TRAINING MANUAL

FOR

GENERAL MOTORS DIESEL LOCOMOTIVES

January, 1952

ELECTRO-MOTIVE DIVISION
General Motors Corporation
LA GRANGE, ILLINOIS, U. S. A.

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FOREWORD

This publication has been designed as a guide for study and to give general information on the E.M.D. Diesel-electric locomotives.

This booklet contains five sections:

First - General data and specifications of current production models.

Second - Basic data of the 567 series engine and various drawings and information pertaining to the engine and its component parts.

Third - Simplified drawings showing the functions and nomenclature of the engine governor.

Fourth - A brief description of the various electrical systems on an E.M.D. Diesel-electric locomotive and diagrams to aid in your understanding of these systems.

Fifth - A general summation of operation and checks to be made and charts showing the location of equipment to be checked.

During your attendance at this E.M.D. training course, we sincerely hope that the abridged information found in this publication will aid in the understanding of the E.M.D. Diesel-electric locomotive.

We suggest that this booklet be used for your notations and that you keep it for future reference.

OUTLINE OF STUDY

A. Introduction to the Locomotive

1. Why Diesel locomotives
2. Why we use a Diesel engine
3. Major components of the locomotive
4. Major components of the engine
   a. Major systems of the engine

B. Construction of the Engine

1. The crankcase, air box, and blowers
2. The crankshaft
3. The oil pan
4. The power assemblies
   a. Camshafts
   b. Connecting rods
   c. Piston
   d. Cylinder liner
   e. Cylinder head

C. The Engine and its Systems

1. The fuel systems
   a. Tanks
   b. Filters
   c. Pumps
   d. Injectors
2. The cooling system
   a. Water and water treatment
3. The lube oil system
   a. Pumps
   b. Filters
   c. Cooler
   d. Vents
   e. Drains
   f. Oil specifications

D. Steam Generator

1. Operation
2. Maintenance
3. Trouble Shooting

E. Basic Electricity

1. Definition and terms
2. Magnets and electricity
3. Ohm's Law

F. High Voltage System

1. Rotating equipment
   a. The main generator and its fields
   b. The traction motor and its fields
2. High voltage contactors
   a. Power contactors
   b. Reverser
3. High voltage protective devices
   a. Ground relay
   b. Wheel slip relay
   c. Transition indicator
   d. Discharge resistors
4. High voltage circuits
   a. Series circuits
   b. Parallel circuits

G. Low Voltage System

1. Low voltage supply and uses
2. Starting circuits
3. Battery charging
4. Main generator excitation

H. Dynamic Braking

1. Why use dynamic braking
2. Dynamic brake circuits
3. Operation and control of dynamic brakes

I. Control Circuits

1. Control equipment
2. Control circuits
3. Wiring diagrams

J. Governor Speed and Load Control

1. Engine speeds
2. Load control
3. Load regulator
4. Oil shutdown
5. Governor settings and adjustments

K. Locomotive Operation and Trouble Shooting

1. Locomotive operation
   a. Cab controls and instrument
   b. Engine room controls and instruments
   c. Alarms and safety features
2. Trouble shooting
   a. Engine
   b. Electrical
   c. Locomotive

SW8 SWITCHING LOCOMOTIVE

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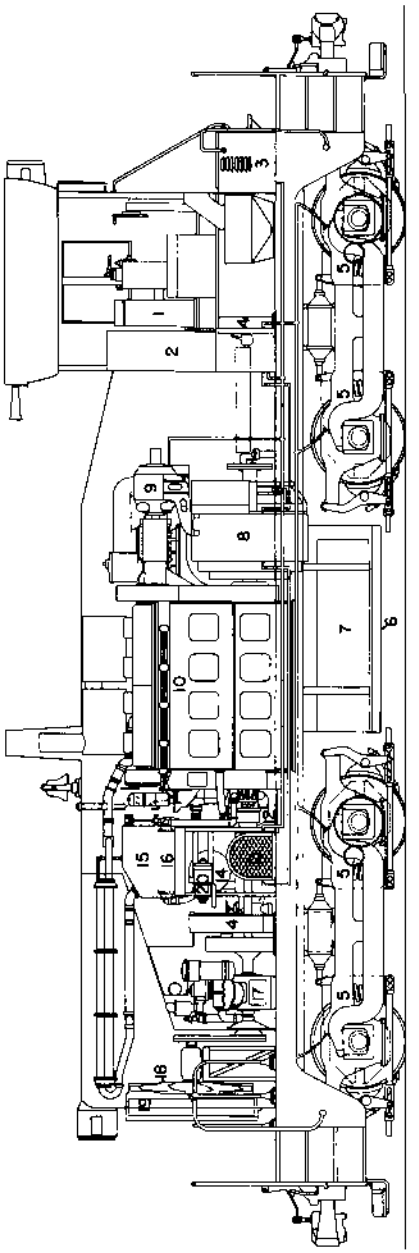

1 ENGINEER'S CONTROLS
2 ELECTRICAL CABINET
3 BATTERY BOX
4 TRACTION MOTOR BLOWERS
5 TRACTION MOTORS
6 FUEL TANK
7 AIR RESERVOIR
8 MAIN GENERATOR
9 AUX GENERATOR
10 DIESEL ENGINE
11 PG GOVERNOR
12 LUBE OIL STRAINERS
13 LOAD REGULATOR
14 LUBE OIL FILTER
15 COOLING WATER TANK
16 LUBE OIL COOLER
17 AIR COMPRESSOR
18 COOLING FAN
19 SHUTTERS
20 FUEL PUMP

General Arrangement — SW Locomotive

GENERAL DATA

Model	SW8	SW9	TR5	TR6
Type	0440	0440	0440-0440	0440-0440
Horsepower	800	1200	2400	1600
Equipment				
8-567B engine	1			2
12-567B engine		1	2	
Model D15C main generator	1	1	2	2
Model D27 traction motors	4	4	8	8
Weight - fully loaded (approx.)	230,000 lbs.	248,000 lbs.	496,000 lbs.	460,000 lbs.
Weight on drivers	100%	100%	100%	100%
Couplers	Type "E"	Type "E"	Type "E"	Type "E"
Supplies				
Fuel oil	600 U.S. gals. 500 Imp. gals.	600 U.S. gals. 500 Imp. gals.	1200 U.S. gals. 1000 Imp. gals.	1200 U.S. gals. 1000 Imp. gals.
Lube oil	130 U.S. gals. 108 Imp. gals.	165 U.S. gals. 137 Imp. gals.	330 U.S. gals. 275 Imp. gals.	260 U.S. gals. 216 Imp. gals.
Cooling water capacity ("G" valve level)	190 U.S. gals. 158 Imp. gals.	223 U.S. gals. 186 Imp. gals.	446 U.S. gals. 372 Imp. gals.	380 U.S. gals. 316 Imp. gals.
Sand	28 cu. ft.	28 cu. ft.	56 cu. ft.	56 cu. ft.
General Dimensions				
Truck gauge	4' 8-1/2"	4' 8-1/2"	4' 8-1/2"	4' 8-1/2"
Length over coupler pulling faces	44' 5"	44' 5"	86' 5"	86' 5"
Width over hand holds	10' 2"	10' 2"	10' 2"	10' 2"
Maximum height above rail	14' 6-1/4"	14' 6-1/4"	14' 6-1/4"	14' 6-1/4"
Truck centers	22' 0"	22' 0"	22' 0"	22' 0"
Truck wheelbase	8' 0"	8' 0"	8' 0"	8' 0"
Wheel diameter	40"	40"	40"	40"
Minimum curve radius	100' 0"	100' 0"	100' 0"	100' 0"
Gear Ratio	62/15-65/12	62/15-65/12	62/15-65/12	62/15-65/12
Maximum Permissible Speed	65-55 MPH	65-55 MPH	65-55 MPH	65-55 MPH
Starting T.E. at 20% Adhesion	46,000 lbs.	49,600 lbs.	99,200 lbs.	92,000 lbs.
Starting T.E. at 25% Adhesion	57,500 lbs.	62,000 lbs.	124,000 lbs.	115,000 lbs.
Starting T.E. at 30% Adhesion	69,000 lbs.	74,500 lbs.	149,000 lbs.	138,000 lbs.

GENERAL DATA
GP7 LOCOMOTIVE

	U.S. Gals.	Imp. Gals.
Fuel Oil Capacity	800	666
Lube Oil Capacity	200	167
Cooling Water Capacity ("G" Valve Level)	230	192
Steam Generator Water Capacity	800	666

Gear Ratios and Maximum Speeds:

65/12	55 MPH
62/15	65 MPH
61/16	71 MPH
60/17	77 MPH
59/18	83 MPH
58/19	89 MPH

Weight - Fully Loaded (Approx.)	240,000 lbs.
Couplers	Type "E"
Sand Capacity	18 cu. ft.
Number Of Drivers	4 pair
Wheel Diameter	40"
Weight On Drivers	100%
Truck Centers	31' 0"
Truck Rigid Wheelbase	9' 0"
Minimum Curve Radius Coupled To Car	150' (39°)
Coupled To Another Locomotive Of Same Type With Type "E" Coupling	274' (21°)
Length Between Coupler Pulling Faces	55' 9"
Maximum Height Above Rail	14' 6"
Width Over Handrails	10' 3"

GP7 DIESEL ROAD SWITCHING LOCOMOTIVE

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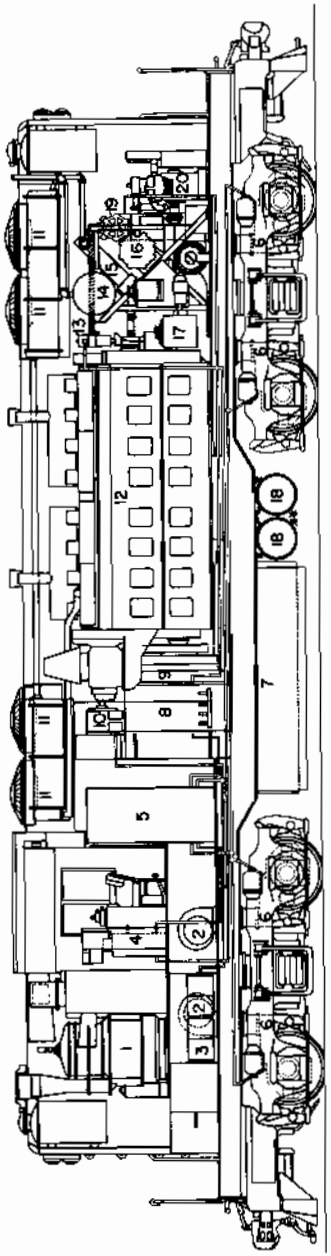


1 STEAM GENERATOR
2 TRACTION MOTOR BLOWERS
3 BATTERIES
4 ENGINEER'S CONTROLS
5 ELECTRICAL CABINET
6 TRACTION MOTORS
7 FUEL AND WATER TANKS
8 D.C. GENERATOR
9 A.C. GENERATOR
10 AUX. GENERATOR
11 COOLING FANS
12 DIESEL ENGINE
13 PG GOVERNOR
14 ENGINE WATER TANK
15 LUBE OIL COOLER
16 LUBE OIL FILTER
17 LUBE OIL STRAINERS
18 MAIN AIR RESERVOIR
19 LOAD REGULATOR
20 AIR COMPRESSOR

General Arrangement — GP7 Locomotive

GENERAL DATA

F7 AND FP7 DIESEL LOCOMOTIVES

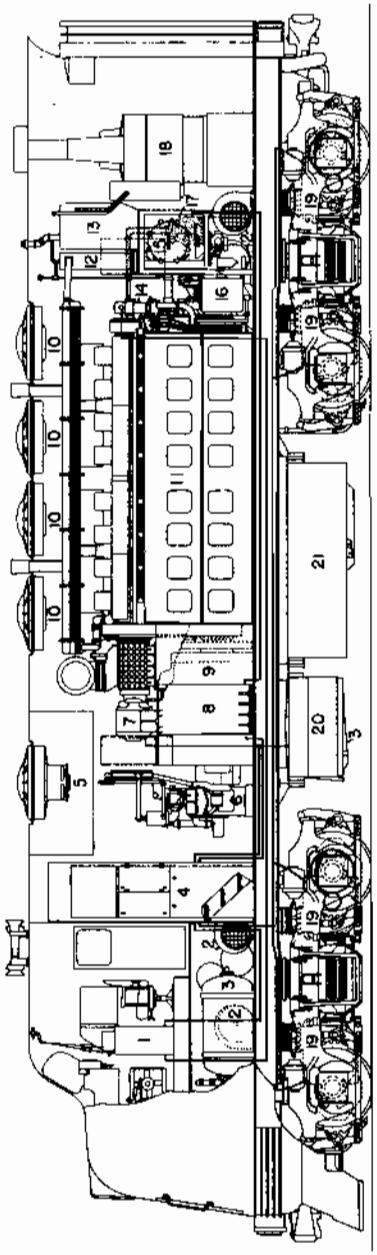
Weight (fully loaded)	F7A Unit (approx.)	230,000 lbs.
	FP7A Unit (approx.)	258,000 lbs.
	F7B Unit (approx.)	230,000 lbs.
Fuel Capacity (per unit)		1,200 gal.
Lubricating Oil Capacity (per engine)		200 gal.
Cooling Water Capacity "A" Unit - "G" Valve		230 gal.
	"B" Unit - "G" Valve	215 gal.
Steam Generator Water Capacity (if used):		
Vertical Tank -	FP7A Unit	820 gal.
	F7B Unit	1,200 gal.
Hatch Tank -	FP7A Unit	330 gal.
(Without dynamic brakes, all units may have an additional 600 gal. hatch tank.)		
Tank Under 2750 lb. Steam Generator		200 gal.

Gear Ratios and Maximum Speeds:

65/12	55 MPH	59/18	83 MPH
62/15	65 MPH	58/19	89 MPH
61/16	71 MPH	57/20	95 MPH
60/17	77 MPH	56/21	102 MPH

Sand Capacity (per unit)	16 cubic feet
Number of Drivers (per unit)	4 pair
Wheel Diameter	40"
Weight on Drivers	100%
Truck Centers (F7)	30' 0"
Truck Centers (FP7)	34' 0"
Truck - Rigid Wheel Base	9' 0"
Minimum Curve Radius	250'
Center of Gravity Above Rail (approx.)	63"
Overall Length Over Coupler F7A Unit	50' 8"
FP7A Unit	54' 8"
F7B Unit	50' 0"
Maximum Height Above Rail	15' 0"
Maximum Width Over Handholds	10' 8"

F7 DIESEL LOCOMOTIVE
"A" UNIT
ELECTRO-MOTIVE DIVISION, GENERAL MOTORS CORP., LA GRANGE, ILL.



1 ENGINEER'S CONTROLS
2 TRACTION MOTOR BLOWERS
3 AIR RESERVOIRS
4 ELECTRICAL CABINET
5 DYNAMIC BRAKE HATCH
6 AIR COMPRESSOR
7 AUX. GENERATOR
8 D.C. GENERATOR
9 A.C. GENERATOR
10 COOLING FANS
11 DIESEL ENGINE
12 LUBE OIL COOLER
13 COOLING WATER TANK
14 ELEC HYDR. GOVERNOR
15 LUBE OIL FILTER
16 LUBE OIL STRAINERS
17 LOAD REGULATOR
18 STEAM GENERATOR
19 TRACTION MOTORS
20 BATTERY BOXES
21 FUEL TANK

General Arrangement — F7 Locomotive

GENERAL DATA
E8 LOCOMOTIVE

Weight (fully loaded) "A" Unit (approx.)	316,500 lbs.
"B" Unit (approx.)	308,300 lbs.
Weight on Drivers "A" Unit (approx.)	210,750 lbs.
"B" Unit (approx.)	207,500 lbs.
Fuel Oil Capacity (per unit)	1,200 gal.
Lube Oil Capacity (per engine)	165 gal.
Cooling Water Capacity (per engine) "G" Valve Level	200 gal.
Steam Generator Water Capacity, Basic	1,350 gal.
Steam Generator Water Capacity with Hatch Tank	1,950 gal.

Gear Ratios and Speeds

Gear Ratio	Cont. T.E.	Min. Cont. Speed	Max. Speed
52/25	19,500 lbs.	37 MPH	117 MPH
55/22	23,500 lbs.	31 MPH	98 MPH
56/21	25,000 lbs.	29 MPH	92 MPH
57/20	27,000 lbs.	27 MPH	85 MPH

Sand Capacity (per unit) approx.	22 cubic feet
Number of Drivers (per unit)	4 pair
Wheel Diameter	36"
Truck Centers	43'
Truck Rigid Wheelbase	14' 1"
Minimum Curve Radius	274' (21°)
Center of Gravity above Rail (approx.)	60-1/2"
Length: Between Coupler Pulling Faces	70' 3"
Height: Over Horns	14' 10-1/2"
Width: Outside Grab Irons	10' 8"

E8 DIESEL LOCOMOTIVE - 2250 HP

"A" UNIT

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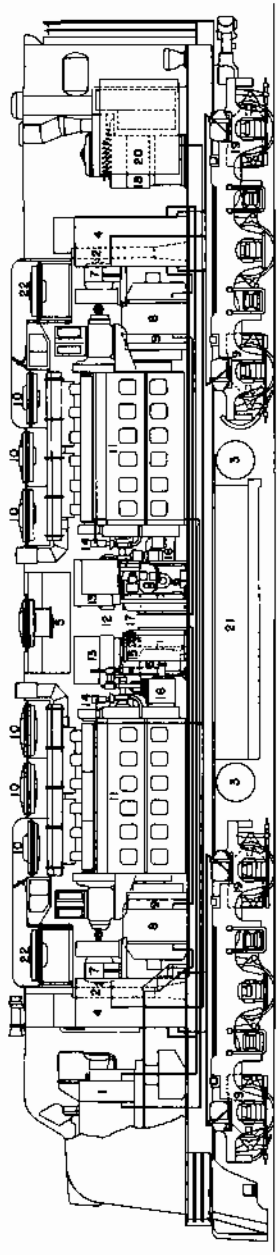
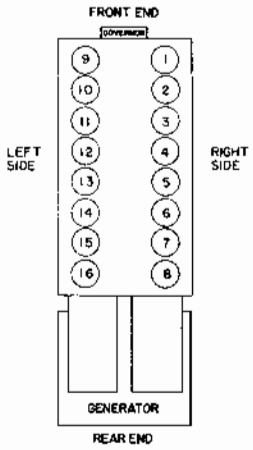


General Arrangement — E8 Locomotive

GENERAL DESCRIPTION AND DATA



The Model 567B Diesel engine is a "V" type, two-cycle engine, incorporating the advantages of low weight per horsepower, fully scavenging air system, solid unit injection, and high compression.

The accompanying sketch serves to identify the cylinder locations, ends and sides of the engine, as they are referred to in this manual. The governor, water pumps and lubricating oil pumps are mounted on the "FRONT END." The blowers, oil separator and generator are mounted on the "REAR END."

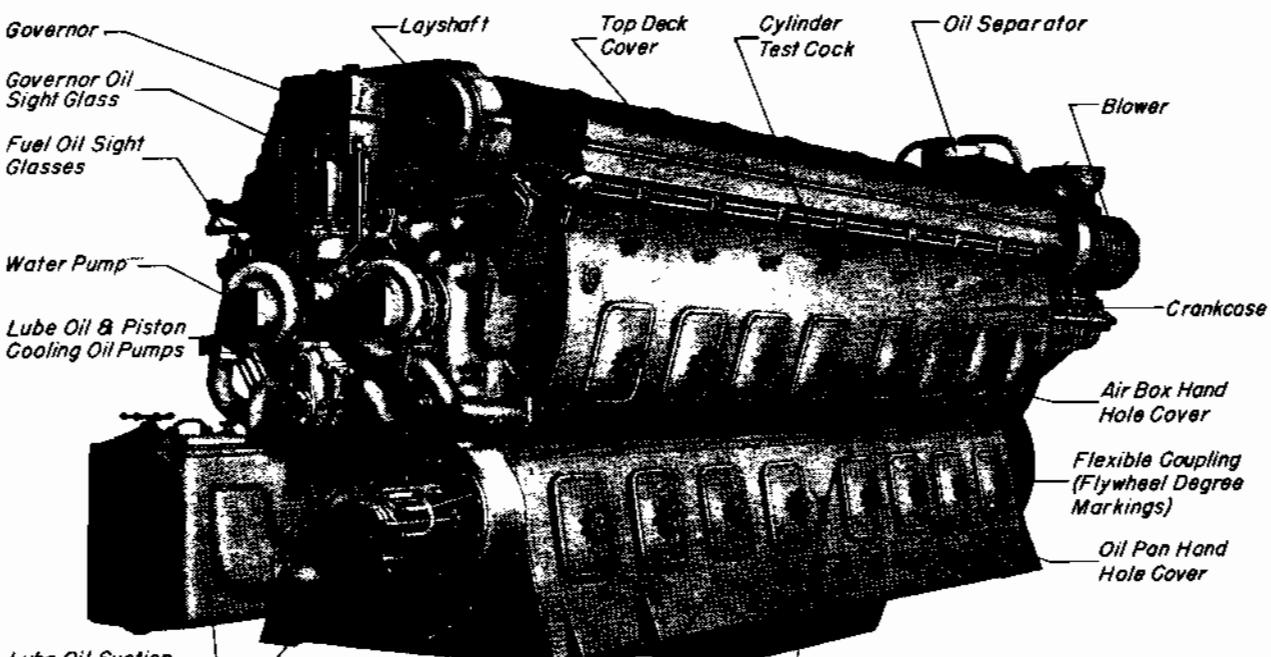
GENERAL DATA

Bore		8-1/2"
Stroke		10"
Compression Ratio		16:1
Maximum Governed Speed		800 RPM
Idling Speed		275 RPM
Starting Speed		75 to 100 RPM
Rotation (Facing Rear End)		Counter-Clockwise
Weight (Approx.)	6-567B	15,000 lbs.
	8-567B	18,000 lbs.
	12-567B	23,000 lbs.
	16-567B	29,000 lbs.
Firing Order	6-567B	1-4-3-6-2-5
	8-567B	1-5-3-7-2-6-4-8
	12-567B	1-12-7-4-3-10
		9-5-2-11-8-6
	16-567B	1-8-9-16-3-6-11-14
		4-5-12-13-2-7-10-15

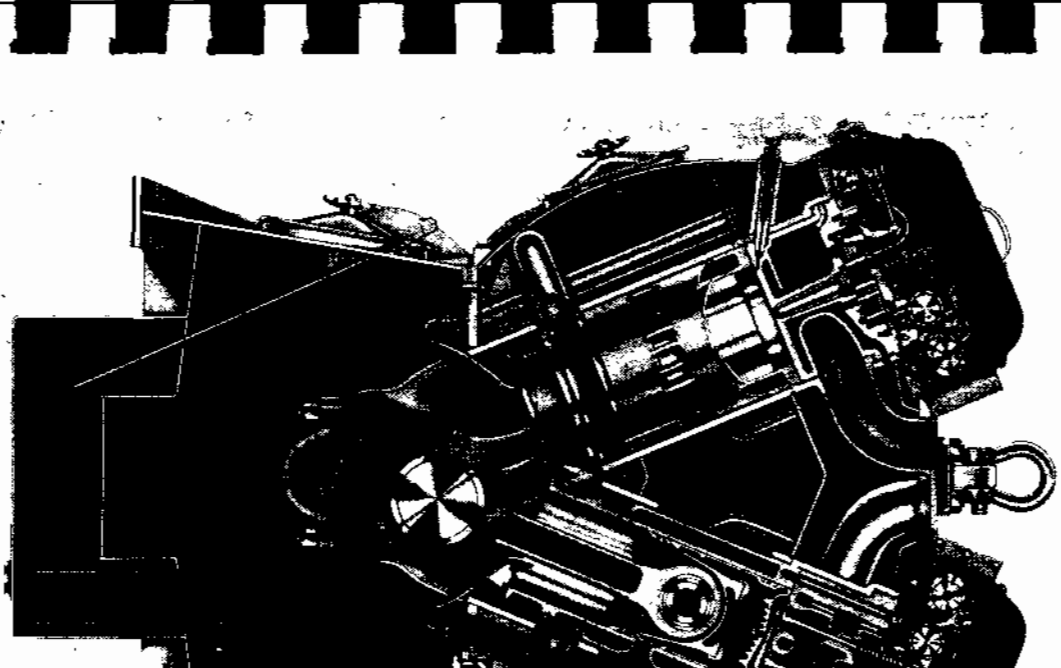
Angle between Banks		45°
Rated Horsepower (at 800 RPM)	6-567A	600 HP
	8-567B	800 HP
	12-567B	1000 HP NW5
	12-567B	1125 HP E8
	12-567B	1200 HP SW7
	16-567B	1350 HP F2
	16-567B	1500 HP F3
	16-567B	1500 HP F7
	16-567B	1500 HP FP7
	16-567B	1500 HP GP7
	16-567B	1500 HP BL
Displacement per Cylinder		567 cubic inches
Number of Exhaust Valves per Cylinder		4
Crankpin Diameter		6-1/2"
Crankshaft Diameter		7-1/2"
Number of Main Bearings	6-567B	4
	8-567B	5
	12-567B	7
	16-567B	10

INJECTOR RACK SETTING (ALL 567 SERIES)
1" RACK AT 7/16" POWER PISTON

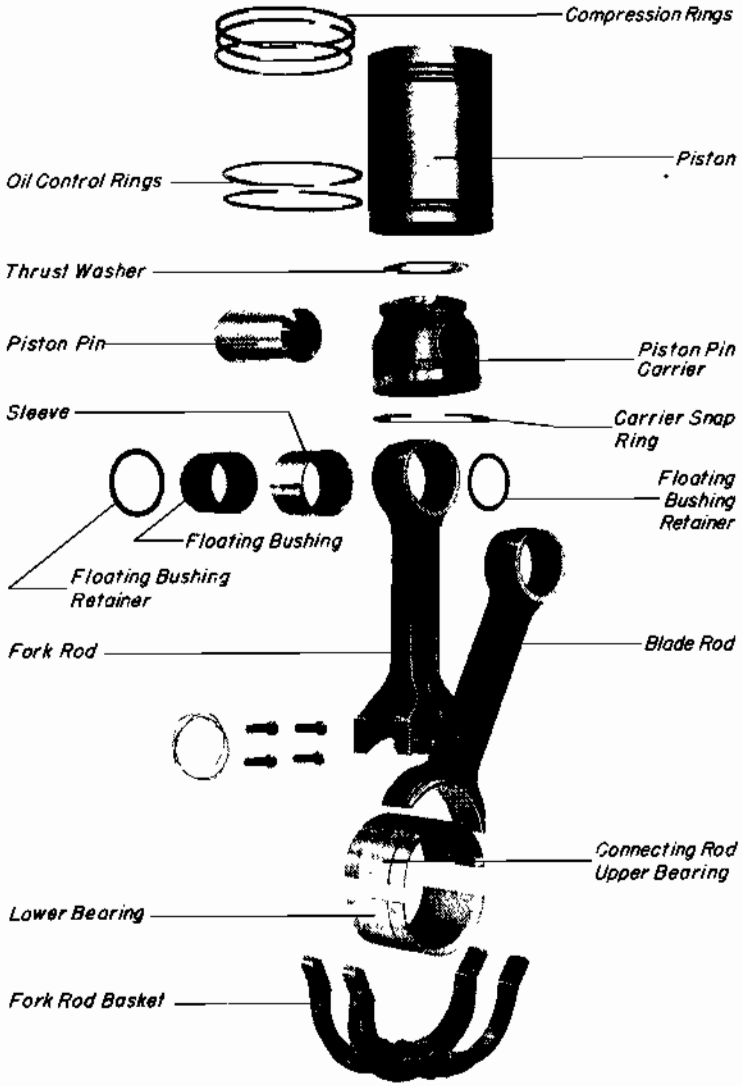
Locomotive	Engine Model	Horsepower Rating	Power Piston	Type of Start
SW1	6-567A	600	5/16"	Max. field
SW8, TR6	8-567B	800	5/16"	Max. field
NW2, NW3	12-567A	1000	7/16"	Max. field
NW5	12-567B	1000	7/16"	Max. field
E3, E6, E7	12-567A	1000	7/16"	Min. field
SW7	12-567A	1200	5/16"	Max. field
SW9, TR5	12-567B	1200	5/16"	Max. field
E8	12-567B	1125	11/32"	Max. field
FT	16-567A	1350	7/16"	Min. field
F2	16-567B	1350	7/16"	Min. field
F3, F7, GP7 BL1, BL2	16-567B	1500	11/32"	Max. field



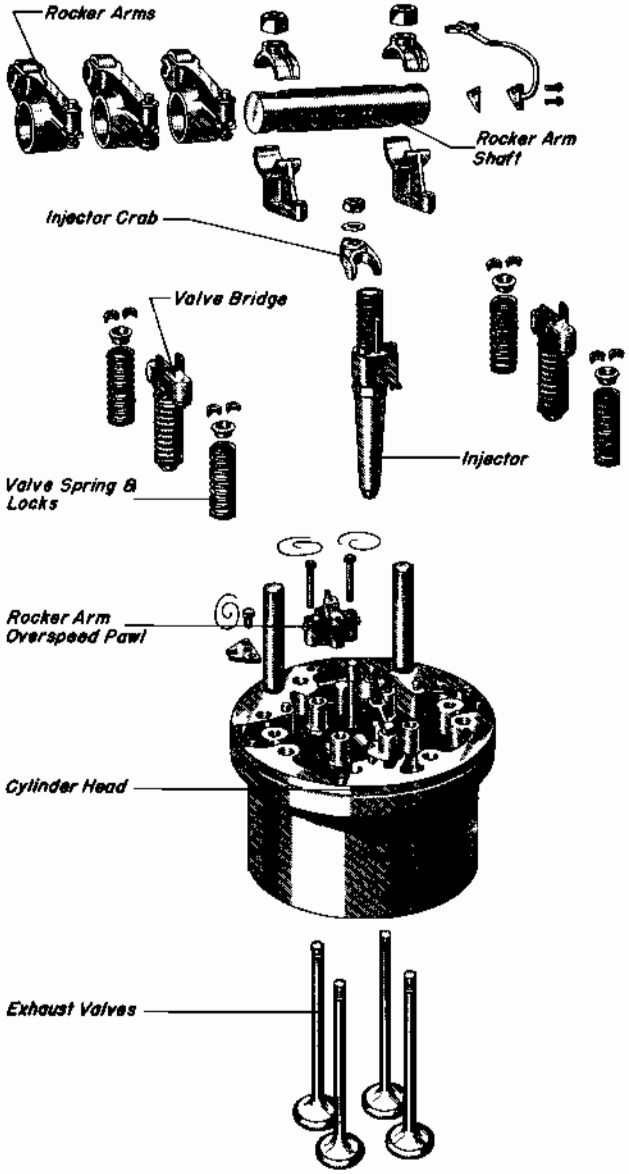
Front Three-Quarter View Model 16-567B Engine



Engine Cross Section

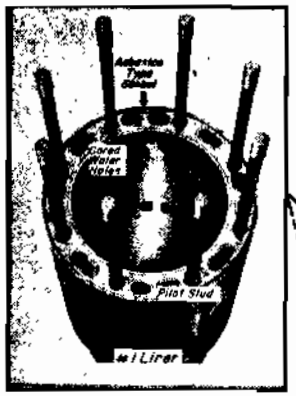


Piston And Connecting Rod Assembly



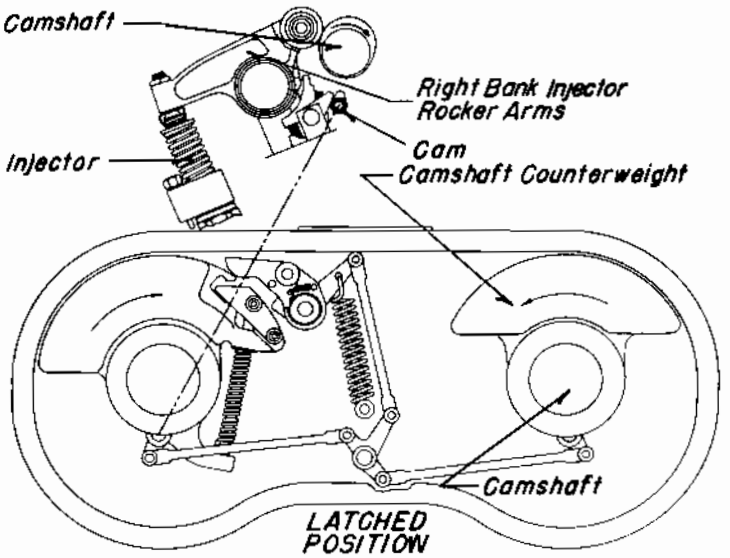
Cylinder Head Assembly

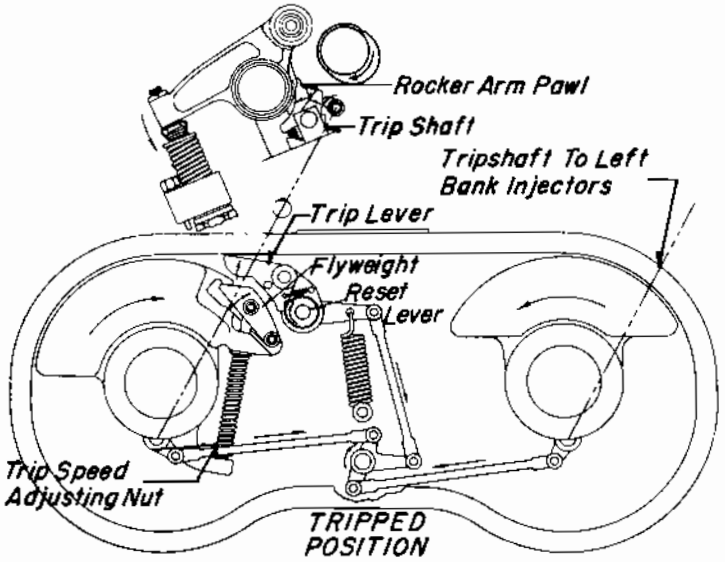
Interchangeability Of Heads To Liners

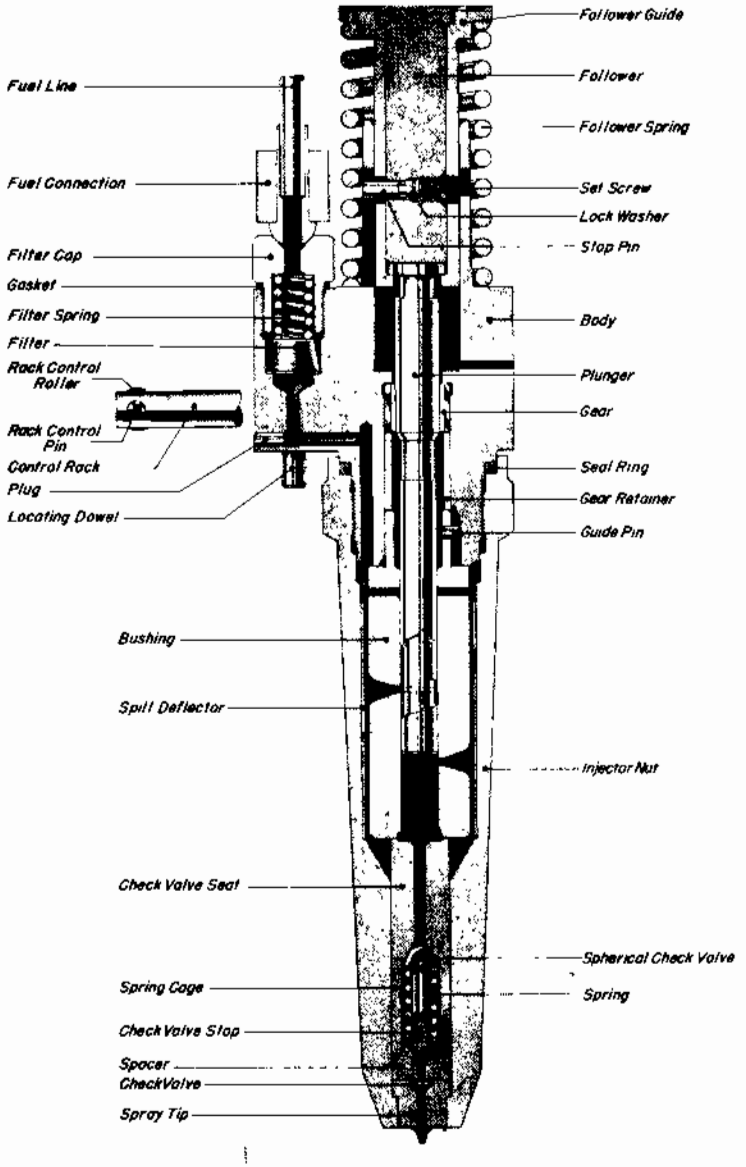


#1 Head

#2 Head







Cross Section Of Unit Injector

GOVERNOR

Governors used on the engine are of two types — S.I. and P.G. The P.G. replaces the S.I. governor on production models and is interchangeable with an S.I. having the same speed control.

The S.I. differs from the P.G. mainly in the compensating mechanisms.

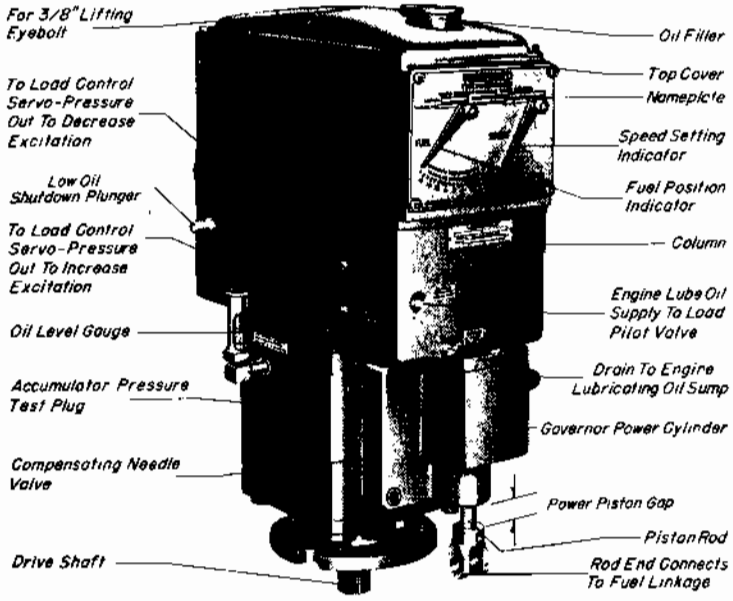
The governor case may be broken down into three main portions — speed measuring and fuel control mechanisms, load control, and low oil shutdown mechanism.

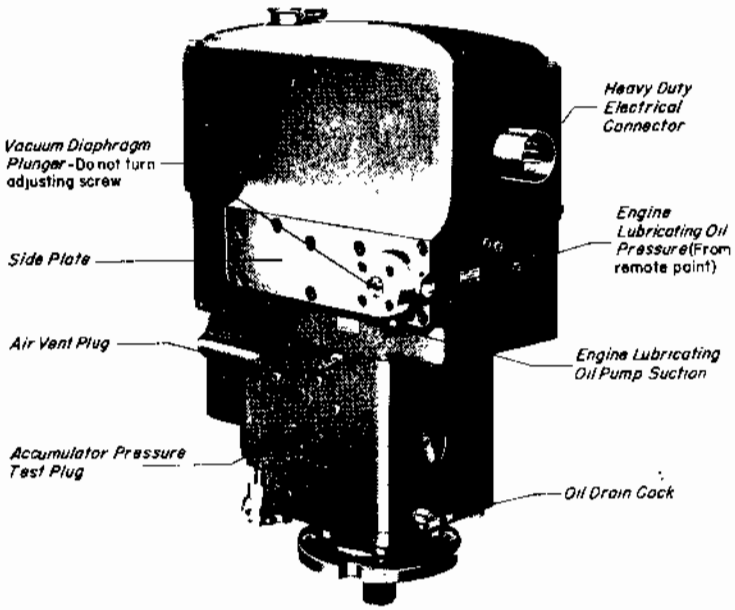
Speed controls now in the field are of four types — mechanical, electro-pneumatic, electro-hydraulic, and pneumatic-hydraulic.

The type of speed control describes the methods employed to transmit the movement of the throttle in the operating cab to the speed setting mechanisms in the governor. For example, the electro-hydraulic uses electricity and hydraulic oil pressure.

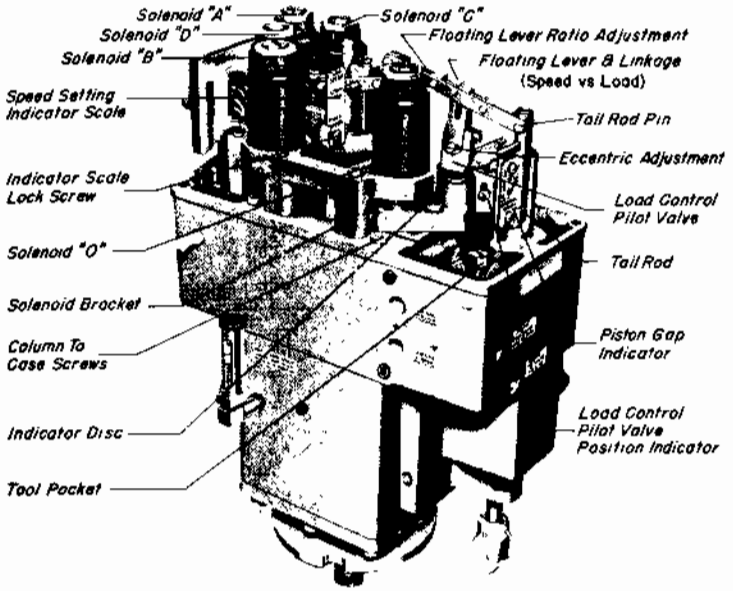
ENGINE SPEED CHART
Electro-Hydraulic — Electro-Pneumatic Control

Throttle Position	Solenoids or Magnet Valves Energized				Engine Speed R.P.M.
	A	B	C	D	
Stop				*	0
Idle					275
1					275
2	*				350
3			*		425
4	*		*		500
5		*	*	*	575
6	*	*	*	*	650
7		*	*		725
8	*	*	*		800

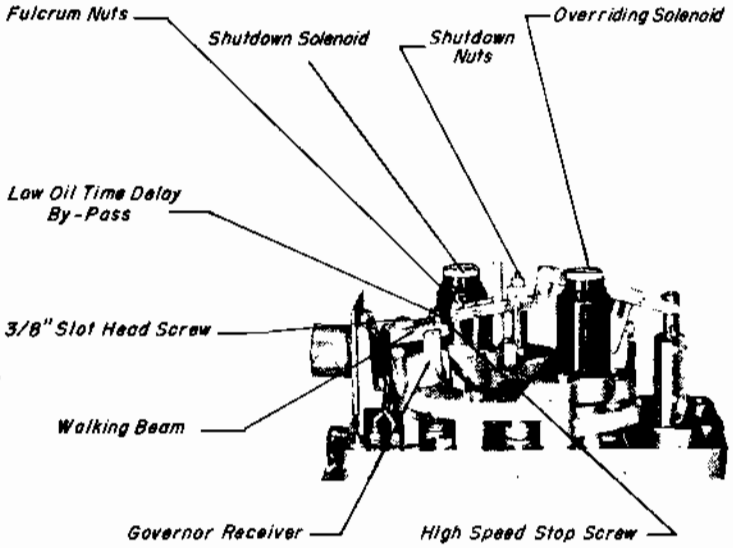




PG Governor — Exterior Views

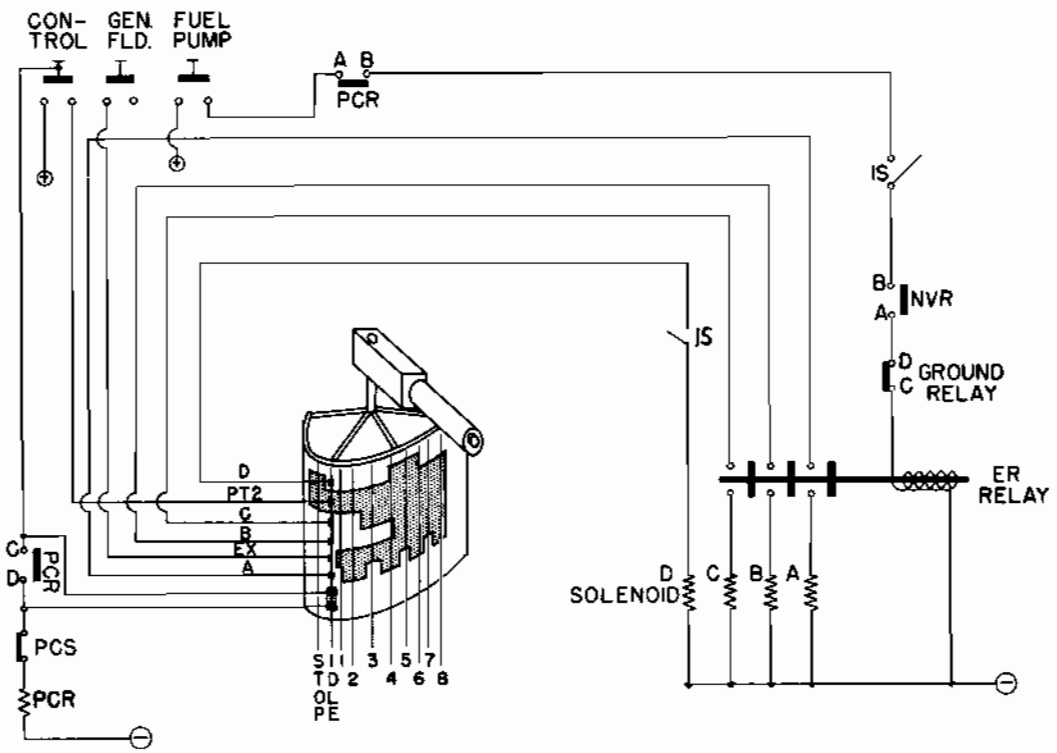


Speed Control — Electro-Hydraulic

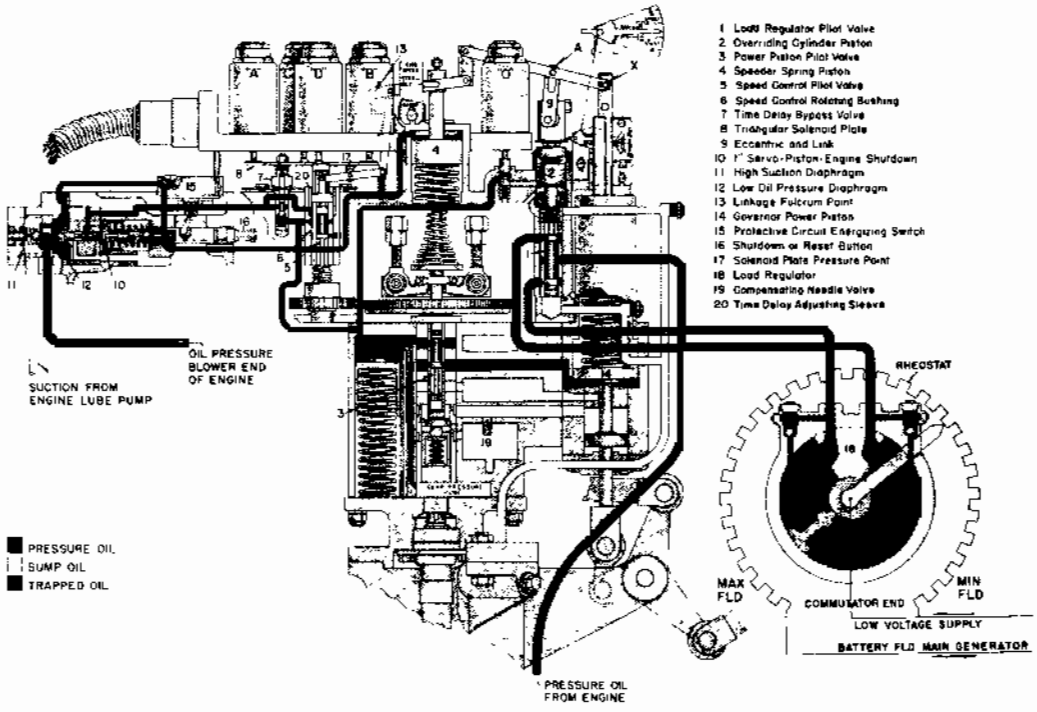


Speed Control — Pneumatic-Hydraulic

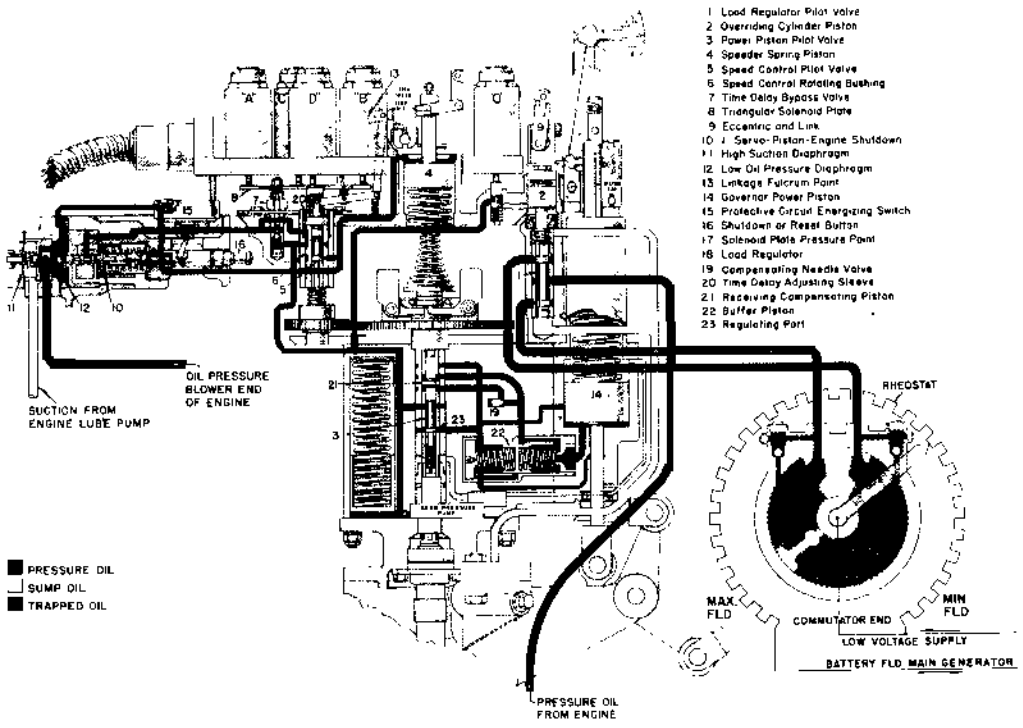
ER Relay Circuit



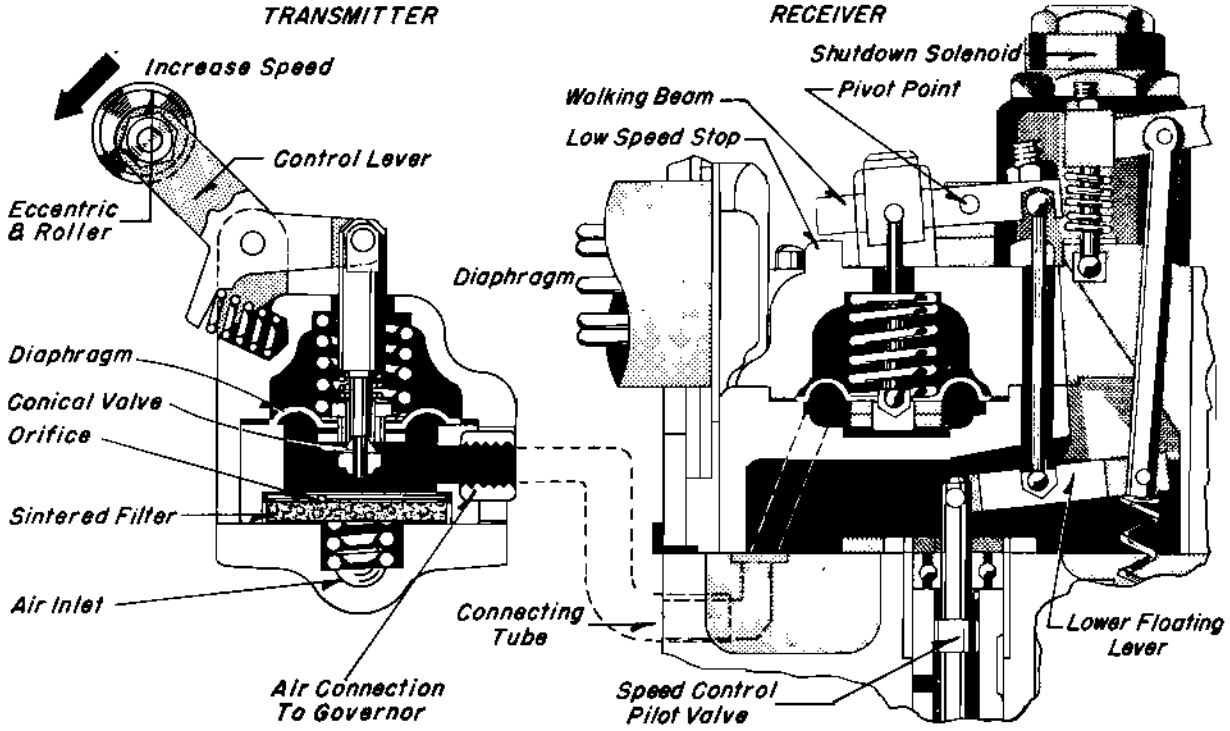
Schematic Of SI Governor With Electro-Hydraulic Speed Control



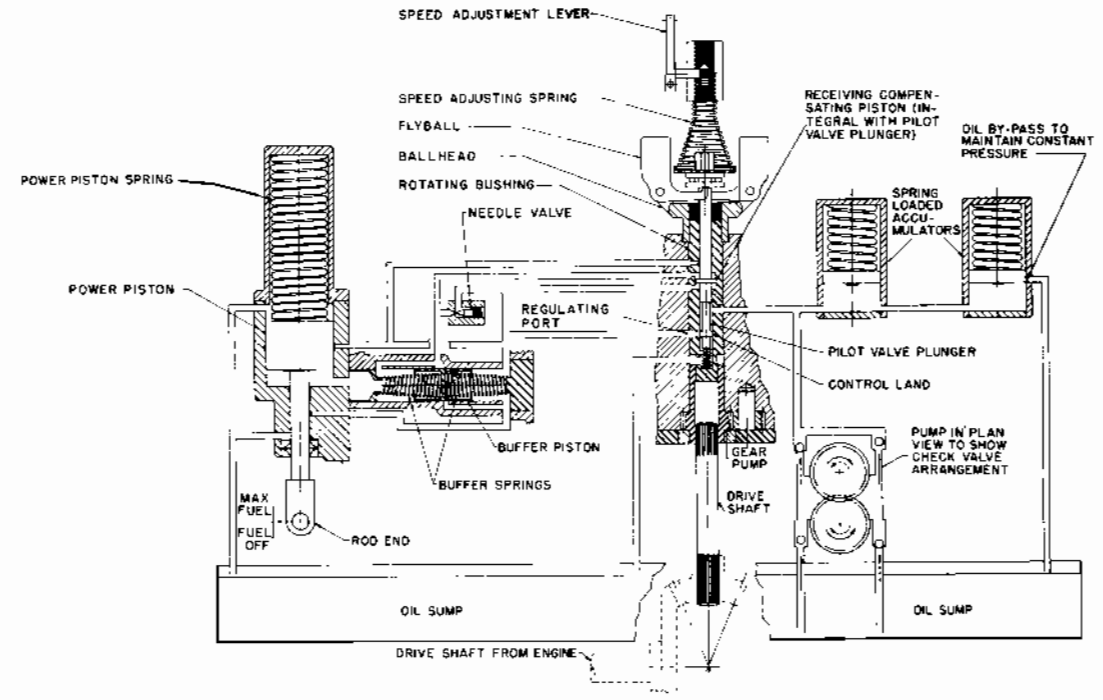
Schematic Of PG Governor With Electro-Hydraulic Speed Control



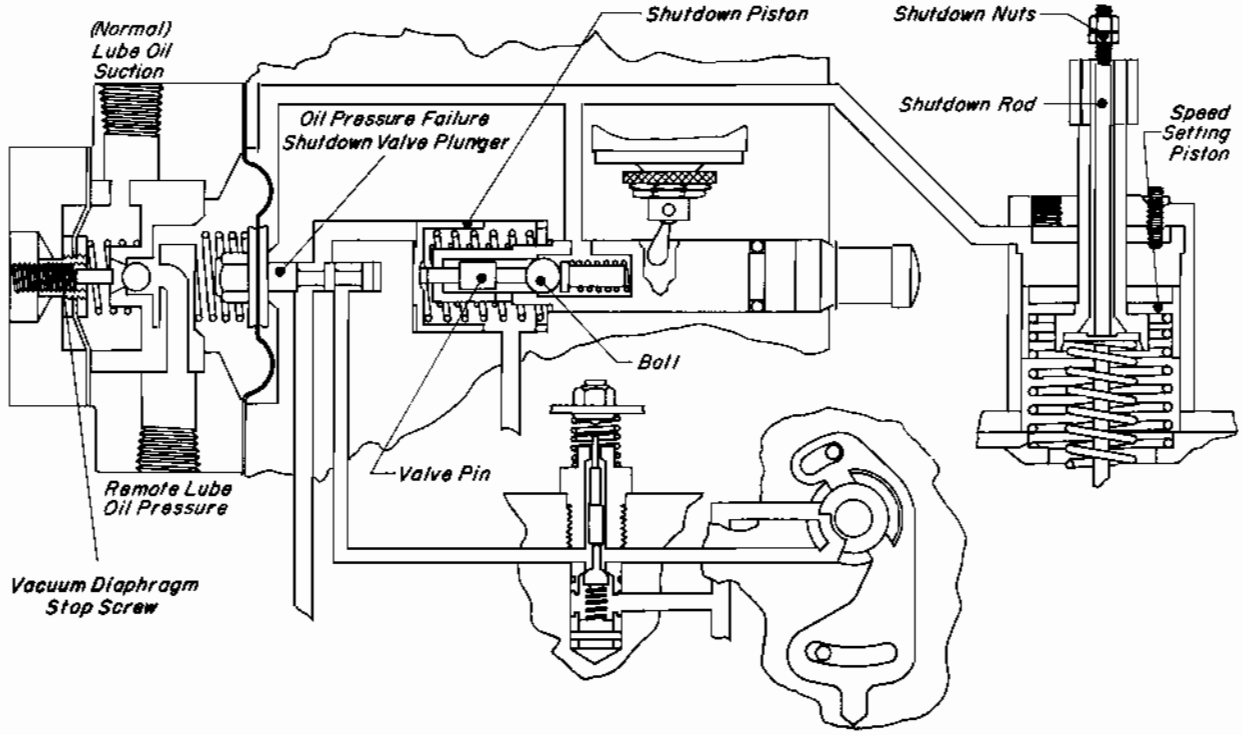
Speed Control — Pneumatic Hydraulic

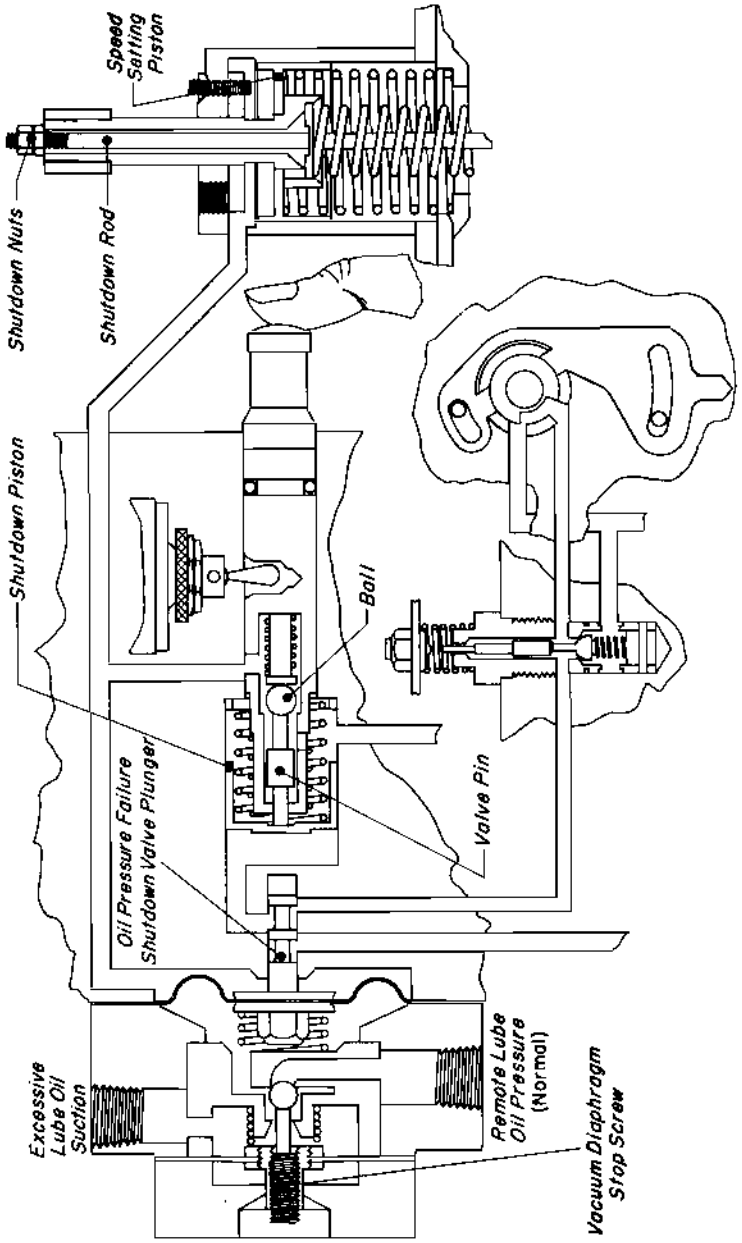


Schematic Diagram — PG Governor



Low Oil Pressure Shutdown





Low Oil Pressure Shutdown Anti-Blocking Device

ELECTRICAL

There are four main electrical systems in the locomotive: high voltage, low voltage, dynamic braking and alternating current. The first three systems operate on Direct current.

The high voltage system which contains the main generator and the traction motors provides the power for the locomotive. The low voltage system supplies all control circuits and most of the accessory circuits. The dynamic braking circuit is supplementary to the high voltage circuit and is used to reverse the function of the power circuit to provide a retarding rather than an accelerating effect, and is used for braking. The alternating current system provides an advantageous means of driving heavy cooling fans and traction motor blowers.

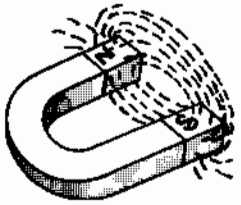
All locomotives have high voltage and low voltage systems.

The alternating current system is used on all present production road locomotives and on the majority of freight power now in railroad use.

The dynamic braking system is optional on any production locomotive.

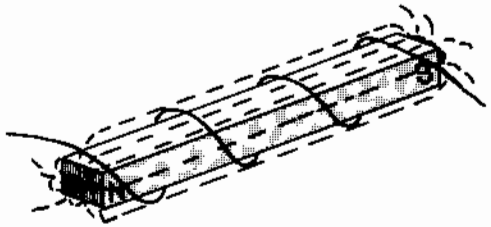
An understanding of electricity requires a knowledge of magnetism and its laws.

There are two types of magnets — temporary and permanent — both of which have a North and South pole.



An illustration of a permanent magnet is the common horseshoe magnet which has a North and a South pole between which exists an area of invisible lines of force. These invisible lines of force are referred to as a magnetic field.

The most common type of temporary magnet is the electro-magnet, which works on the principle that a wire carrying electricity has magnetic lines of force (field) around it. A coil of wire with a piece of iron in it will strengthen the force of this electro-magnet.



Electro-magnets are used extensively on the Diesel-electric locomotive, such as magnet valves, generator fields, motor fields, etc.

Laws Of Magnetism

Unlike poles of two magnets attract each other:

Like poles of two magnets repel each other:

ELECTRICAL DEFINITIONS

Term	What It Is	Different Terms	Measured	Water Comparison	Symbols Used
Voltage	Electrical Pressure	EMF Potential Diff. Voltage Drop	Volts	Water Press. (PSI)	E V
Amperage	Electrical Flow	Current Intensity Amount	Amps	Water Flow (gpm)	I A
Resistance	Electrical Restriction	Resistance Fixed Res. Variable Res.	Ohms	Press. Drop	R Ω
Wattage	Electrical Power	Output Rating Power Consumption	Watts	Water Power HP	W

A conductor is a substance which has low resistance to electrical flow. Examples are silver, copper, and aluminum.

An insulator is a substance which has high resistance to electrical flow. Examples are mica, glass, and rubber.

OHM'S LAW

Ohm's law is a basic electrical law governing the relationship of voltage, amperage, and resistance.

$$E = IR$$

$$R = \frac{E}{I}$$

$$I = \frac{E}{R}$$

If two of the above three items are known, the third can be found by the use of Ohm's law.

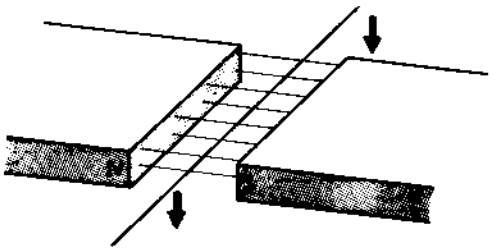
ELECTRICAL POWER LAW

Electrical power (watts) is voltage multiplied by amperage.

$$W = EI$$

746 Watts = 1 HP

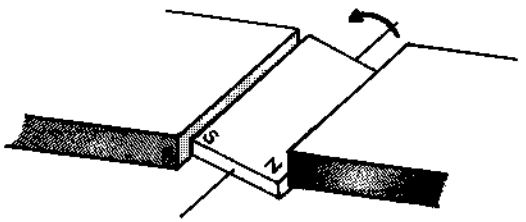
Basic Generator



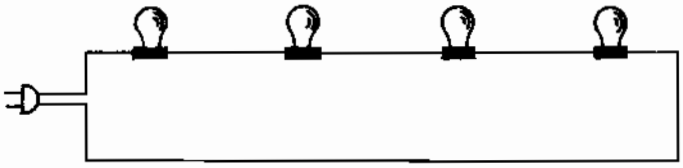
To generate electricity, we must have:

1. A magnetic field.
2. A conductor in the field.
3. Relative motion between conductor and field cutting the lines of force in the magnetic field.

Basic Motor

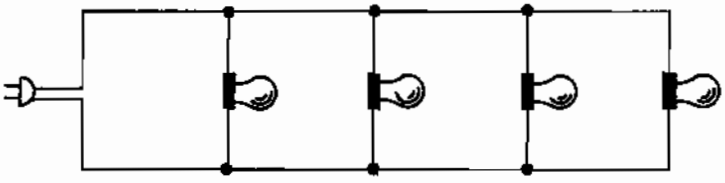


A motor works on the principle of magnetic attraction and repulsion.



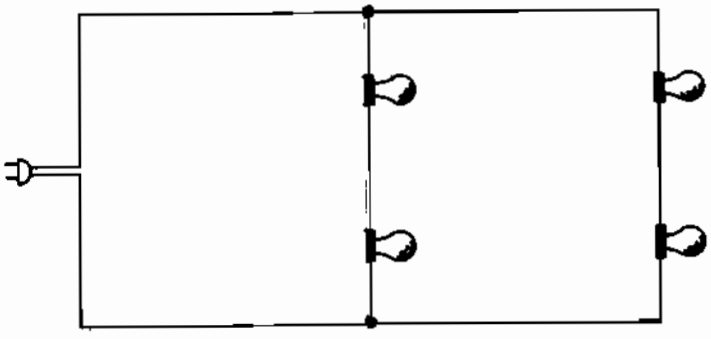
SERIES CIRCUIT

1. A series circuit has only one path of flow.
2. The current throughout this path is the same.
3. The total resistance to flow is the sum of the individual resistances.
4. The total voltage is equal to the sum of the individual voltage drops.

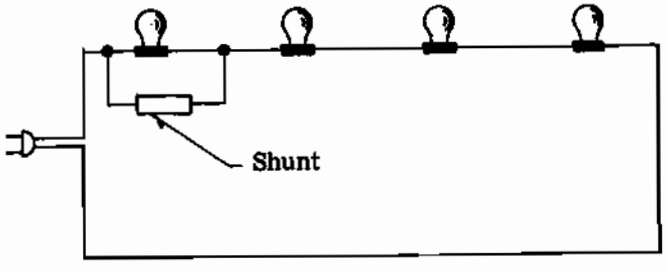


PARALLEL CIRCUIT

1. A parallel circuit has more than one path of flow.
2. The total circuit amperage is equal to the sum of the individual path amperage.
3. The total resistance is smaller than any of the resistances.
4. The total voltage of a parallel circuit is the same as the individual path voltages.



A series-parallel circuit arrangement is a combined form of a series circuit and a parallel circuit.



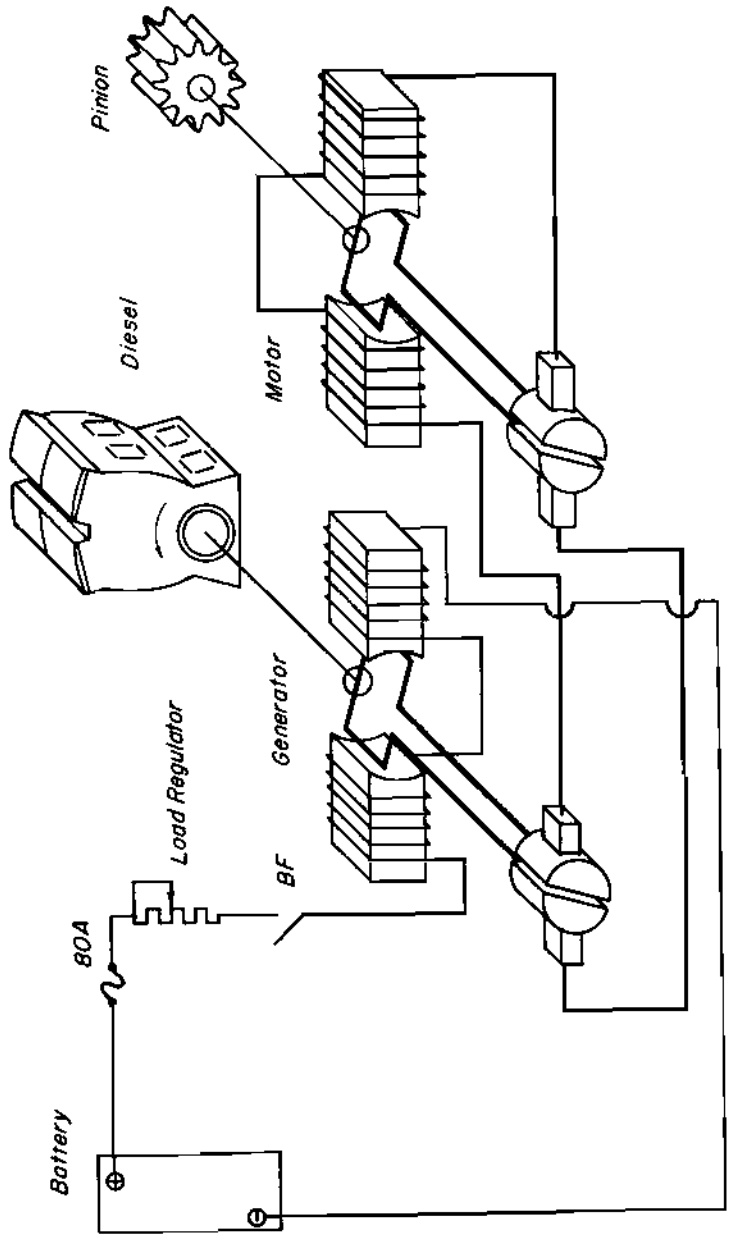
A shunt is an electrical by-pass circuit.

WHY WE MAKE TRANSITION

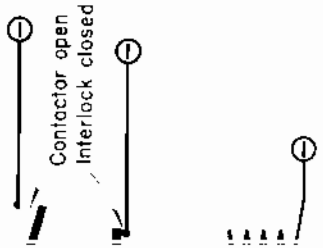
When the Diesel engine throttle has been advanced to the 8th notch, or full throttle position, it will develop a fixed amount of horsepower in that engine, and the generator will convert this horsepower into voltage (electrical pressure) and amperage (electrical flow). As the speed of the traction motors increase, the back pressure of the motors force the generator pressure to rise. If the generator pressure were unlimited, we could leave the motors in series and keep forcing the necessary electrical flow into the motors. BUT — the generator has a limited voltage (or pressure) capacity, so we put the motors into parallel before we reach the maximum pressure. This hook-up reduces the back pressure in the motor circuit, the generator pressure can then drop to a lower amount than is required in Series. It will build up again and continue to force electrical flow into the motors until the train reaches its rated speed.

The shunt position in transition is not a major change in motor hook-up, but a method of getting more electrical flow into the armature by the use of low resistance shunts, which by-pass electrical flow from the motor fields. This cuts down the back pressure of the motors.

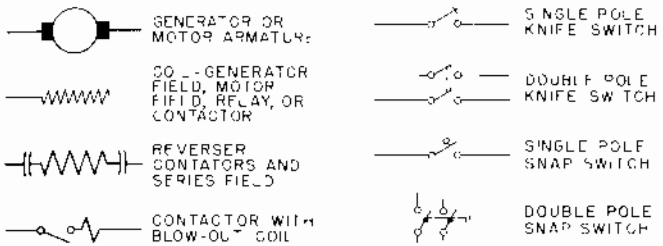
The fact that the horsepower of the Diesel engine is fixed means that we cannot take a train up a grade at the same speed that can be obtained on level track. For example, 6000 h.p. will take about 5,000 tons at 50 m.p.h. on level track, or about 5,000 tons up a 1% grade at 15 m.p.h. (62/15 gear ratio). When the speed of the train decreases due to a grade, the back pressure of the motors also decreases. If the motors were left in parallel, they would draw more electrical flow than the generator rated output. To protect the generator from overheating, the motors are put back into a series hook-up.



Basic Generator And Motor Principle



Basic Electro-Pneumatic And Electro-Magnetic Contactors And Interlocks



Electrical Symbols

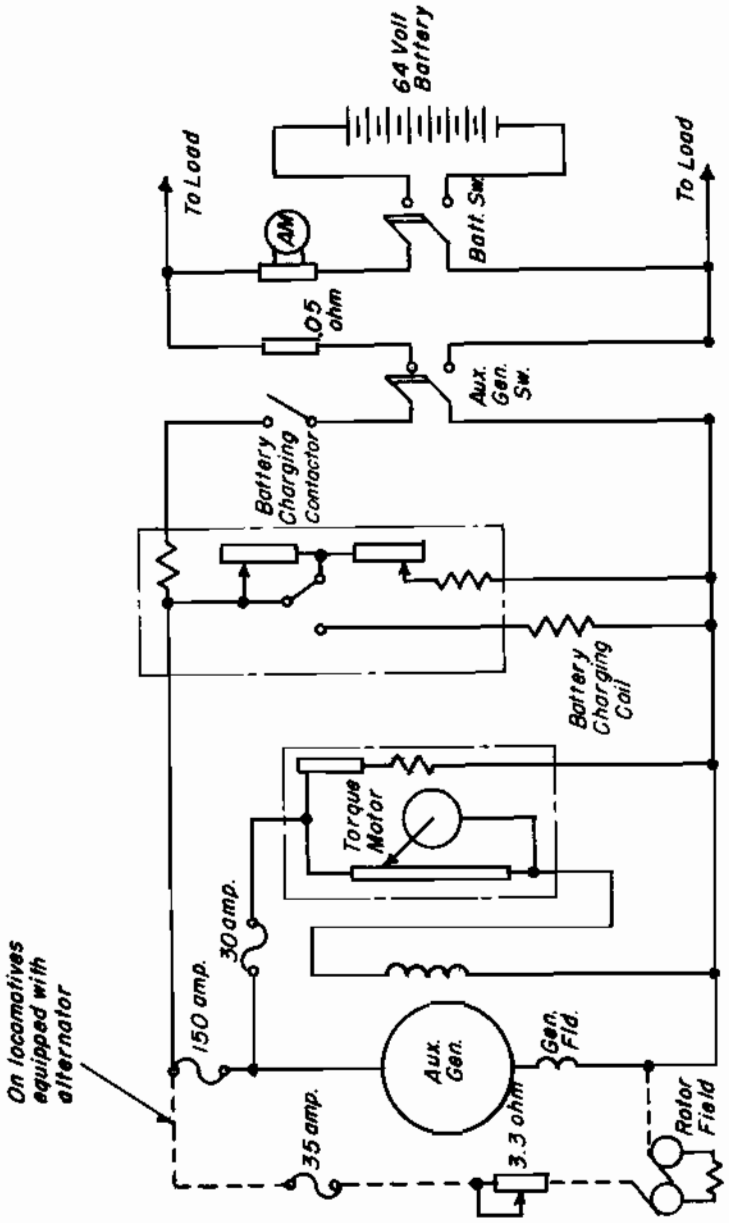
LEGEND OF ELECTRICAL EQUIPMENT

The following is a list of abbreviations used to identify electrical equipment on the schematic wiring diagram.

A, B, C	Teaser Circuit Control Relays
AC1, AC2, AC3, AC4	Cooling Fan Motor Contactors
AM	Battery Charging Ammeter
AV, BV, CV, DV	Governor Control Solenoids
B, B1, B2, B3	Dynamic Braking Contactors
BA	Boiler Signal Light
BC	Battery Charging Contactor
BF	Battery Field Contactor
BR	Dynamic Brake Relay
BTP	Backward Transition Parallel
BTR	Backward Transition Relay
BTS	Backward Transition Series
BW	Dynamic Brake Warning Light
BWR	Dynamic Brake Warning Relay
CC	Compressor Control Magnet Valve
CCS	Compressor Control Switch
CL	Class Light or Switch
CLR	Current Limiting Relay
COMM	Commutating Field
COMP	Compensating Field
CO	Cut Out Switch
CO	Truck Cut Out
CR	Compressor Control Relay
CS	Cam-Switch (Power-Braking Transfer Switch)
DIFF	Differential Field
ER	Engine Relay
ETS	Engine High Temperature Switch
FL	Field Loop Contactor
FOR	Reverser Magnet Valve - Forward Position
FPC	Fuel Pump Contactor
FTM	Forward Transition Motor Shunting

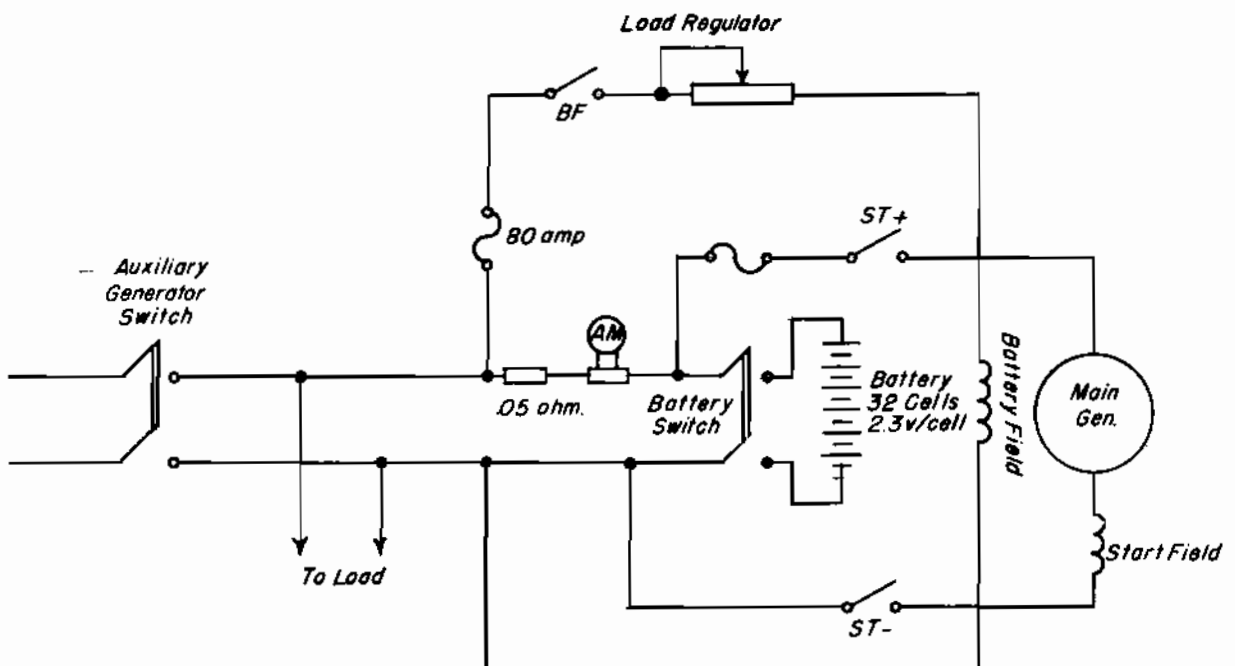
FTP	Forward Transition Parallel
FTR	Forward Transition Voltage Relay (Automatic Transition)
FTS	Forward Transition Switch
G	Ground Light
GA	Gauge Light or Switch
GR	Ground Protective Relay
HLDT	Headlight
IL	Load and Transition Indicating Meter Light
IM	Load and Transition Indicating Meter
IS	Isolation Switch
LOP	Low Oil Pressure Alarm Switch
LOS	Lube Oil Suction Alarm Switch
LRC	Load Regulator Control
LRS	Load Regulator Shunting Switch
M	Oscillating Motor (Mars Headlight)
M	Motor Field Shunting Contactor Magnet Valve
M1, M2, M3, M4	Motor Field Shunting Contactors
MCO1	Motor Cutout #1
MCO2	Motor Cutout #2
MOT	Cam-Switch Magnet Valve — For Power Position
MU	Multiple Unit
N	Number Light or Switch
NP	No Power Light
NV	"Alternator Failure" Signal Light
NVR	"No AC Voltage" Relay
ORS	Overriding Solenoid
OS	Low Oil Signal Light
P1, P2, P3, P4	Parallel Contactors
PCR	Pneumatic Control Relay
PCS	Pneumatic Control Switch
PR	Parallel Relay
R	Red Lens (Mars Headlight)
RCR	Reverse Current Relay
REV	Reverser Magnet Valve — Reverse Position
RM	Rotating Motor (Mars Headlight)

RS	Rotary Switch
RVR	Reverser Interlock
RY	Pole Changer Relay (Mars Headlight)
S14, S23, S13, S24	Series Contactors
SA	Spark Arrester
SFT	Shunt Field Transfer
SH	Shunt Field Contactor
SMV	Shutter Magnet Valve
SP	Speed Recorder Light
SR	Signal Relay
ST+, ST-	Starting Contactors
START	Starting Field
STS	Shutter Temperature Switch
SWS	Summer Winter Switch
TCR	Temperature Control Relay
TD	Time Delay Relay
TDB	Time Delay Backward Relay
TL	Throttle Light
TOW	Cam-Switch Magnet Valve — For Dynamic Braking or Towing Position
TO1, TO2, TO3, TO4	Thermal Overload Relays
TR	Transition Forestalling Relay
TSA	Thermostat Switch Assembly
TS	Engine High Temperature Signal Light
V	Vestibule Light
VT	Time Delay Relay
W	White Lens (Mars Headlight)
WSA	Wheel Slip Auxiliary
WSL	Wheel Slip Light
WSR	Wheel Slip Relay
WSR1, WSR2	Wheel Slip Relays
WS	Wheel Slip Light

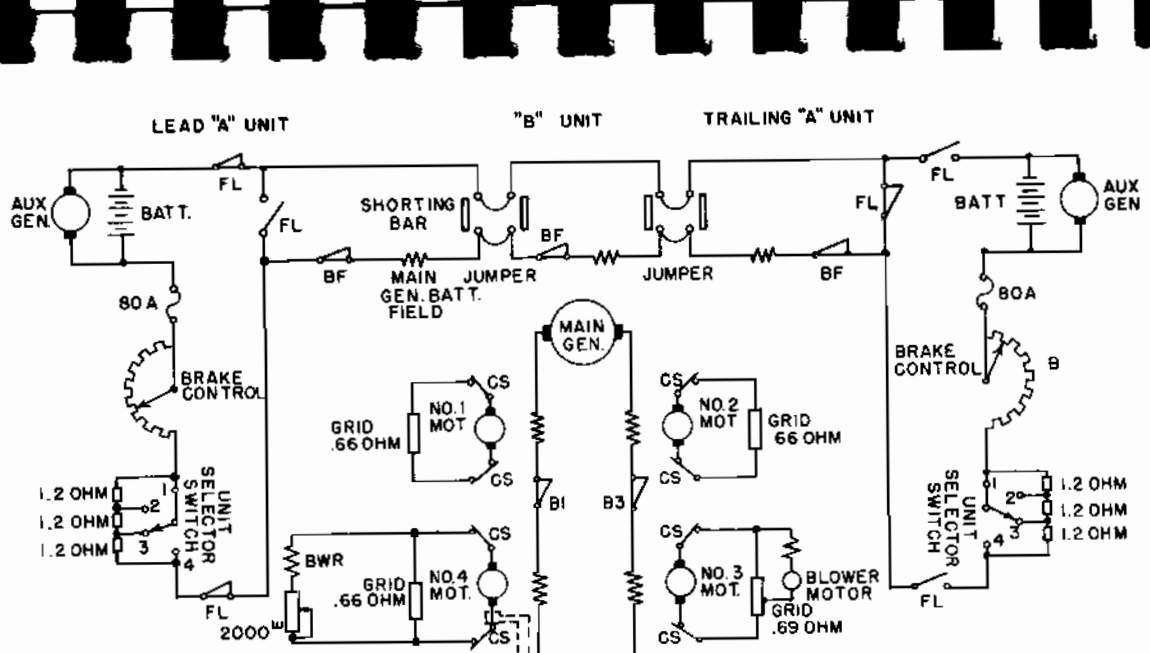


Auxiliary Generator Charging Circuit

Battery Field And Starting Field Circuits



Dynamic Brake Circuit



OPERATION

The successful operation of all locomotives is dependent upon the quality of inspection and repairs at regular maintenance periods, as well as the skill of the operating crews. Many road failures may be prevented by a pre-service "check" made by the engine crew before the locomotive leaves on its run and a few "know-hows" for locomotive operation.

Fuel Consumption For Engines

Type	Idle	Full Load	Power Piston
6-567	1.5 GPH	37 GPH	5/16"
8-567	2.0 GPH	49 GPH	5/16"
12-567	2.5 GPH	64 GPH	7/16"
12-567	2.5 GPH	72 GPH	11/32"
16-567	3.5 GPH	95 GPH	3/8"
16-567	3.5 GPH	85 GPH	7/16"
16-567	3.5 GPH	98 GPH	11/32"
12-567	2.5 GPH	75 GPH	5/16"

The above figures are approximate and are not intended for any use other than general information.

CHANGING OPERATING ENDS

When the consist of the locomotive includes two units with operating controls, the following procedures should be followed in changing from one operating end to the opposite end.

1. Locomotive equipped with 24 RL brake.

   a. REMOVE REVERSE LEVER.
   b. With safety control foot pedal depressed (if used) release independent air brake by placing independent brake valve handle in "RELEASE" position.
   c. Make full service automatic brake reduction.
   d. Close brake pipe cutout cock (double heading cock) and release safety control foot pedal.
   e. Move the Rotair valve to the proper "LAP" position.
   f. Move the automatic brake valve handle to "RUNNING" position and remove the handle from the brake valve.
   g. Remove the independent brake valve handle in "RELEASE" position.
   h. Open all switches at engineman's control station ("Off" position).
   i. Proceed to cab at opposite end. Check "PC" switch (if used). Close control and fuel pump switches ("On" position) and other switches as are necessary.
   j. Insert reverse lever, automatic brake valve and independent brake valve handles. Place independent brake valve in "full application" position.
   k. Move the Rotair valve to the proper operating position.
   l. Open brake pipe cutout cock (double heading cock) slowly, pausing from five to ten seconds in mid-position.
   m. When ready to move locomotive, depress safety control foot pedal or automatic brake valve handle

and move the independent brake valve to "RELEASE" position.

2. Locomotive equipped with 6 BL brake.

   a. REMOVE REVERSE LEVER.
   b. Make a full service brake pipe reduction.
   c. Move double heading cock to "Trailing" (4 o'clock) position and release safety control foot pedal (if used).
   d. Move the independent brake valve handle to "RELEASE" position.
   e. Leave the automatic brake valve handle in the "LAP" position.
   f. Set the transfer valve operating cock to open or "Trailing" position. (If not included as part of the double heading cock.)
   g. Open all switches at engineman's control station ("Off" position).
   h. Proceed to cab at opposite end. Check "PC" switch (if used). Close control and fuel pump switches ("On" position) and any other switches that are necessary.
   i. Insert reverse lever and brake valve handles. Place independent brake valve in full "application" position.
   j. Open double heading cock to "Lead" (6 o'clock) position slowly.
   k. Place automatic brake in "running" position.
   l. When ready to move locomotive, depress safety control foot pedal, and move independent brake valve to "RELEASE" position.

NOTE: When hauling locomotive "dead" place the independent and automatic brake valve handles in the RELEASE and RUNNING positions, respectively, move the double heading cock to the 3 o'clock position and open the dead engine cock.

Locomotives equipped with safety control, foot pedal or automatic train control, use the N-1-A brake application valve. The brake valve cutout cock (double heading cock) is mounted on this N-1-A brake application valve instead of on the automatic brake valve. The N-1-A brake application valve is located under the operating cab and can be reached through a small trap door in the operating cab floor.

STARTING A TRAIN

Starting a train depends not only on the class of locomotive being used, but also on the type, length, weight, and the amount of slack in the train, in addition to grade and weather conditions. It is important that the air brakes be completely released before attempting to start the train. Actual tests have shown that a 100-car train, having the average uniformly distributed leakage, may require nine minutes to completely release the brakes. It requires approximately 30 minutes (with 130# main reservoir pressure) to completely charge a depleted air system on a similar 100-car train.

Although it will generally be unnecessary to take slack in starting, there will be cases where it is wise to do so. A tonnage train should be started in as low a throttle position as possible, bearing in mind that the speed of the locomotive must be kept at a minimum until the train has been stretched. Sometimes it is advisable to reduce the throttle a notch the moment the locomotive begins to move, in order to prevent stretching the slack too quickly. The engineman must be the judge of the acceleration and the conditions under which the train is being started. When the locomotive has moved far enough to completely stretch the train, the throttle may be advanced as quickly as desired, but should not be advanced so quickly that slipping results.

It is never necessary to move the throttle hastily, except in an emergency. The throttle should be opened with a steady motion, but gradually enough to move the load without slipping the wheels. It is a poor practice and unnecessary to pump (rapid opening and closing) the throttle when starting; a smooth flow of power is desirable. If wheel slipping occurs, the engineer should wait until the light stops flashing before any sand is used. Sand should be used to prevent slipping, not to stop it.

OPERATING OVER RAILROAD CROSSING

When going over railroad crossings, reduce throttle to fifth notch and leave reduced until all units are over crossing. On a locomotive without throttle notches, reduce (to about one-third full throttle) until all units are over crossing. This will reduce arcing from brushes to the motor commutator.

TOWING LOCOMOTIVE

1. Be sure reverse lever is in neutral position. If locomotive is to be towed in a train any appreciable distance, the reverser switch must be placed in neutral and locked in that position. To lock the reverser switch, remove the locking pin which during normal operation is screwed into the left hand side of the reverser housing. With the reverse lever in neutral, punch the buttons on top of reverser switch lightly, to center (if control air is not available, place wrench on square portion of switch shaft and center switch manually). After switch has been centered, shut off control air. Insert pin into hole in the right side of reverser housing, pushing pin all the way through the reverser switch shaft, and screw pin into threaded hole in reverser housing.

2. All isolation switches must be in START position. If it is necessary to keep the engines idling for any reason while towing locomotive, the fuel pump and control switches should be left in the closed position.

3. The air brake equipment should be set according to the air brake manufacturer's bulletin.

BRAKE RECOVERY AFTER PENALTY APPLICATION

1. Place automatic brake valve in LAP.
2. CLOSE THROTTLE TO IDLE.

3. Place foot on safety control foot pedal.
⊛ 4. Wait until application pipe builds up to main reservoir pressure. (Listen for exhaust or watch PCS light.)
5. Reset train control.
6. Release brakes.

RUNNING THROUGH WATER

Under ABSOLUTELY no circumstances should the locomotive pass through water which is deep enough to touch the bottom of traction motor frames. When passing through water always go at a very low speed (2 to 3 miles per hour). Water any deeper than three inches above the top of the rails is likely to cause damage to the traction motors.

DYNAMIC BRAKE OPERATION

Some locomotives are provided with additional electrical equipment permitting a portion of the power developed by the momentum of the train to be converted into an effective negative power, retarding the speed of the train. This feature is known as the dynamic brake and is especially useful as a holding brake, on descending grades.

The traction motor armatures, being geared to the axles, are rotating whenever the train is moving. When using the dynamic brake, electrical circuits are set up which change the traction motors into generators. Since it takes power to rotate a generator this action retards the train. The power thus generated is dissi-

⊛ If PCS will not reset (i.e. light stays lit) with automatic brake valve handle in LAP, after an emergency application, place brake valve handle in running position.

pated in resistors, called grids, which are cooled by a motor driven fan. The grids and fan are located in the top of the carbody. The grid cooling fan receives power that is generated by the "traction motor."

Before using the dynamic brake a check should be made to see that the unit selector switch, located next to the instrument panel, is set to correspond with the number of units in the locomotive consist, and that the reverse lever is in the direction in which the locomotive is moving. Following this, place the throttle in Idle, waiting about 10 seconds before moving the transition lever to the Off position. In the Off position the dynamic braking circuits are partially established and depending upon the speed of the train, enough braking may be present in this position to bunch the slack. If necessary, move the lever to "B" and wait until the slack is bunched. After the slack is bunched the lever may be moved farther to the right to give the desired amount of braking effort.

The dynamic brake is, in effect, very similar to an independent brake and the load indicating meter serves the purpose of a "brake cylinder pressure gauge." The needle of the load indicating meter should not be allowed to remain beyond the maximum allowable amperage indicated on the engineer's instrument panel, nor must the dynamic brake warning light be permitted to stay lit. In either case, slightly reduce the brake (transition) lever until these conditions are remedied.

Variations in the idling speed of the engines, motor and generator characteristics, and setting of the brake warning relay may cause the dynamic brake warning light to come on before the meter needle reaches the maximum allowable amperage; in any case, the light must not be permitted to remain lit. The light is an overload indication and operating with it ON might damage traction motors, braking grids, or grid cooling fan motors.

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

AIR BRAKING WITH POWER

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

ALARM BELLS AND LIGHTS (IF USED)

An alarm signal light will be lit in the unit affected:

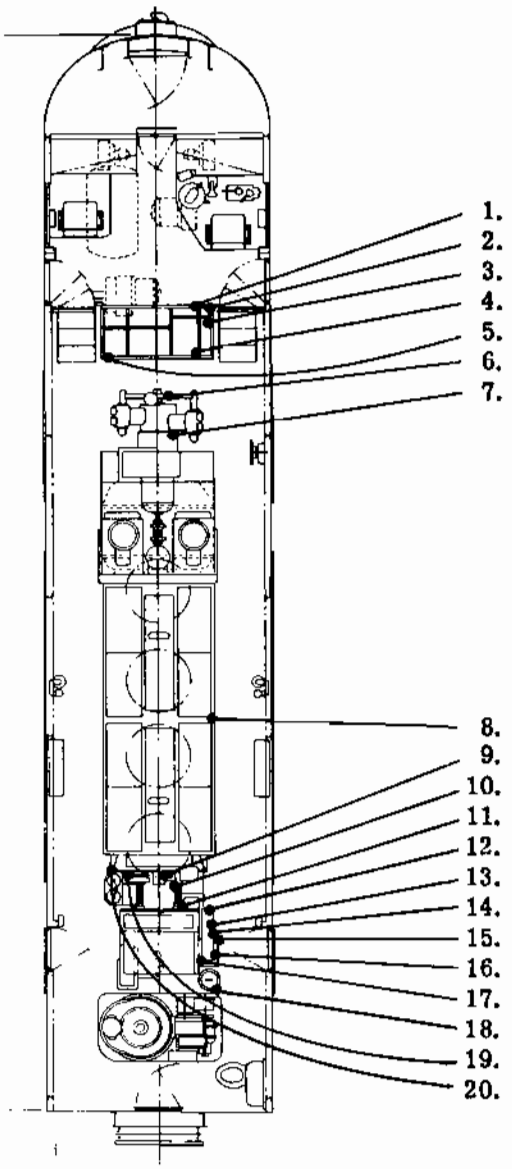
RED Engine water outlet temperature over 208°. Check water level, shutters and fans. If condition cannot be corrected at once, isolate engine (allowing engine to idle) and investigate the cause. If the fuel pump motor fuse is blown the pump will stop; the cooling system fan and shutter control will also be inoperative. See that shutter air supply valve, mounted on left wall of carbody, is open.

YELLOW & BLUE Low lube oil pressure or high lube oil pump suction. Engine is stopped. Isolate engine and reset governor trip button to stop alarm. Check oil level and condition. If no difficulty is evident start engine, check oil pressure and suction gauges. Put engine on the line.

BLUE Alternator failure (if engine stops while "on the line" this light will light, since stopping engine stops the alternator). Check overspeed trip and fuel flow, start engine and put it "on the line." If light comes on instantly, stop engine and check auxiliary generator field and alternator field fuses. If light does not come "on" after engine is started, but engine will not respond to throttle, check the ground relay.

GREEN Steam generator failure.

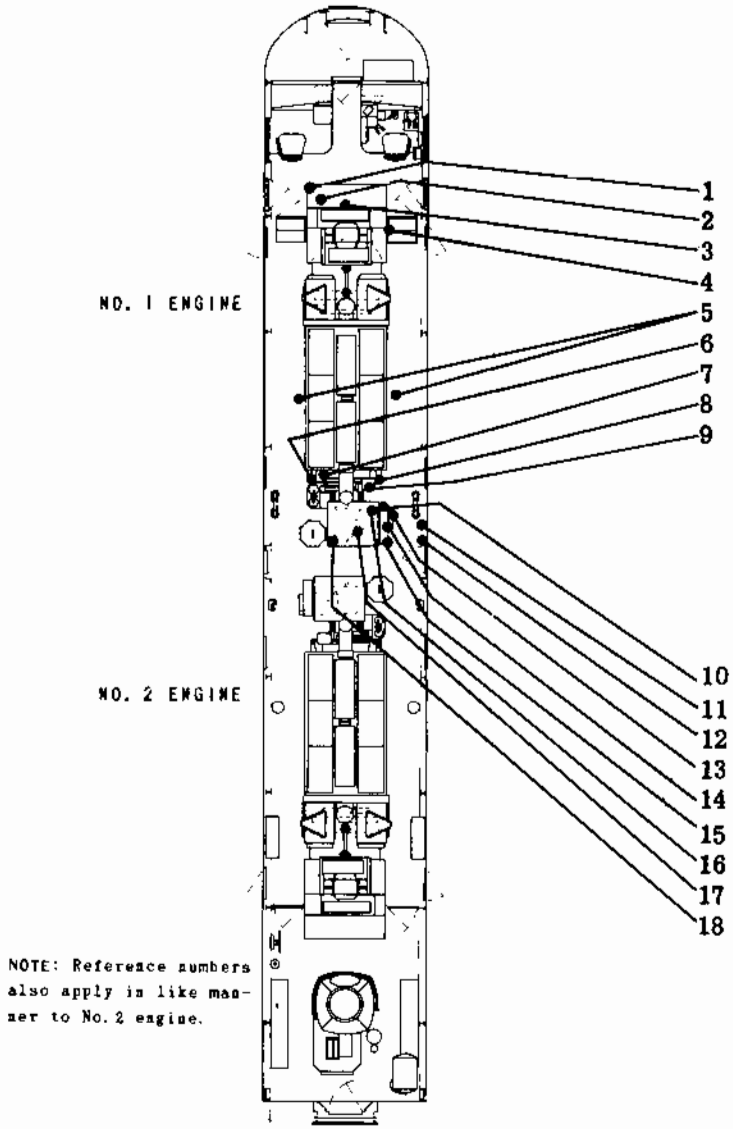
NOTE: The yellow alarm light will burn whenever the governor low oil alarm switch is tripped, regardless of the isolation switch position. The Low Oil and Alternator Failure alarm lights will not operate if (1) the PC switch is tripped, (2) the cab fuel pump switch is OUT, or (3) the fuel pump control fuse is blown in the operating unit.



Location Of Gauges, Relays And Equipment
F7 Locomotive

ENGINE ROOM CHECK CHART

	ITEM	Reading	
		Idle	800 RPM
1	Starting Contactors	Must not stick closed	
2	Battery Ammeter	0 or +	0 or +
3.	Control Air Pressure	90 $\overset{+}{-}$ 3	
4.	Ground Relay	Yellow	
5.	Main Reservoir	130 to 140	
6.	Air Comp. Intercooler	30# When Pumping	
7.	Air Comp. Oil Pres.	10# Min.	
8.	Lube Oil Level	Run Level	
9.	Eng. Speed & Fuel Ind.	Speed (8) Fuel (5-1/2)	
10	Gov. Oil Level	Between Lines	
11.	Water Temperature	120° Min.	165° $\overset{+}{-}$ 15°
12.	Isolation Switch	"RUN"	
13.	Lube Oil Pressure	6# Min.	30# to 45#
14.	Fuel Supply	As Needed	
15.	Load Regulator	Same as other units	
16.	Lube Oil Suction	Green	
17.	Water Level	Between Lines	
18.	Gen. Water Supply	As Needed	
19.	Overspeed Trip	Latched (Pull to Set)	
20.	Fuel Flow	Thru Glass Nearer Engine	

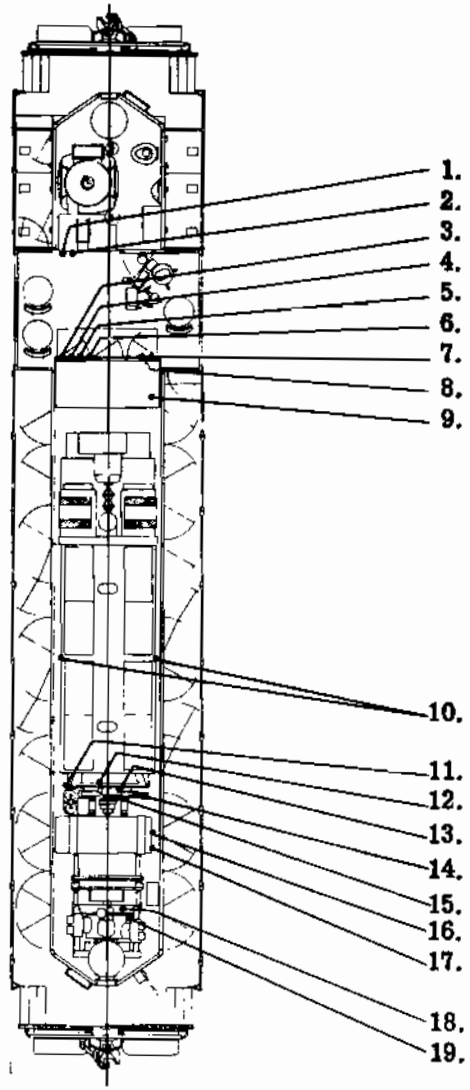


Location Of Gauges, Relays And Equipment
E8 Locomotive

ENGINE ROOM CHECK CHART

	Item	Reading	
		Idle	800 RPM
1	Aux. Gen. Ammeter	20	20+
2	Starting Contactors	Not Stuck St. Position	
3	Ground Relay	Yellow	
4	Control Air Pressure	90+3	
5	Lube Oil Level	Run Level	
6	Fuel Flow	Thru Glass Nearer Engine	
7	Overspeed Trip	Latched (Pull to Set)	
8	Eng. Speed & Fuel Ind.	Speed (8) Fuel (6-1/2)	
9	Gov. Oil Level	Between Lines	
10	Isolation Switch	"RUN"	
11	Fuel Supply Gauge	As Needed	
12	Gen. Water Supply	As Needed	
13	Load Regulator	Same as other units	
14	Lube Oil Pressure	6# Min.	30# to 45#
15	Lube Oil Suction	Green	
16	Water Temperature	125° Min.	165° ± 15°
17	Air Comp. Oil Pres.	10# Min.	
18	Water Level Gauge	Between Lines	
*19	Main Reservoir	130 to 140	

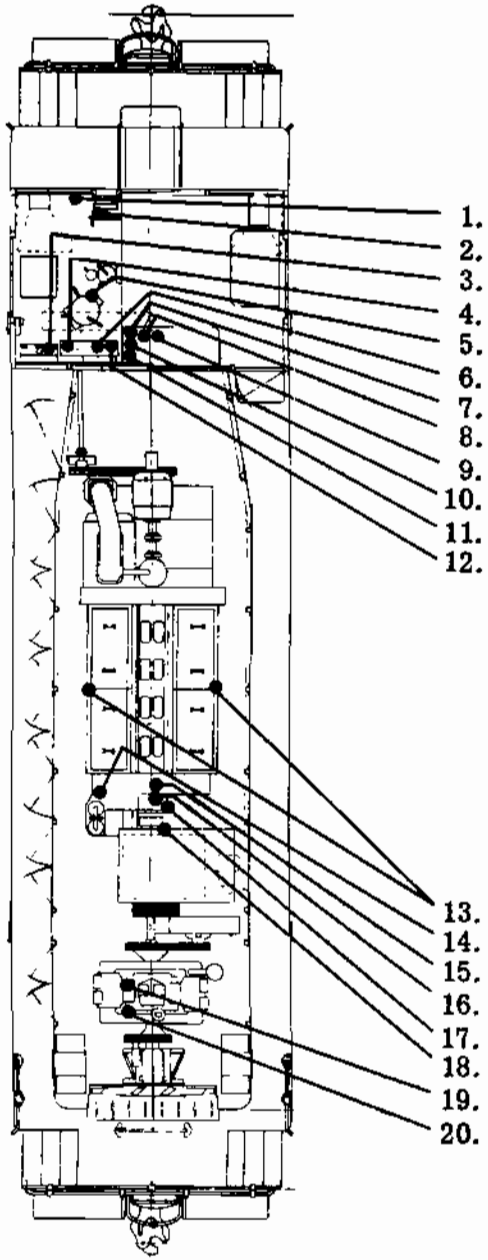
* Not Shown



Location Of Gauges, Relays And Equipment
GP7 Locomotive

ENGINE ROOM CHECK CHART

Item	Reading	
	Idle	800 RPM
1. Stm. Gen. Water Supply	Sufficient supply	
2. Fuel Oil Supply	Sufficient supply	
3. Water Temperature	128° Min.	165° ± 16°
4. Control Air Pressure	90 ± 8 lbs.	
5. Lube Oil Pressure	6 lbs. min.	36 to 45 lbs.
6. Ground Relay	Pointer to yellow dot	
7. Isolation Switch	Run position	
8. Auxiliary Gen. Am.	0 or +	0 or +
9. Starting Contactors	Not stuck in start position	
10. Lube Oil Level	Run level	
11. Fuel Flow	Thru: glass nearer eng.	
12. Overspeed Trip	Latched (Pull to set)	
13. Eng. Speed & Fuel Ind.	Speed (8) Fuel (5-1/2)	
14. Water Pressure	0 to 5 lbs.	25 to 35 lbs
15. Governor Oil Level	Between lines	
16. Cooling Water Level	Between lines	
17. "G" Valve	Run closed	
18. Air Comp. Intercooler	Approx. 80 lbs. when pumping	
19. Air Comp. Oil Pres:	10# Min.	



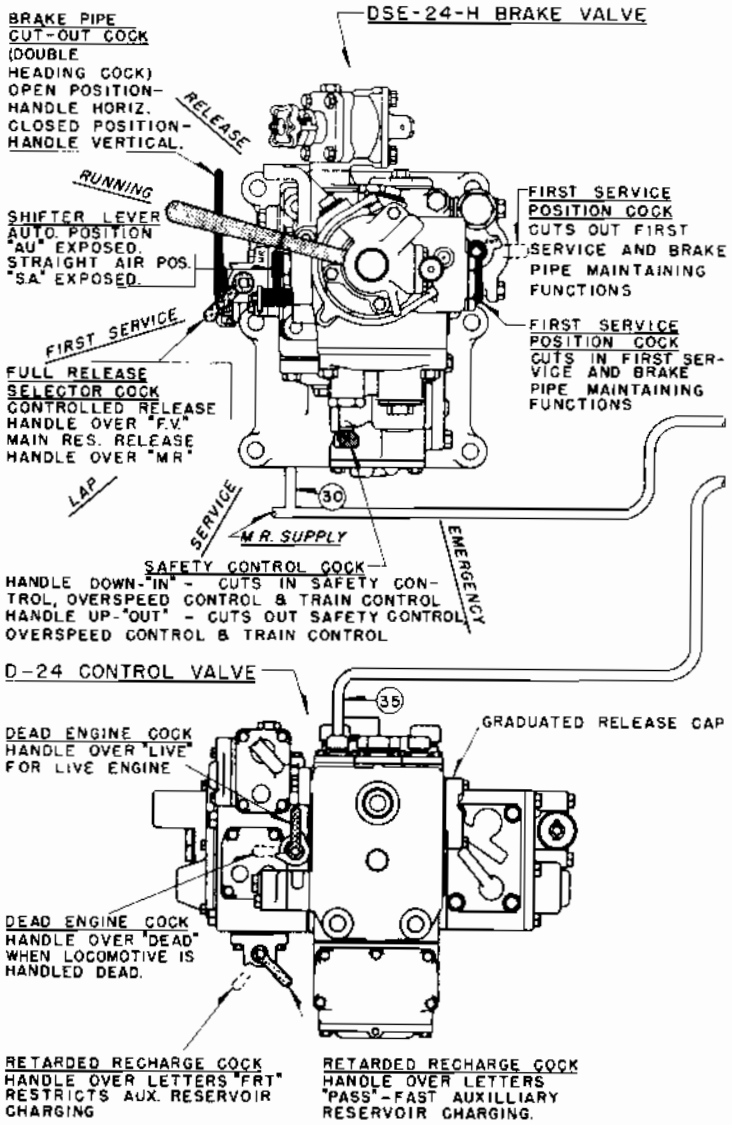
Location Of Gauges, Relays And Equipment
SW8 And SW9 Locomotives

ENGINE ROOM CHECK CHART

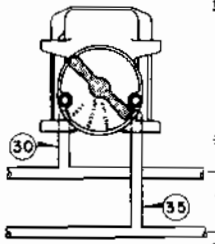
Items In Cab	Reading	
	Idle	800 RPM
1. Isolation Sw. (If used)	Run Position	
2. Hand Brake	Released	
3. Main Reservoir	130 to 140	
4. Lube Oil Pressure	6# Min.	25# to 45#
5. Trans. Selector Sw.	In-(series)	Out-(auto.)
6. Water Temperature	125° Min.	165° ± 15
7. Battery Ammeter	0 or +	0 or +
8. Starting Contactors	Not stuck in start position	
9. Ground Relay	Should be set	
10. Control Air Pressure	90# ± 3	
11. Road Service Switch	(Road-Modified Max.) (Switching-Max.)	
12. Fuel Pressure	5# Min.	

Items In Engine Room

13. Lube Oil Level	Run level
14. Fuel Flow	Thru; glass nearer eng.
15. Overspeed Trip	Latched (Pull to set)
16. Eng. Speed & Fuel Ind.	Speed (8) Fuel (5)
17. Governor Oil Level	Between lines on glass.
18. Water Level	At full mark
19. Air Comp. Oil Pres.	10# Min.
20. Air Comp. Intercooler	Approx. 30# when pumping



K-2-A ROTAIR VALVE



HANDLE OVER LETTERS "FRGT"
CUTS IN CONTROLLED EMERGENCY FEATURE, SPLIT SERVICE REDUCTION, & INDEPENDENT BRAKE VALVE.

HANDLE OVER LETTERS "FRGT LAP" *
CUTS OUT INDEPENDENT BRAKE VALVE CONTROLLED EMERGENCY STILL IN EFFECT.

HANDLE OVER LETTERS "PASS LAP" *
CUTS OUT CONTROLLED EMERGENCY & THE INDEPENDENT BRAKE VALVE

HANDLE OVER LETTERS "PASS"
ALL FEATURES REMAIN CUTOUT AS IN "PASS LAP," EXCEPT INDEPENDENT BRAKE VALVE IS CUT IN.

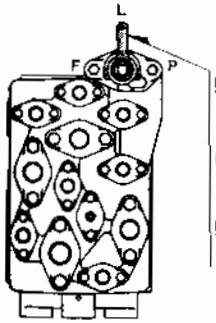
* POSITION USED FOR TRAILING "A" UNITS.

TO INDEPENDENT BRAKE VALVE →

"B" UNIT CONTROL VALVE SECTION

NOTE: WHEN DOUBLE HEADING, THE ROTAIR VALVE ON THE SECOND OPERATING UNIT SHOULD BE LEFT IN A LIVE POSITION, "FRGT" OR "PASS", TO RETAIN USE OF INDEPENDENT BRAKE VALVE

WHEN OPERATING A "B" UNIT ALONE WITH THE HOSTLER'S CONTROL, THE CONTROLLED EMERGENCY SELECTOR COCK MUST BE PLACED IN "PASS" POSITION TO EFFECT QUICK ACTING EMERGENCY IF NEEDED



HANDLE OVER "F"
CUTS IN CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE

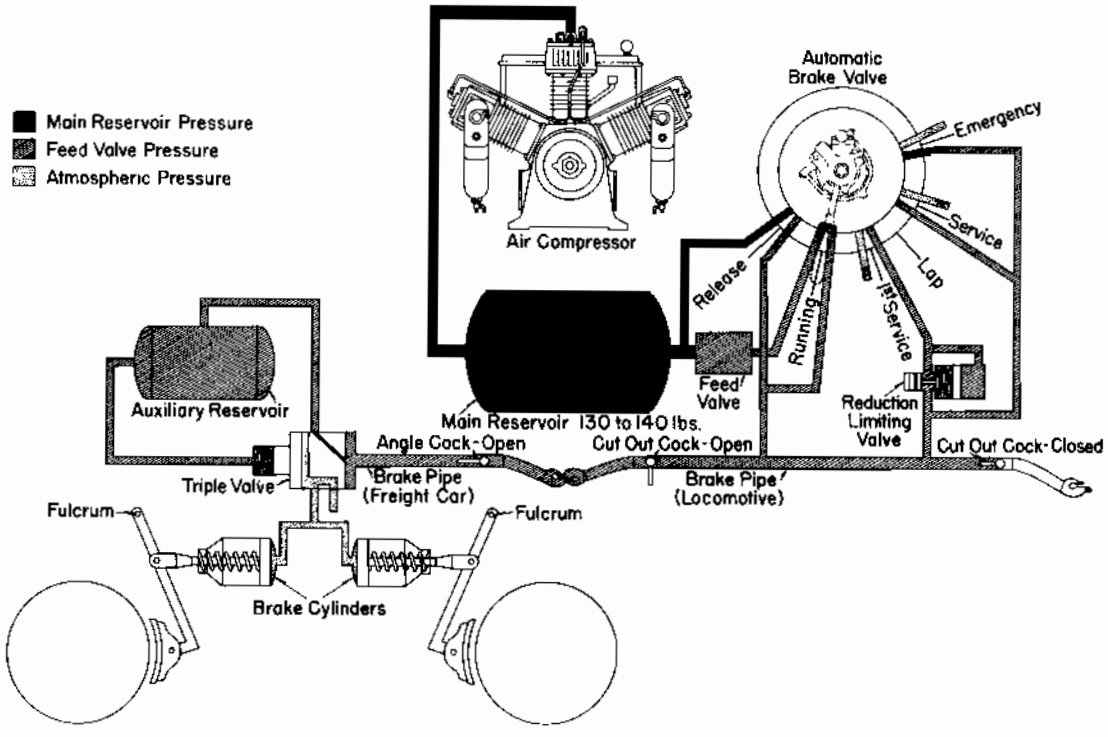
HANDLE OVER "L"
POSITION NOT USED WITH OUR EQUIPMENT HANDLE MUST BE IN PASSENGER OR FREIGHT POSITION.

HANDLE OVER "P"
CUTS OUT CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE

VIEW OF PIPE BRACKET FOR CONTROL VALVES
SHOWING CONTROLLED-EMERGENCY CUT-OUT COCK IN "B" UNITS

Cock Handle Positions
24 RL Brake
All Types Of Service

Basic Automatic Air Brake



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