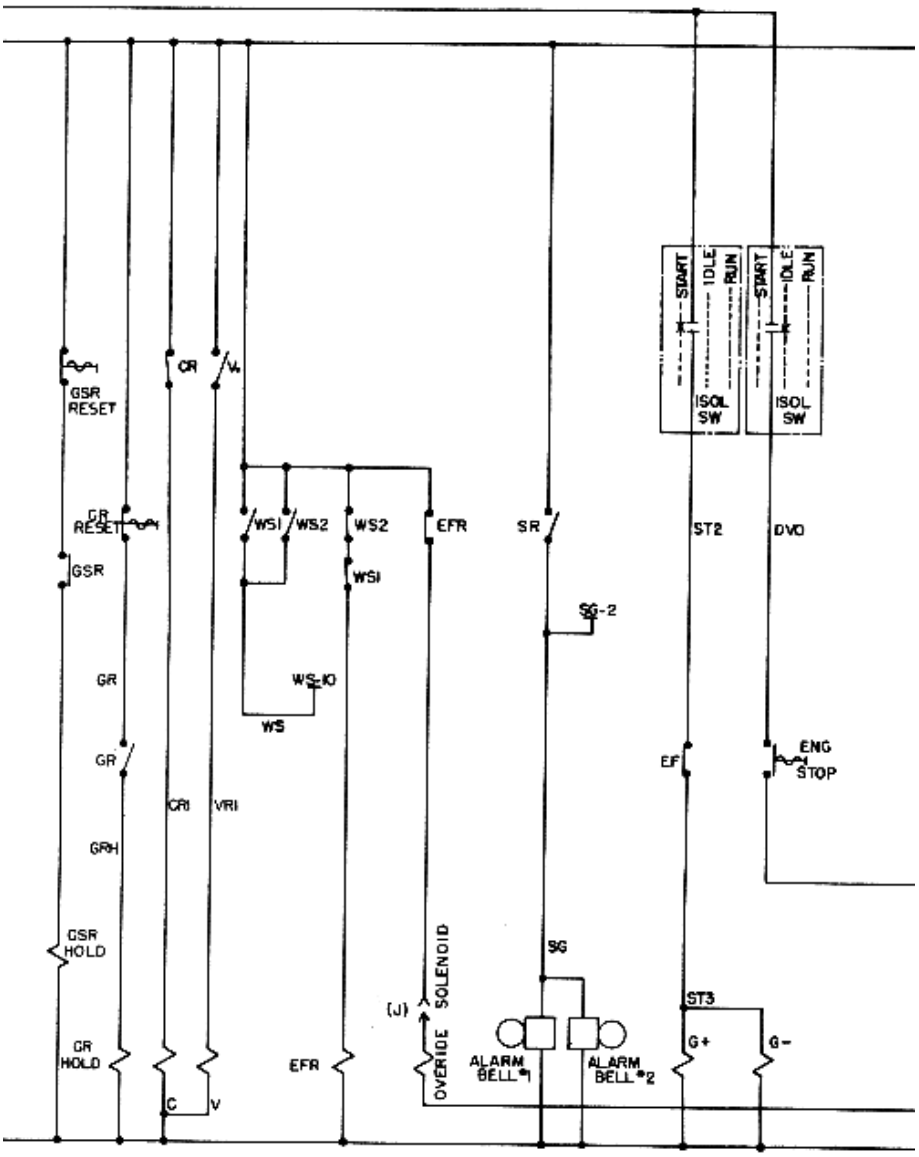
Voltage Regulator, Auxiliary Generator and Battery - "B" Units



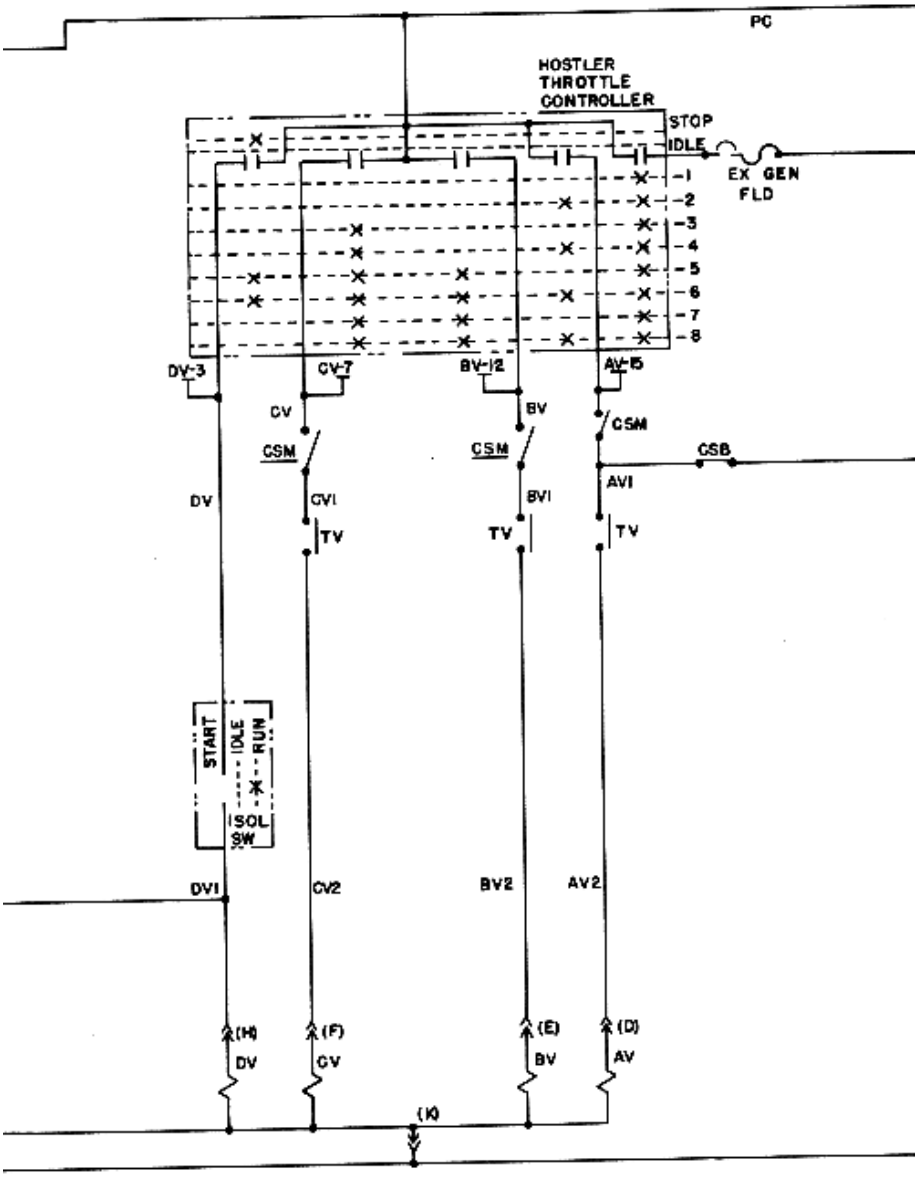
Lighting and Marker Light Circuits - "B" Units



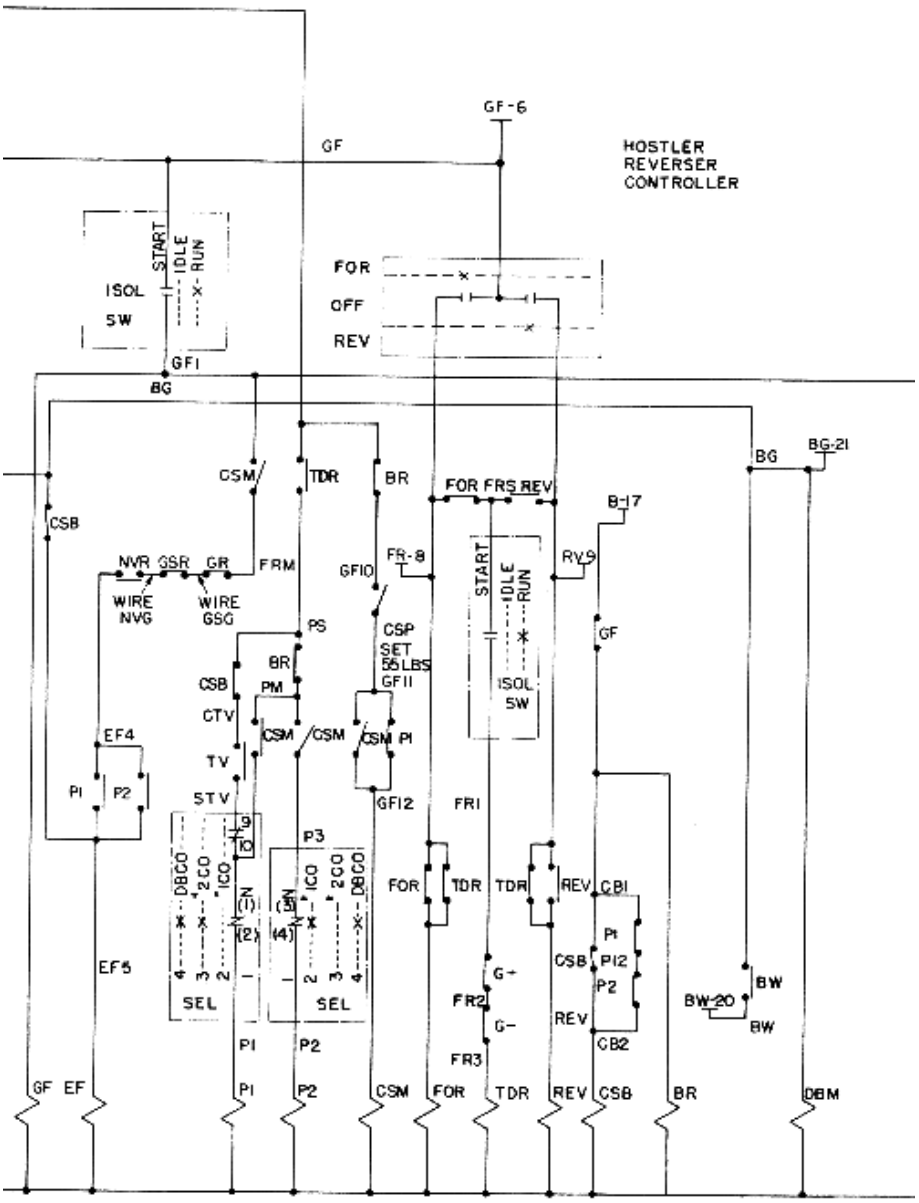
Fan Shutter Control, Fuel Pump, Compressor Synchronizing, Sanding Engine - Idle and Alarm Circuits - "B" Units



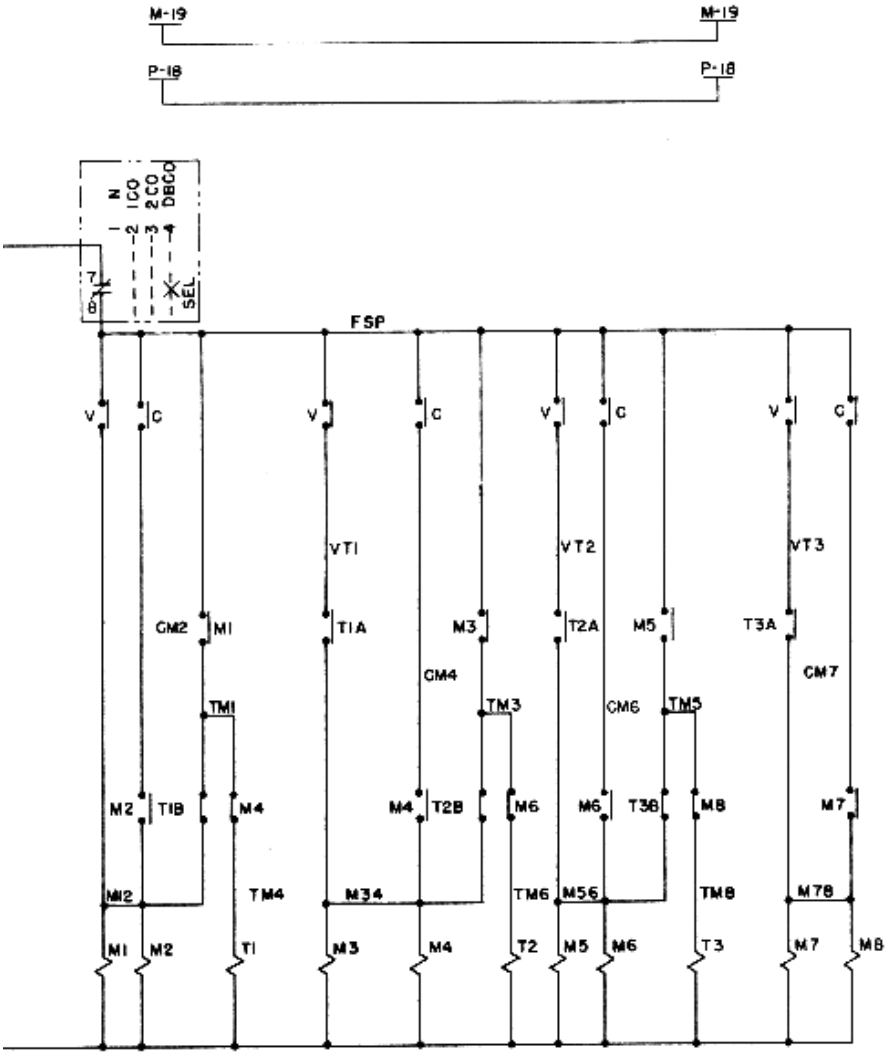
Ground Relay, Wheel Slip, Shunting Control, Alarm Bell & Engine Start & Stop Circuits - "B" Units with Dynamic Braking



Hostler Control Circuits - "B" Units with Dynamic Braking



Propulsion Control Circuits - "B" Units with Dynamic Braking



Traction Motor Field Shunting Control Circuits - "B" Units with Dynamic Braking

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

Field Shunt Relays

Settings of these relays are subject to change for certain types of service. General values are given here but for specific units of a particular railroad; reference should be made to the service bulletin covering those units.

All "C" Line units

	1600 hp	2000 hp	2400 hp
Vv Pickup Volts	900	1100	1140
Vv Dropout Volts	810	1010	1050
CR Pickup Amperes	1700 (650V)	1700 (830V)	1900 (880V)

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

Generator Surge Relay

Type URD-27B. Set at 160 amp. in main generator field.

Ground Relay

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

Wheel Slip Relays

Type URD-127A set at 14 volts across coil.

No A. C. Voltage Relay

Set at 100 volts.

TDR Relay - Power Contactors

Set at 2-1/2 seconds.

Voltage Regulator

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

Reverse Current Relay

Dropout adjusted for 25 amp. discharge.

Alternator Field Resistor

Set to give 440 volts on the alternator at full engine speed with three (3) radiator fans running.

Generator Field Contactor Parallel Resistor (Only on units with dynamic braking)

Adjusted to give 880 amps. in motor field circuit in full dynamic braking position, with unit selector switch in No. 1 position and engine speed at 380 rpm.

Brake Warning Relay (Only on units with dynamic braking)

Set at 770 volts. (Equivalent of 880 amps in motor armatures)

Exciter Battery (4-pole) Field Maximum Amperes

Fixed resistor adjusted for following maximum current with load regulator at maximum field:

1600 hp	2000 hp	2400 hp
3. 35 amps	3. 75 amps	5.08 amps

Exciter 2-Pole Field Resistor

1600 hp	2000 hp	2400 hp
9. 5 ohms	10 ohms	11 ohms

Governor and Load Regulator (See also Sec. 101A)

1. Full-load governor power piston gap is 3/8 inch. Engine fuel racks set at 16 total to correspond.

2. Idle governor power piston gap is 1516 inch.Engine fuel rack position at idle is determined by full-load setting. For details refer to governor maintenance bulletins.

3. Load regulator timing:

   7 seconds minimum to maximum
   14 seconds maximum to minimum

4. Locomotive Start: With load regulator in minimum field.

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 byclosing 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. Pilot relay C energizes when the control breaker is closed.

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

3. Pilot relay V energizes.

4. Shunt contactors M1 and M2 close.

5. An interlock on M1 closes to energize time delay relay T1. After a few secondstime delaycontact TIA closes to permit the next step of shunting tooccur;and contact TIB opens.

6. Due to decreased generator voltage after shuntcontactors M1 and M2 close, voltage relay Vv drops out, and pilot relay V de-energizes. M1 and M2 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 Vv closes a second time (provided the time delay has elapsed to allow TlA to close) to start. the sequence of the second step of shunting. This is similar to that of the first step. V again energizes, M3 and M4 close, and T2 energizes. Vv drops out and V de-energizes. C holds in M3 and M4. M4 being energized drops out T1 causing contact TlB to close. This makes a holding circuit for M1 and M2.

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.

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

11. If speed lessons further, generator voltage again drops, and C re-opens. M5 and M6 drop out, provided the time delay has elapsed since M7 and M8 dropped out. (Contact T3B provides this.) C recloses. Time delay relay T2 energizes to keep M3 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 M2 drop out, providing the time delay has elapsed since M3 and M4 dropped out. Locomotive is now operating in full field at low speed.

SECTION 238. WRECKER LIFTING DATA 'C' LINE UNITS

LIFTING PRECAUTIONS

Maximum Permissible Span

Diesel-electric locomotive frames are designed to be supported at the bolsters. Frames can be damaged when too long a span is allowed between points of sling support. This applies whether the lift is made from couplers or from front or rear jacking pads, or rear collision post special lifting lugs.

All "C" Line locomotives can be lifted at the extreme end PROVIDED the other end is supported AT THE BOLSTER.

Lifting with Trucks Attached

Where it is necessary to lift units at the extreme ends, trucks should be dropped. This lowers the weight lifted 43 to 50 tons depending upon the type unit involved.

However, frames used on "C" Line locomotives are amply strong to permit lifting operations with the trucks attached as long as one end is supported at the bolster. If trucks are to be lifted with the car-body, springs should be blocked; and blocking placed between journal boxes and pedestal tie bars. This will reduce the required lift to a minimum.

Lifting at Couplers

As an emergency lift in case of a wreck, a unit may be lifted by the coupler shank provided proper blocking is used between the top and sides of coupler shank and coupler pocket. Although this operation has been done without damage, it should only be used in extreme emergencies. A new coupler should be available as breaking or bending of the coupler is likely to occur.

Truck Center Plate Protection

Where one end only of a unit is lifted, care must be taken to avoid breaking the center plates between truck and bolster at the other end. Although one end can drop considerably BELOW rail height without damage to the liners on the truck remaining on the rail, the same does not apply when the derailed end if lifted excessively high.

Some clearance is provided to absorb normal deflections, but in rerailing this i s mostly absorbed by deflection of the truck springs. Lift of one end only should never exceed 8" above the rail unless the other end is lifted sufficiently to separate the center plates on its truck and bolster. This precaution must be taken both under wreck conditions and in maintenance removal o f a truck.

Use of Special Lifting Lugs on Square End Collision Posts

Special lifting lugs can be applied as an extra at the top of square-end collision posts on "C" Line units. (Nose ends have lifting pads accessible through removable covers on each side of the pilot. All pads are designed for use with the standard railroad wrecker hooks without the use of special lifting levers.

These special collision post lifting lugs are designed for VERTICAL lifting only. Any attempt to slide the locomotive by attaching to these lugs will most likely result inconsiderable additional damage.

LIFTING DATA

Lifting Pads

At bolsters, square end corners, and at nose end. Pilot side openings with bolted covers for wrecker hook access to nose end pads. All pads designed for use with standard R-1044 railroad wrecker hook without use of lifting levers.

Bolster lifting pads designed to be lifted using 8055964 lifting device in common use in railroad diesel shops.

Standard Lifts

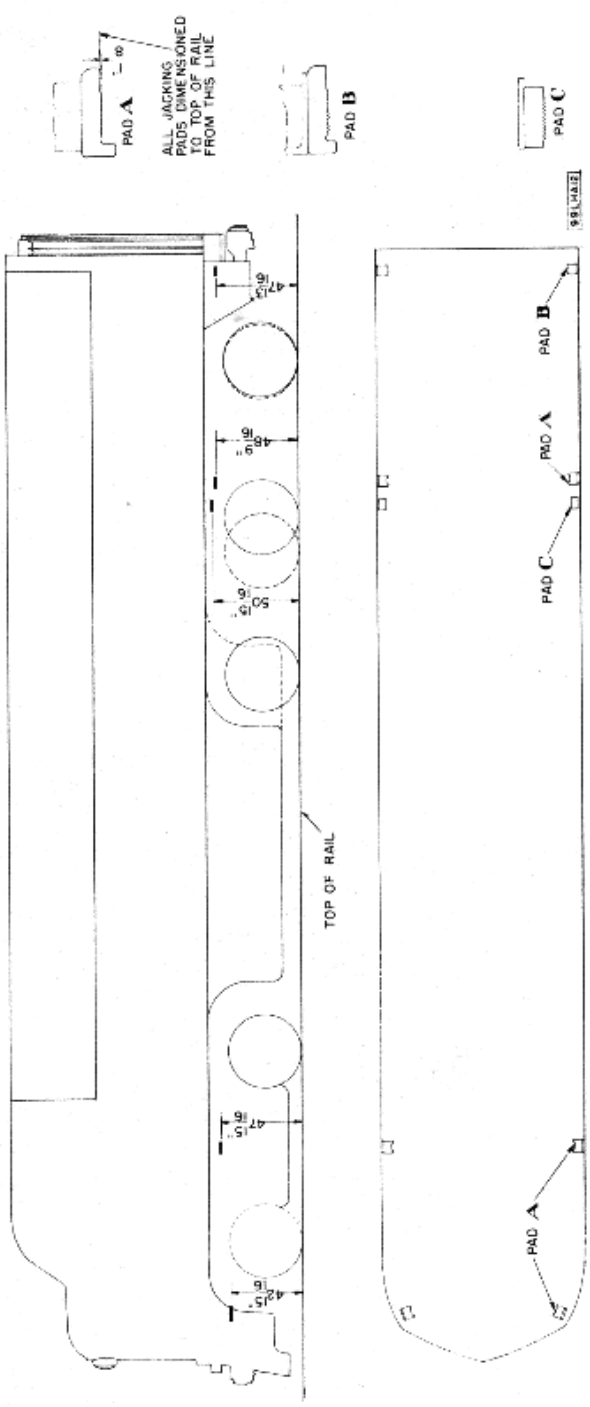
1. At bolsters.

2. At end lifting pads if opposite bolster is supported.

3. Vertical lift only on square end collision post lugs.

Emergency Lift

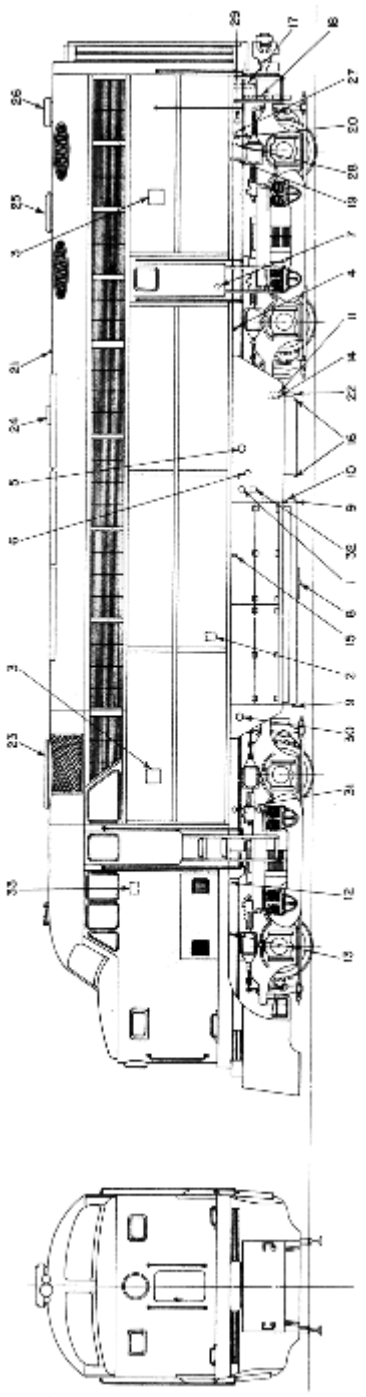
By coupler shank if opposite bolster is supported.

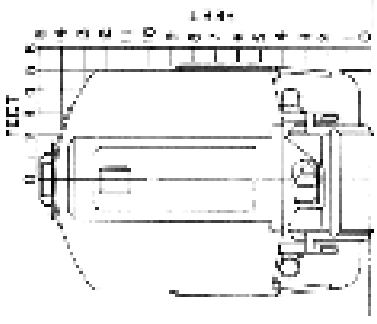


Illus. 1. Jacking Diagram

Approximate Maximum Weights with Full Supplies
(Vary according to extras aboard.)

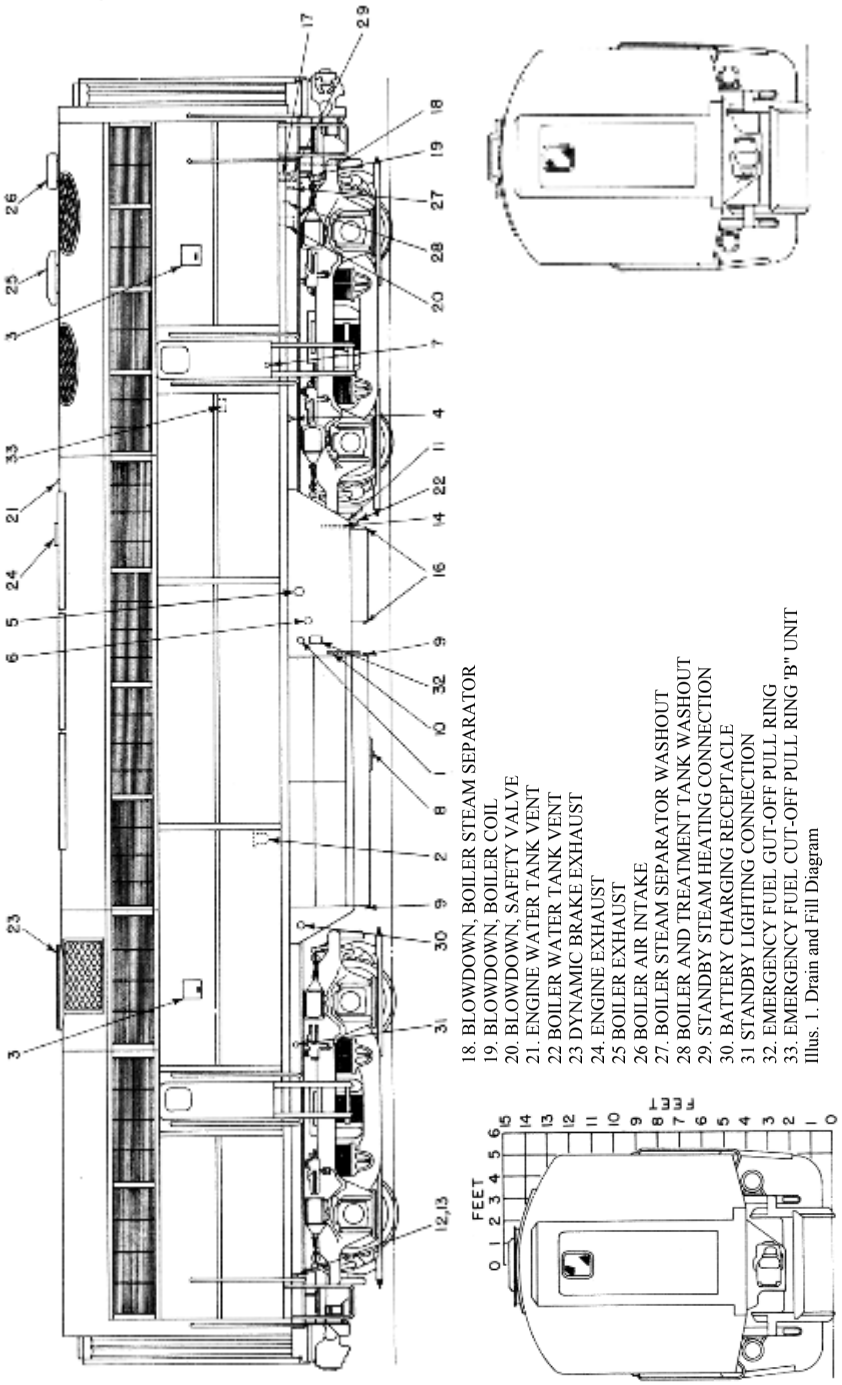
Model Total, Lbs.	CF-16-4 250, 000	CF 20-4 257, 000	CP 20-5 293, 000	CP 24-5 307, 000
Front Truck, Lbs.	43, 000	43,000	43,000	43,000
Rear Truck, Lbs.	43,000	43,000	57,000	57, 000
No. 1 Center Plate Load, Lbs.	82,000	85,500	76,000	85,000
No. 2 Center Plate Load, Lbs.	82, 000	85,500	117,000	118,000
Dyn. Brake Included (As example)	Yes	Yes	No	Yes
Gal. Boiler Water (As example)	None	None	1800	1800





1. FUEL OIL FILL
2. ENGINE LUBE OIL FILL
3. SAND BOX FILL
4. ENGINE WATER TANK FILL AND OVERFLOW
5. BOILER WATER FILL
6. ENGINE LUBE OIL DRAIN
7. LUBE OIL FILTER DRAIN
8. FUEL OIL TANK SUMP DRAIN
9. FUEL OIL TANK DRAINS AND CLEAN OUTS
10. WASTE FUEL DRAIN
11. LOCOMOTIVE FRAME SUMP DRAIN
12. 1st MAIN RESERVOIR DRAIN
13. 2nd MAIN RESERVOIR DRAIN
14. EXHAUST SNUBBER DRAIN
15. CAB HEATER WATER DRAIN
16. BOILER WATER TANK DRAIN
17. BOILER DRAIN

"A" UNIT



18. BLOWDOWN, BOILER STEAM SEPARATOR
19. BLOWDOWN, BOILER COIL
20. BLOWDOWN, SAFETY VALVE
21. ENGINE WATER TANK VENT
22 BOILER WATER TANK VENT
23 DYNAMIC BRAKE EXHAUST
24. ENGINE EXHAUST
25 BOILER EXHAUST
26 BOILER AIR INTAKE
27. BOILER STEAM SEPARATOR WASHOUT
28 BOILER AND TREATMENT TANK WASHOUT
29. STANDBY STEAM HEATING CONNECTION
30. BATTERY CHARGING RECEPTACLE
31 STANDBY LIGHTING CONNECTION
32. EMERGENCY FUEL GUT-OFF PULL RING
33. EMERGENCY FUEL CUT-OFF PULL RING 'B" UNIT
Illus. 1. Drain and Fill Diagram