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
## GENERAL DATA

<table>
<thead>
<tr>
<th>Model</th>
<th>SW8</th>
<th>SW9</th>
<th>TR5</th>
<th>TR6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>0440</td>
<td>0440</td>
<td>0440-0440</td>
<td>0440-0440</td>
</tr>
<tr>
<td>Horsepower</td>
<td>800</td>
<td>1200</td>
<td>2400</td>
<td>1600</td>
</tr>
</tbody>
</table>

### Equipment

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8-567B engine</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12-567B engine</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Model D15C main generator</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Model D27 traction motors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Weight

- Fully loaded (approx.): 250,000 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

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500 Imp. gals. 500 Imp. gals. 1000 Imp. gals. 1000 Imp. gals.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>108 Imp. gals. 137 Imp. gals. 275 Imp. gals. 216 Imp. gals.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Cooling Water Capacity

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>158 Imp. gals. 186 Imp. gals. 372 Imp. gals. 316 Imp. gals.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sand

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28 cu. ft. 28 cu. ft. 56 cu. ft. 56 cu. ft.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### General Dimensions

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck gauge</td>
<td>4' 8-1/2&quot; 4' 8-1/2&quot; 4' 8-1/2&quot; 4' 8-1/2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length over coupler pulling faces</td>
<td>44' 5&quot; 44' 5&quot; 86' 5&quot; 86' 5&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width over hand holds</td>
<td>10' 2&quot; 10' 2&quot; 10' 2&quot; 10' 2&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum height above rail</td>
<td>14' 6-1/4&quot; 14' 6-1/4&quot; 14' 6-1/4&quot; 14' 6-1/4&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track centers</td>
<td>22' 0&quot; 22' 0&quot; 22' 0&quot; 22' 0&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck wheelbase</td>
<td>8' 0&quot; 8' 0&quot; 8' 0&quot; 8' 0&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>40&quot; 40&quot; 40&quot; 40&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum curve radius</td>
<td>100' 0&quot; 100' 0&quot; 100' 0&quot; 100' 0&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting T.E. at 20% Adhesion</td>
<td>46,000 lbs. 49,600 lbs. 99,200 lbs. 92,000 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting T.E. at 25% Adhesion</td>
<td>57,500 lbs. 62,000 lbs. 124,000 lbs. 115,000 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting T.E. at 30% Adhesion</td>
<td>69,000 lbs. 74,500 lbs. 149,000 lbs. 138,000 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## GENERAL DATA
### GP7 LOCOMOTIVE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil Capacity</td>
<td>800</td>
<td>666</td>
</tr>
<tr>
<td>Lube Oil Capacity</td>
<td>200</td>
<td>167</td>
</tr>
<tr>
<td>Cooling Water Capacity (&quot;G&quot; Valve Level)</td>
<td>230</td>
<td>192</td>
</tr>
<tr>
<td>Steam Generator Water Capacity</td>
<td>800</td>
<td>666</td>
</tr>
</tbody>
</table>

### 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

### Specifications:
- Weight - Fully Loaded (Approx.): 240,000 lbs.
- Couplers: Type "E"
- Sand Capacity: 18 cu. ft.
- Number of Drivers: 4 pair
- Wheel Diameter: 40" (1016 mm)
- Weight on Drivers: 100%
- Truck Centers: 31' 0" (9450 mm)
- Truck Rigid Wheelbase: 9' 0" (2743 mm)
- Minimum Curve Radius Coupled To Car: 150' (39 m)
  - Coupled To Another Locomotive Of Same Type With Type "E" Coupling: 274' (21 m)
- Length Between Coupler Pulling Faces: 55' 9" (1693 mm)
- Maximum Height Above Rail: 14' 6" (442 mm)
- Width Over Handrails: 10' 3" (3128 mm)
GENERAL DATA

F7 AND FP7 DIESEL LOCOMOTIVES

Weight (fully loaded) F7A Unit (approx.)...230,000 lbs.
FP7A Unit (approx.)...256,000 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...230 gal.
"B" Unit...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 58/21......102 MPH

Sand Capacity (per unit)...15 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"
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

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

INJECTOR RACK SETTING (ALL 567 SERIES)

1" RACK AT 7/16" POWER PISTON

<table>
<thead>
<tr>
<th>Locomotive Model</th>
<th>Engine Model</th>
<th>Horsepower</th>
<th>Power</th>
<th>Type of Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>6-567A</td>
<td>600</td>
<td>5/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>SW3, TR6</td>
<td>8-567B</td>
<td>800</td>
<td>5/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>NW2, NW3</td>
<td>12-567A</td>
<td>1000</td>
<td>7/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>NW5</td>
<td>12-567A</td>
<td>1000</td>
<td>7/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>E3, E6, E7</td>
<td>12-567A</td>
<td>1000</td>
<td>7/16&quot;</td>
<td>Min. field</td>
</tr>
<tr>
<td>SW7</td>
<td>12-567A</td>
<td>1200</td>
<td>5/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>SW9, TR5</td>
<td>12-567B</td>
<td>1200</td>
<td>5/16&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>E8</td>
<td>12-567B</td>
<td>1125</td>
<td>11/32&quot;</td>
<td>Max. field</td>
</tr>
<tr>
<td>FT</td>
<td>16-567A</td>
<td>1350</td>
<td>7/16&quot;</td>
<td>Min. field</td>
</tr>
<tr>
<td>F2</td>
<td>16-567B</td>
<td>1350</td>
<td>7/16&quot;</td>
<td>Min. field</td>
</tr>
<tr>
<td>F3, F7, GP7, BL1, BL2</td>
<td>16-567B</td>
<td>1500</td>
<td>11/32&quot;</td>
<td>Max. field</td>
</tr>
</tbody>
</table>
Front Three-Quarter View Model 16-567B Engine

- Governor Oil Sight Glass
- Fuel Oil Sight Glasses
- Water Pump
- Lube Oil & Piston Cooling Oil Pumps
- Layshaft
- Top Deck Cover
- Cylinder Test Dock
- Oil Separator
- Blower
- Crankcase
- Air Box Hand Hole Cover
- Flexible Coupling (Flywheel Degree Markings)
- Oil Pan Hand Hole Covers
- Scavenger Oil Pump
- Oil Pan
- Lube Oil Dipstick

Engine Cross Section
Interchangeability Of Heads To Liners

#1 Head

#2 Head

Latched Position

Camshaft

Right Bank Injector Rocker Arms

Cam Camshaft Counterweight

Crank Camshaft

Rocker Arm Pawl

Trip Shaft

Tripshaft To Left Bank Injectors

Trip Lever

Flyweight Reset Lever

Trip Speed Adjusting Nut

Tripped Position
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

<table>
<thead>
<tr>
<th>Throttle Position</th>
<th>Solenoids or Magnet Valves Energized</th>
<th>Engine Speed R.P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>Idle</td>
<td>B</td>
<td>275</td>
</tr>
<tr>
<td>1</td>
<td>C</td>
<td>275</td>
</tr>
<tr>
<td>2</td>
<td>*</td>
<td>350</td>
</tr>
<tr>
<td>3</td>
<td>*</td>
<td>425</td>
</tr>
<tr>
<td>4</td>
<td>*</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>*</td>
<td>575</td>
</tr>
<tr>
<td>6</td>
<td>*</td>
<td>650</td>
</tr>
<tr>
<td>7</td>
<td>*</td>
<td>725</td>
</tr>
<tr>
<td>8</td>
<td>*</td>
<td>800</td>
</tr>
</tbody>
</table>

Cross Section Of Unit Injector

- 21 -

- 22 -
ER Relay Circuit

Schematic Of SI Governor With Electro-Hydraulic Speed Control
Schematic Of PG Governor With Electro-Hydraulic Speed Control
Schematic Diagram - PG Governor

Low Oil Pressure Shutdown
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:
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 amperages.
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, 8000 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.
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 Réverser Magnet Valve - Forward Position
FPC Fuel Pump Contactor
FTM Forward Transition Motor Shunting
FTP Forward Transition Parallel
FTR Forward Transition Voltage Relay
FTS Forward Transition Switch
(G) (Automatic Transition)
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 Switch
IS Isolation Switch
LBP 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
M 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 Réverser 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
ST5  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
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Idle</th>
<th>Full Load</th>
<th>Power Piston</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-567</td>
<td>1.5 GPH</td>
<td>37 GPH</td>
<td>5/16&quot;</td>
</tr>
<tr>
<td>8-567</td>
<td>2.0 GPH</td>
<td>49 GPH</td>
<td>5/16&quot;</td>
</tr>
<tr>
<td>12-567</td>
<td>2.5 GPH</td>
<td>64 GPH</td>
<td>7/16&quot;</td>
</tr>
<tr>
<td>12-567</td>
<td>2.5 GPH</td>
<td>72 GPH</td>
<td>11/32&quot;</td>
</tr>
<tr>
<td>16-567</td>
<td>3.5 GPH</td>
<td>95 GPH</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>16-567</td>
<td>3.5 GPH</td>
<td>85 GPH</td>
<td>7/16&quot;</td>
</tr>
<tr>
<td>16-567</td>
<td>3.5 GPH</td>
<td>98 GPH</td>
<td>11/32&quot;</td>
</tr>
<tr>
<td>12-567</td>
<td>2.5 GPH</td>
<td>75 GPH</td>
<td>5/16&quot;</td>
</tr>
</tbody>
</table>

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 reverse switch must be placed in neutral and locked in that position. To lock the reverse switch, remove the locking pin which during normal operation is screwed into the left hand side of the reverse housing. With the reverse lever in neutral, punch the buttons on top of reverse 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 reverse housing, pushing pin all the way through the reverse switch shaft, and screw pin into threaded hole in reverse 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.

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 dissipated 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.

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.
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.
ENGINE ROOM CHECK CHART

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Starting Contactors</td>
<td>Must have all closed</td>
</tr>
<tr>
<td>2. Battery Ammeter</td>
<td>0 or +</td>
</tr>
<tr>
<td>3. Control Air Pressure</td>
<td>42 ± 3</td>
</tr>
<tr>
<td>4. Ground Relay</td>
<td>Yellow</td>
</tr>
<tr>
<td>5. Main Reservoir</td>
<td>130 to 140</td>
</tr>
<tr>
<td>6. Air Comp. Intercooler</td>
<td>Dry when pumping</td>
</tr>
<tr>
<td>7. Air Comp. Oil Press.</td>
<td>160 min.</td>
</tr>
<tr>
<td>8. Lube Oil Level</td>
<td>Run Level</td>
</tr>
<tr>
<td>9. Eng. Speed &amp; Fuel Ind.</td>
<td>Speed (RPM) Fuel (gph/h)</td>
</tr>
<tr>
<td>10. Gov. Oil Level</td>
<td>Between lines</td>
</tr>
<tr>
<td>11. Water Temperature</td>
<td>100°F to 140°F</td>
</tr>
<tr>
<td>12. Isolation Switch</td>
<td>80°C±</td>
</tr>
<tr>
<td>13. Lube Oil Pressure</td>
<td>50 lbf/in² to 450 lbf/in²</td>
</tr>
<tr>
<td>14. Fuel Supply</td>
<td>As needed</td>
</tr>
<tr>
<td>15. Load Regulator</td>
<td>Same as other units</td>
</tr>
<tr>
<td>16. Lube Oil Suction</td>
<td>Green</td>
</tr>
<tr>
<td>17. Water Level</td>
<td>Between lines</td>
</tr>
<tr>
<td>18. Gen. Water Supply</td>
<td>As needed</td>
</tr>
<tr>
<td>19. Overspeed Trip</td>
<td>Latched (pull to det)</td>
</tr>
<tr>
<td>20. Fuel Flow</td>
<td>Thru glass resealer engine</td>
</tr>
</tbody>
</table>

Location Of Gauges, Relays And Equipment
P7 Locomotive
ENGINE ROOM CHECK CHART

<table>
<thead>
<tr>
<th>Item</th>
<th>Reading</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Aux. Gen. Ammeter</td>
<td>20</td>
<td>20+</td>
</tr>
<tr>
<td>2 Starting Contactors</td>
<td>Not Stock St. Position</td>
<td></td>
</tr>
<tr>
<td>3 Ground Relay</td>
<td>Yellow</td>
<td></td>
</tr>
<tr>
<td>4 Control Air Pressure</td>
<td>90°-120°</td>
<td></td>
</tr>
<tr>
<td>5 Lube Oil Level</td>
<td>Not Level</td>
<td></td>
</tr>
<tr>
<td>6 Fuel Flow</td>
<td>Speed 60% Near Radiator</td>
<td>Latched (Full to Set)</td>
</tr>
<tr>
<td>7 Overspeed Trip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Eng. Speed &amp; Fuel Ind.</td>
<td>Speed 60% Near Radiator</td>
<td>Speed of Fuel (6-1/2)</td>
</tr>
<tr>
<td>9 Gov. Oil Level</td>
<td>Between Lines</td>
<td></td>
</tr>
<tr>
<td>10 Isolation Switch</td>
<td>&quot;Yes&quot;</td>
<td></td>
</tr>
<tr>
<td>11 Fuel Supply Gauge</td>
<td>As Needed</td>
<td></td>
</tr>
<tr>
<td>12 Gen. Water Supply</td>
<td>As Needed</td>
<td></td>
</tr>
<tr>
<td>13 Load Regulator</td>
<td>Same as other units</td>
<td></td>
</tr>
<tr>
<td>14 Lube Oil Pressure</td>
<td>60 psi to 100 psi</td>
<td></td>
</tr>
<tr>
<td>15 Lube Oil Suction</td>
<td>Greens</td>
<td></td>
</tr>
<tr>
<td>16 Water Temperature</td>
<td>180°F Min. 140°F Max.</td>
<td>180°F + 10°F</td>
</tr>
<tr>
<td>17 Air Comp. Oil Pres.</td>
<td>100 psi</td>
<td></td>
</tr>
<tr>
<td>18 Water Level Gauge</td>
<td>Between Limits</td>
<td></td>
</tr>
</tbody>
</table>

* Not Shown

Location Of Gauges, Relays And Equipment
E8 Locomotive
### ENGINE ROOM CHECK CHART

<table>
<thead>
<tr>
<th>Item</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Fuel Oil Supply</td>
<td>Sufficient supply</td>
</tr>
<tr>
<td>3. Water Temperature</td>
<td>180° Max. 140° Min.</td>
</tr>
<tr>
<td>4. Control Air Pressure</td>
<td>30 ± 5 lbs</td>
</tr>
<tr>
<td>5. Lube Oil Pressure</td>
<td>15 lbs. Min. 35 to 45 lbs.</td>
</tr>
<tr>
<td>6. Ground Relay</td>
<td>Pointer to yellow dot</td>
</tr>
<tr>
<td>7. Isolation Switch</td>
<td>Eng position</td>
</tr>
<tr>
<td>8. Auxiliary Gen. Am.</td>
<td>0 or + 0 or +</td>
</tr>
<tr>
<td>9. Starting Contactors</td>
<td>Not stuck to start</td>
</tr>
<tr>
<td>10. Lube Oil Level</td>
<td>Run level</td>
</tr>
<tr>
<td>11. Fuel Flow</td>
<td>3/4 full-gauge mark</td>
</tr>
<tr>
<td>12. Overspeed Trip</td>
<td>Latched (Pull to set)</td>
</tr>
<tr>
<td>13. Eng. Speed &amp; Fuel Ind.</td>
<td>Speed (rpm) Fuel (L/H)</td>
</tr>
<tr>
<td>14. Water Pressure</td>
<td>0 to 5 lbs. 25 to 35 lbs.</td>
</tr>
<tr>
<td>15. Governor Oil Level</td>
<td>Between lines</td>
</tr>
<tr>
<td>16. Cooling Water Level</td>
<td>Between lines</td>
</tr>
<tr>
<td>17. &quot;C&quot; Valve</td>
<td>Run closed</td>
</tr>
<tr>
<td>18. Air Comp. Intercooler</td>
<td>Approx. 40 lbs when full</td>
</tr>
<tr>
<td>19. Air Comp. Oil Press.</td>
<td>100 lbs.</td>
</tr>
</tbody>
</table>

Location Of Gauges, Relays And Equipment
GP7 Locomotive
HANDLE OVER LETTERS "FAST"  
CUTS OUT CONTROLLING EMERGENCY FEATURE, SPLIT SERVICE REDUCTION & INDEPENDENT BRAKE VALVE.

HANDLE OVER LETTERS "FLAT"  
CUTS OUT INDEPENDENT BRAKE VALVE CONTROLLING EMERGENCY STILL IN EFFECT.

HANDLE OVER LETTERS "PASS"  
CUTS OUT CONTROLLING EMERGENCY B THE INDEPENDENT BRAKE VALVE.

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

* POSITION USED FOR TRAILING 'A' UNITS.

"B" UNIT CONTROL VALVE SECTION

NOTE WHEN DOUBLE HEADER, THE ROTARY VALVE ON THE SECOND OPERATING UNIT SHOULD BE LEFT IN A SAFE POSITION, "FAST" OR "PASS", TO RETAIN USE OF INDEPENDENT BRAKE VALVE.

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

HANDLE OVER "A"  
CUTS OUT CONTROLLING 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 "D"  
CUTS OUT CONTROLLING 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