OPERATOR'S MANUAL

STANDARD 1600-H.P. ALL-SERVICE DIESEL-ELECTRIC LOCOMOTIVES

BALDWIN-LIMA-HAMILTON CORPORATION
PHILADELPHIA, PA.

OPERATOR'S MANUAL

No. AS-101-A

STANDARD 1600-HP. ALL-SERVICE DIESEL-ELECTRIC LOCOMOTIVES

WITH D-1 CONTROLLER and 6-SL BRAKE EQUIPMENT

Plus Modifications, Such As

MULTIPLE UNIT CONTROL
DYNAMIC BRAKING
CE-100 CONTROL STAND
24-RL BRAKE EQUIPMENT
DUAL CONTROL STANDS, etc.

BALDWIN-LIMA-HAMILTON CORPORATION
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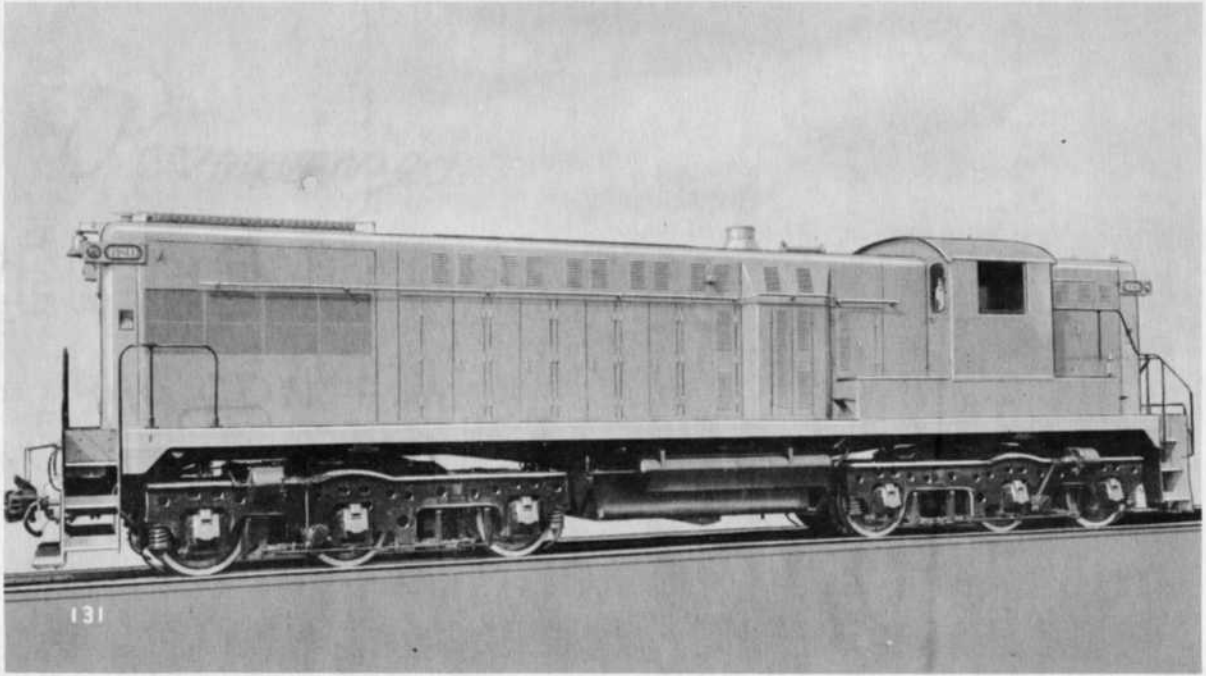

1600-HP., ALL-SERVICE LOCOMOTIVE (AS-616) — FIGURE 1

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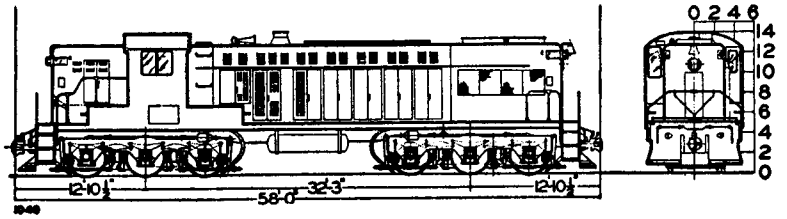
LIST OF ILLUSTRATIONS



TYPICAL LOCOMOTIVE DIAGRAM

Over-all Length and Center Pin Locations are Identical for All Three Classifications Listed Below.

FIGURE 2

1600-HP. ALL-SERVICE LOCOMOTIVE

GENERAL SPECIFICATIONS

B.L.W. Classification	AS-16	AS-416	AS-616
Wheel Arrangement	0-4-4-0	0-6-6-0	0-6-6-0
Wheel Diameter	42"	42"	42"
Driving Motors	4	4	6
Gear Ratio	15:68 15:63 17:62	15:68 15:63 —	15:68 15:63 —
Max. Speed—MPH (15:68 Gear Ratio)	65	65	60
Max. Speed—MPH (15:63 Gear Ratio)	70	65	60
Max. Speed—MPH (17:62 Gear Ratio)	80	—	—
Total Approx. Wgt. Lb., in Working Order	242,000	255,000	325,000
Diesel Engine (One) Supercharged	8 Cylinder	8 Cylinder	8 Cylinder
Fuel Oil Tank, Gal. Capacity	900	900	1900

Lubricating Oil Capacity ..... 200 Gal.

Cooling Water Capacity ..... 300 Gal.

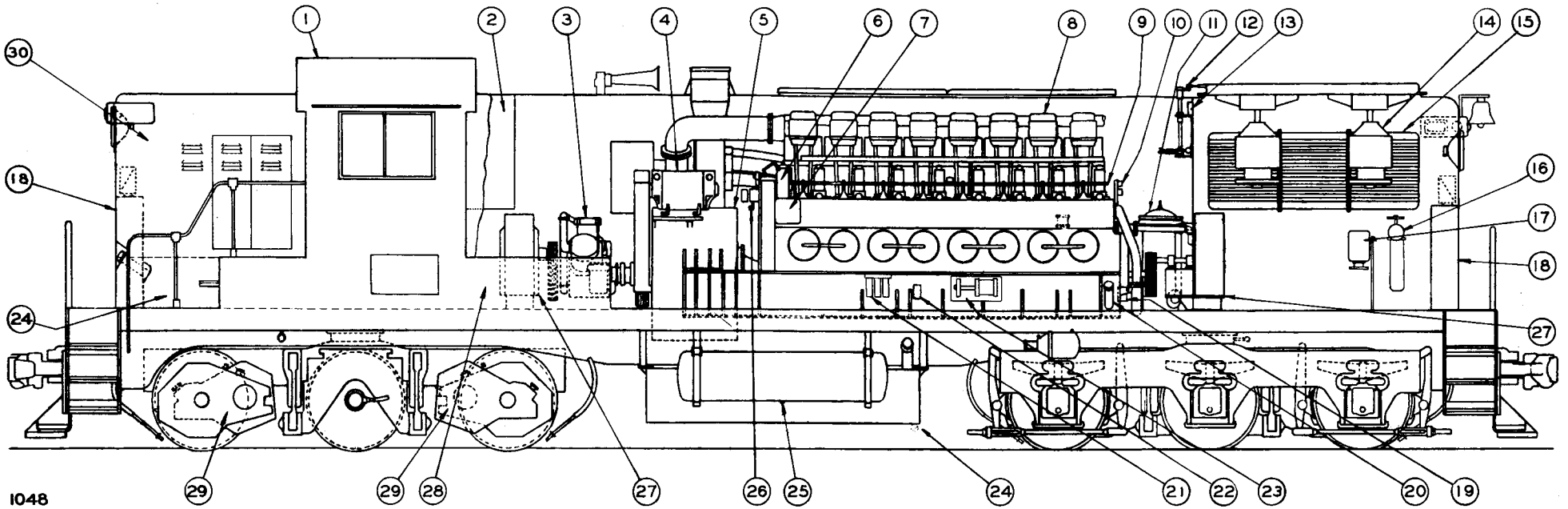
Sand Capacity ..... 30 Cu. Ft.

GENERAL DESCRIPTION

The following operating instructions apply to standard 1600-hp all-service locomotives. These locomotives are designed for flexible operation in either general switching or road service. The standard 4-motor or 6-motor single unit locomotives may be obtained with modifications which permit multpile unit operation or dynamic braking. Such equipment is an addition to the locomotive, and normal operation of multiple unit locomotives as a single unit, or of dynamically braked locomotives in motoring, remains unchanged except to check that certain items are properly set. Such equipment is generally designated "if installed," and its absence on any locomotive in no way affects the suitability of the remaining instructions. Other modifications, such as 24-RL brake equipment, and dual control stands, require revision instead of addition to the instructions, and such operating instructions are described in separate paragraphs.

Crews should be familiar with the cab and equipment cabinet which are described on the pages immediately following. They should also be familiar with manual fan and shutter operation, and with various protective devices located elsewhere on the locomotive, such as circuit breakers, the overspeed stop, the emergency fuel cut-off valve, engine shut-down valve, ground relay, etc., and the related alarm system. Location of principal items outside the cab and cabinet are shown in Figure 3, and the description thereof may be found by reference to the index.

An eight cylinder, supercharged diesel engine drives a direct connected main generator which delivers electric power to traction motors geared to the driving axles. Automatic load regulation is provided through an Auto-Load control system, which protects the diesel engine from overload, and assures maximum smooth acceleration and full engine power output throughout the normal operating range. This automatic determination of available power does not require judgment by the engineer. The throttle controls speed and power with maximum



LOCOMOTIVE — ARRANGEMENT OF EQUIPMENT

FIGURE 3

1. OPERATING CAB
2. ELECTRICAL EQUIPMENT CABINET
3. COMPRESSOR
4. AUXILIARY GENERATOR
5. MAIN GENERATOR
6. ENGINE GOVERNOR
7. OVERSPEED STOP
8. ENGINE
9. FUEL CONTROL SHAFT
10. PANEL—LUBE OIL SWITCH, HOT WATER SWITCH (if installed), ENGINE SHUTDOWN VALVE
11. LUBE OIL FILTER
12. MANUAL SHUTTER CONTROL
13. TEMPERATURE CONTROL EQUIPMENT
14. FAN MOTOR
15. WATER RADIATOR
16. LUBE OIL STRAINER (Metal Edge)
17. HEAT EXCHANGER
18. SAND BOX
19. LUBE OIL SUCTION STRAINER
20. LUBE OIL FILLER
21. FUEL OIL FILTER
22. FUEL OIL STRAINER
23. FUEL PUMP
24. FUEL TANK (Tank under locomotive supplied as extra optional equipment)
25. AIR RESERVOIR
26. LOAD REGULATOR
27. BLOWERS
28. BATTERY BOX
29. TRACTION MOTORS
30. REAR COMPARTMENT (Houses Dynamic Braking or Boiler, if installed)

simplicity, leaving the engineer free to handle other controls and observe gauges, signals and road conditions.

An auxiliary generator charges the battery, energizes the control circuits, and supplies the exciter 4-pole field at a regulated constant voltage. The exciter furnishes main generator field excitation. The battery starts the engine and provides standby lighting service. The engine is started from the cab by pressing the start buttons which control the starting circuit, connecting the battery at the main generator which acts as a motor while cranking the engine. Traction motor blowers are engine driven; radiator fans are motor driven.

Air for the brakes is supplied from a main reservoir at a pressure of 125 lb. to 140 lb. Air is pumped into the reservoir by a two-stage compressor which operates whenever the diesel engine runs. A compressor governor, connected to the main reservoir, determines whether or not the compressor is actually pumping air into the high pressure lines. A governor cut-out is set to prevent pressure in excess of 140 lb., and to resume pumping when pressure drops to 125 lb. A pneumatic control system operating in conjunction with the throttle and electrical equipment, functions at a pressure of 70 psi. It will require no attention during normal operation if the gauges indicate the proper reading.

Crews who are not familiar with multiple unit operation should carefully observe the distinction between double heading and multiple unit operation when reading or applying these instructions. In multiple unit operation, locomotives of the same type are connected electrically in addition to the coupling of the draw bar and air lines, and one locomotive controls all units. In double heading, locomotives which are not similar may be coupled, and are controlled independently except the brakes which are handled by the designated lead locomotive.

LOCOMOTIVE CAB

Controls and instruments necessary for routine operation of the locomotive are conveniently located in front of the engineer. A thorough knowledge of the engineer's equipment in the accompanying illustrations will enable the operator to understand various modifications which may be encountered on specially equipped individual locomotives.

Throttle—The throttle controls the speed and power of the locomotive pneumatically, as shown on page 43 for standard D-1 control equipment. Piping is somewhat different for the CE-100 controller. However, in both types the throttle is advanced smoothly through an infinite number of positions. There is a definite engine speed and power output at each position, which enables the operator to handle the train more smoothly, and reduces the likelihood of wheels slipping from stepped-up applications of power. No transition is necessary. The CE-100 controller is used largely with dynamic braking installations because of the increased number of electrical connections involved. The electrical and pneumatic action is automatic in normal operation of both types of controller.

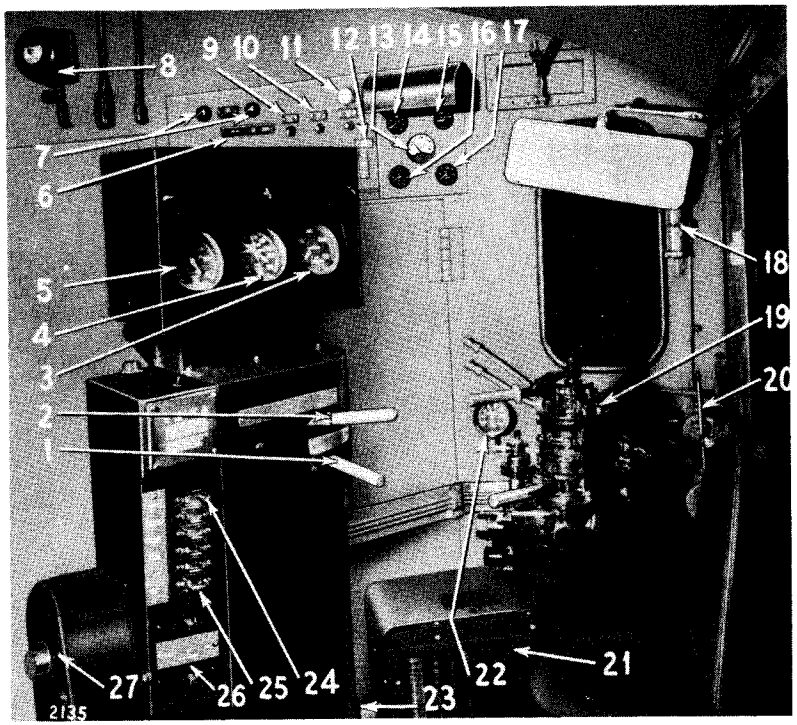
Reverse Lever—The reverse lever controls the direction of travel, and is interlocked with the throttle so that it cannot be moved except when the throttle is off. It has 3 positions, Forward, Reverse and Off. An additional braking position is provided on locomotives equipped for dynamic braking.

Brake Equipment—Standard 6-SL brake equipment is mounted on the brake pedestal, unless otherwise stated in these instructions. Gauges are located on the control stand, or the control panel on the front wall of the cab.

Nameplates identify the various electrical switches in the cab. The function of the lighting switches is obvious, and the use of other switches is clearly set forth in the operating instructions. Briefly, these switches are provided for the following purposes.

Control Switch—This is the master switch to the control circuits, and must be closed to start the diesel engines or

ENGINEER'S POSITION IN CAB



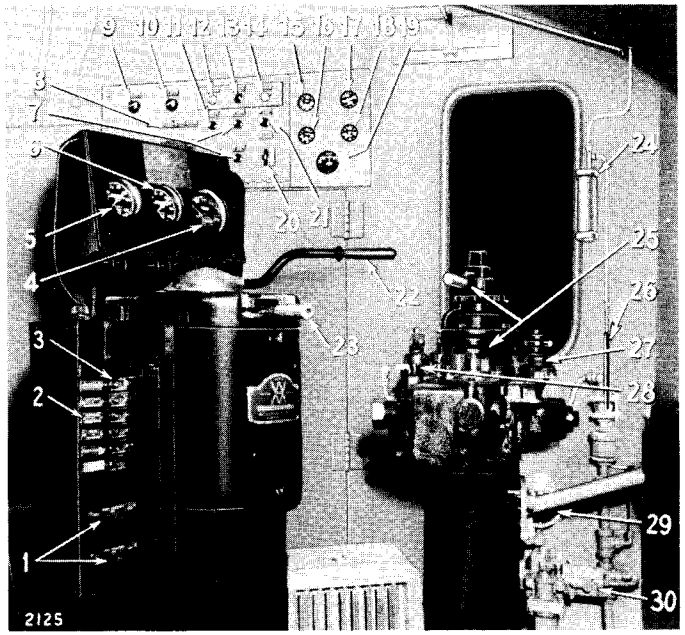
MANUAL CONTROLS

Typical D-1 Control Stand with 6-SL Brake Equipment

FIGURE 4

1. REVERSE LEVER
2. THROTTLE
3. LOAD AMMETER
4. MAIN AND EQUALIZING RESERVOIR PRESSURE GAUGE
5. BRAKE PIPE AND CYLINDER PRESSURE GAUGE
6. FIELD OR CONTROL SWITCHES (see nameplate)
7. HEATER RHEOSTAT
8. ALARM BELL
9. STACK ALARM BUTTON
10. ENGINE START BUTTON
11. GROUND RELAY LIGHT AND RESET
12. RADIATOR FAN AND SHUTTER SWITCH
13. BATTERY AMMETER
14. FUEL OIL PRESSURE GAUGE
15. WATER TEMPERATURE GAUGE
16. LUBE OIL PRESSURE GAUGE (Turbocharger)
17. LUBE OIL PRESSURE GAUGE (Engine)
18. WINDSHIELD WIPER
19. BRAKE PEDESTAL (Automatic and Independent Brake Valves, Bell Ringer, etc.)
20. WHISTLE
21. CAB HEATER
22. CONTROL AIR PRESSURE GAUGE
23. WHEEL SLIP BUZZER
24. CONTROL SWITCH
25. LIGHTING SWITCHES
26. HEADLIGHT SWITCH
27. HAND BRAKE

ENGINEER'S POSITION IN CAB



MANUAL CONTROLS

Typical CE-100 Control Stand with Dynamic Braking

FIGURE 5

1. HEADLIGHT SWITCHES
2. LIGHTING SWITCHES
3. CONTROL SWITCH
4. LOAD AMMETER
5. BRAKE PIPE AND CYLINDER PRESSURE GAUGE
6. MAIN AND EQUALIZING RESERVOIR PRESSURE GAUGE
7. ENGINE STARTING BUTTONS
8. LIGHTING HEATER AND AUXILIARY GENERATOR FIELD SWITCHES
9. HEATER RHEOSTAT
10. HEATER RHEOSTAT
11. BRAKE FAN RELAY RESET BUTTON
12. INDICATING LIGHT—FAN STOPPED
13. INDICATING LIGHT—BRAKING OVERLOAD
14. INDICATING LIGHT—GROUND
15. FUEL OIL PRESSURE GAUGE
16. LUBE OIL PRESSURE GAUGE (Turbocharger)
17. WATER TEMPERATURE GAUGE
18. LUBE OIL PRESSURE GAUGE (Engine)
19. BATTERY AMMETER
20. FAN AND SHUTTER SWITCH
21. GROUND RELAY RESET BUTTONS
22. THROTTLE
23. REVERSE LEVER
24. WINDSHIELD WIPER
25. BRAKE VALVES (Automatic and Independent)
26. WHISTLE VALVE
27. BELL RINGER
28. SANDER
29. CONTROL AIR PRESSURE GAUGE
30. CONTROL AIR REDUCING VALVE

operate the locomotive. On locomotives connected for multiple unit operation, the control wire is train-lined to all units, and only the leading or controlling unit should have its control switch closed.

Auxiliary Generator Field Switch—This switch must be closed to excite the fields and charge the battery. Without field excitation, there is no power. This 35-amp switch in the cab is separate from the 200-amp Auxiliary Generator Power Switch in the cabinet, which is normally closed.

Fan and Shutter Switch—This switch feeds the fan control circuit. It is normally in the automatic position. See further details under "Cooling Water System."

Engine Control Switch—This switch is only on locomotives equipped for multiple unit operation, unless otherwise specified. It is fed through the Control Switch, and enables the operator to idle or stop an engine without cutting out the locomotive control circuits. It must be closed to run the diesel engine on any unit so equipped. Locomotives in multiple may be controlled from the cab of a leading unit which is idled or stopped by the engine control switch.

Stack Alarm Button—This is a cut-out switch to check whether high exhaust temperature is the cause of an alarm. Press the button and if the alarm stops, it is caused by high temperature.

Ground Relay Reset Button—Cuts out ground relay. See detailed description of its function, page 25.

Circuit Breakers—Breaker type switches are used to protect various electrical circuits, thereby eliminating fuses. These switches open automatically when overloaded, and are closed manually. After opening, they must be moved to the full "off" position before being reclosed. The Control Switch, the Auxiliary Generator Field Switch and all lighting switches except the headlight switch are breakers.

Alarm System—All indicator lights and audible alarms should be thoroughly understood. The wheel slip buzzer

is independent of any other alarm. The alarm bell may be connected to several protective devices, in which case indicator lights will generally show the nature of the trouble. The simplest installation on single unit locomotives provides an alarm bell for the stack switch, and the ground relay in many cases lights a light without ringing the bell. On multiple unit locomotives, the ground relay, water temperature switch, and engine shut-down (low lube oil) are also connected to the alarm bells, which will ring in all units, but indicator lights, if any, will burn only in the faulty unit. Frequently a light is not provided if the protective device shuts down or idles the engine, because that in itself is an indication. In dynamic braking, additional lights may be installed, as described thereunder.

Heater Rheostats—Controls variable-speed fans in cab heaters.

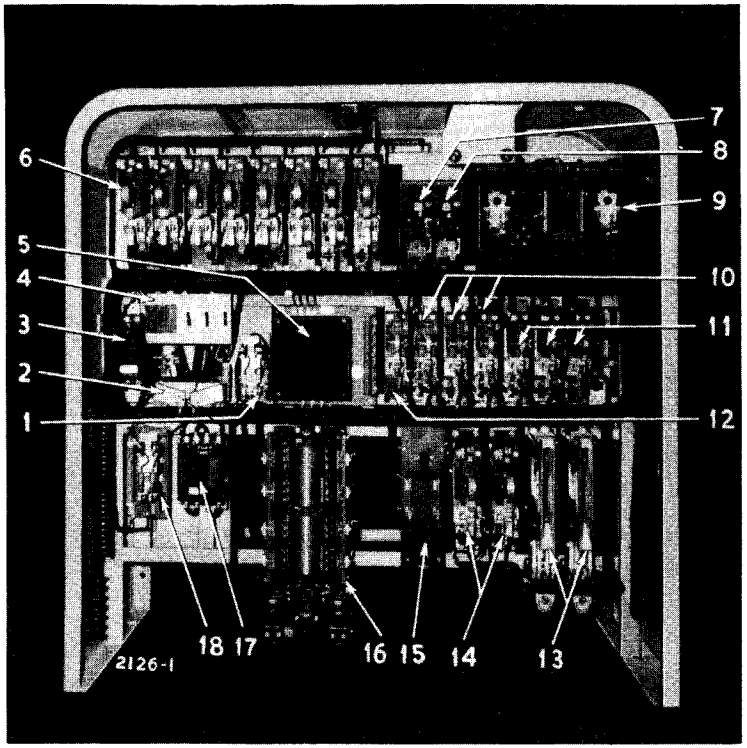
ELECTRICAL EQUIPMENT CABINET

SAFETY NOTE: The main power circuits operate at 600 volts or more. Cabinet doors should not be opened except by authorized and qualified personnel. When doors are open, it is important that adequate safety rules be observed.

Most of the electrical equipment is located in a cabinet situated between the cab and the diesel engine. This equipment as viewed from the cab is shown on the opposite page.

Most of the equipment in the cabinet functions automatically. The following manually controlled switches are in the low voltage control circuit, and crews should be familiar with their use as outlined below.

Battery Switch—Must be closed to energize all control circuits, and all lighting circuits except the cab and cabinet lights which are fed directly from the battery.



VIEW OF CABINET FROM CAB

FIGURE 6

1. PROTECTIVE STARTING RELAY
2. REVERSE CURRENT RELAY
3. AUXILIARY GENERATOR POWER SWITCH
4. SWITCHES (for cutting out Traction Motors, Ground Relay, M.U., etc., see name plates)
5. VOLTAGE REGULATOR
6. TRACTION MOTOR FIELD SHUNTING CONTACTORS (8)
7. POWER CONTROL CONTACTOR
8. EXCITER FIELD CONTACTOR
9. TRACTION MOTOR FIELD SHUNTING CONTROLLER
10. FAN MOTOR CONTACTORS
11. GENERATOR FIELD CONTACTORS
12. REVERSE CURRENT CONTACTOR
13. PNEUMATIC POWER SWITCHES
14. ENGINE STARTING CONTACTORS
15. BATTERY SWITCH
16. REVERSER
17. FAN MOTOR BREAKER
18. FAN MOTOR RELAY

Circuit Breakers—The following protective switches open automatically when overloaded, and must be closed manually.

Fan Motor—high voltage power from the main generator.

Auxiliary Generator—low voltage power to the control circuits, fuel pump motor, lights and battery.

Control and Lighting—various low voltage circuits.

Traction Motor Cut-out Switches—Use in event of a traction motor failure (page 21).

Ground Relay Cut-out Switch—For use in cutting out ground relay until a ground in the high power voltage circuit can be rectified (page 25).

Multiple Unit Switch—When installed, is utilized for transferring control to opposite end when two or more locomotives are being operated as a single unit (pages 29-32).

It is important that operators do not attempt to adjust or repair the load regulator or the voltage regulator or change relay settings.

The principal items of electrical control equipment not mounted in the electrical cabinet are: the shutter valve, engine shut-down valve, lube oil pressure switch, hot water switch (if installed), and temperature control switches. Consult "Arrangement of Equipment" diagram, Figure 3 for location of these items.

LOCOMOTIVE OPERATION

SUMMARY OF NORMAL OPERATION

I. To Start Diesel Engine:

A. The auxiliary generator field switch should be open.
B. The battery switch must be closed.
C. The control switch must be closed. (In multiple unit operation, close leading unit only.)
D. On multiple unit equipment, close engine control switch and check that multiple unit switch is in correct position.
E. Check that throttle and reverse lever are off.
F. Press No. 1 start button. If necessary to crank faster, press No. 2 start button, keeping No. 1 button in. Press firmly, until lube oil pressure reaches 19 pounds. (Do not drain battery if engine does not turn.)
G. Close auxiliary generator field switch after starting.

II. To Move Locomotive:

A. Check air pressure and perform brake test.
B. Move reverse lever to desired direction.
C. Release brakes.
D. Advance throttle (slowly).

III. Miscellaneous:

A. Keep ammeter readings within posted load limits.
B. Come to full stop before reversing.
C. Reverse lever is interlocked so it cannot be moved except when throttle is off.
D. Check gauge readings.
E. When stopping, retard throttle before applying brakes, to avoid electrical overload.

IV. To Shutdown Locomotive:

A. Open control switch. This stops the engine.
B. Open battery switch.
C. Open auxiliary generator field switch.
D. Set hand brake. Remove reverse lever and brake handles.

DETAILS OF OPERATION

Normal operating procedures for standard all-service locomotives for single unit operation, or with additional equipment for multiple unit operation or dynamic braking, are almost identical with each other. The following information applies to all such locomotives unless otherwise designated. Separate paragraphs are devoted to special modifications in equipment, and to specific details of multiple unit operation and dynamic braking.

I. Preliminary:

A. Check the following supplies:
   1. Fuel oil.
   2. Engine crankcase oil.
   3. Air compressor crankcase oil.
   4. Engine governor oil.
   5. Engine cooling water.
   6. Sand.

B. Check for any leaks in fuel, water and lubricating oil piping. Leaks are more probable on a warm engine under normal pressure, and any leaks observed under such conditions should be reported.

C. Turn on lights, if necessary. On most locomotives, no lights but the cab lights will burn until the battery switch in the equipment cabinet is closed.

D. Inspect the engine, generator and other machinery for rags, tools, etc., that may have been accidentally left near moving parts.

II. Starting the Diesel Engine:

A. Close the battery switch in the cabinet. While cabinet doors are open, check that circuit breakers are closed (Auxiliary Generator, Fan, and Control-Lighting Breakers), check that Traction Motor Cut-out Switch, Ground Relay Cut-out Switch, etc., are set properly.

.ultiple unit operation, the Engine
hould be on, and the multiple unit

switch should be in single unit position "S" when operating alone, or in lead.

C. Insert reverse lever. Leave it in the "off" position.

D. Check that throttle is off.

E. Close the control switch on control stand. The fuel supply pump should start, and a pressure of 25 lbs. minimum should be indicated on the fuel oil pressure gauges. If pump runs and no pressure is indicated, check fuel supply or emergency fuel cut-off valve at the fuel tank and reset if necessary. On multiple unit locomotives alarm bell rings until start button is pressed. The control switch is not closed in trailing units.

F. Press No. 1 "engine start" button. If necessary to crank faster, press No. 2 "engine start" button, keeping No. 1 button in. Press firmly until the engine fires and a lubricating oil pressure of 19 lb. shows on the gauge. Releasing the start button before the required pressure is indicated, permits the engine shut-down device to stop the engine. If engine does not fire, do not hold button in for prolonged periods because continued cranking will run down the battery. If the engine does not rotate, release button immediately.

G. Close the auxiliary generator field switch at engineer's position to establish normal field excitation and charge the battery.

H. Let the engine idle until the water temperature reaches 120° F.

III. Pumping Air:

A. As the engine runs, the air compressor will pump air into the main reservoirs. Check the main reservoir air pressure to be sure the compressor stops pumping when the governor cut-out setting of 140 lb. is reached.

B. Air may be pumped at a higher rate with the locomotive at standstill (initially charging the line), or while coasting downgrade with a train. Bring the engine speed above idling as follows:
   1. Leave the reverse lever in the "off" position.
   2. Increase the throttle setting, speeding up the engine and the compressor, until the pumping rate desired is reached.
   3. Return the throttle to the "off" position when air pressure gauge registers required pressure.

C. Be sure the air compressor resumes pumping when the main reservoir pressure drops to the lower governor setting of 125 lb.

D. Check the control air pressure gauge. It should read 70 lb.

IV. Moving the Locomotive:

A. With the engine running and the throttle and reverse lever off, make sure that:
   1. The automatic and independent air brakes apply and release properly. Release hand brake.
   2. The traction motor blowers are operating properly.
   3. The radiator fans are operating. They are electrically driven. The fan switch should be in "auto" position. (See Cooling System for non-automatic operation.)

B. Move the reverse lever to the "forward" or "reverse" position according to the direction the locomotive is to travel.

C. Release brakes and advance the throttle slowly until current is indicated on the load ammeter. If the train is not too heavy nor the grade severe, the locomotive will move. If the locomotive does not move, return the throttle to the "off" position immediately.

D. When the meter registers current and the train starts to move, slowly move the throttle to the position required for the train acceleration desired. As train speed increases the traction motor fields are automatically weakened by shunting the field windings with resistance, rendering it possible to run at higher speeds. Amperage increases at time of shunting. No transition, or manual operation, is required.

E. The throttle should be moved slowly to prevent the wheels from slipping. If the wheels should slip, the wheel slip buzzer will sound and the diesel engine speed will automatically decrease until the slipping stops. If wheels slip again, retard the throttle until wheel slip stops. Do not use sand. See next paragraph.

V. Sanding:

Do Not Apply Sand While the Wheels are Slipping.

Sand is a preventive, not a corrective, measure. Always use sand sparingly. The even starting torque of the diesel-electric locomotive makes use of sand seldom necessary. If sand is necessary, it may be applied as follows:

1. On locomotives equipped with hand sanding, moving the sanding lever to the forward position will apply sand in front of both trucks; and moving the lever to the reverse position will apply sand to the rear of both trucks.
2. On locomotives equipped with electric sanding, turning the sander valve will sand either the front or the rear of both trucks, depending on the position of the reverser.

VI. Electrical Load Limits:

Overheating due to excessive loads can result in serious damage to electrical equipment which may not be apparent immediately but can cause failure later. Electrical apparatus will safely carry an overload for a

limited time if maximum allowable temperature has not been reached. A table of allowable load limits under full cooling (i.e., full engine speed) is posted in front of the engineer.

Operators Should Always Keep Within the Posted Load Limits. Overload is permitted only after the equipment has been adequately cooled (either by an idling engine, or by certain non-overload operation as set forth on the plate). When the time limit is reached for any overload, no overload capacity exists at any other amperage above continuous rating. The engine must then be idled to cool the equipment unless the train can continue at full engine speed at or below the continuous rating. The crew should pay careful attention to load limits in any abnormal operation as for example, when a traction motor is cut out, or when motors are overloaded at less than full engine speed (full throttle). The latter condition may exist in humping, or with heavy tonnage upgrade under speed restrictions. Overload capacity is considerably reduced when blowers operate at less than full engine speed.

VII. Inspections During Operation:

A. Check gauges frequently. Investigate and report any great deviation from normal.

1. Lube oil pressure, engine—Normal 50 lb. to 55 lb. when engine is operating at full speed and normal operating temperatures have been reached.
2. Lube oil pressure, turbocharger—Normal 22 lb. to 25 lb. at full engine speed.
3. Fuel oil pressure—Normal 20 to 25 lb.
4. Water temperature—about 150° to 190° F. If engine is too hot, check that manual shutter control handle is not partially closed, or try manual operation described on page 41, or stop engine.
5. Control air pressure—Normal 70 lb.

B. Rotate the handles on the metal edge lubricating oil strainer two full turns every day. This strainer is located in the radiator compartment.

C. Check the cooling water level on the gauge at expansion tank every 8 hours. Level must be maintained so that water is visible at all times.

D. Check the lubricating oil level once every 8 hours. It must be maintained above the "low" mark on the bayonet gauge.

E. Drain the main air reservoirs once every 8 hours.

F. Check battery ammeter. It should never show a discharge when engine is running. Report such condition to maintainer. The high charging rate after starting the engine will decrease and approach zero as the battery becomes fully charged.

G. Make periodic visual inspection of equipment under the locomotive for loose or dragging parts. Report unusual noises or odors to maintainer.

VIII. Cutting Out a Traction Motor:

Should a failure occur in a traction motor, it may be taken out of service by means of a traction motor cutout switch in the equipment cabinet. This switch may be a 2-position knife switch or toggle switch, or a multi-pole 4-position rotary switch. All the traction motors in any one circuit are affected simultaneously by such a switch. On 4-motor locomotives, No. 1 and No. 3 motors are in one circuit and No. 2 and No. 4 motors are in another circuit. On 6-motor locomotives, all the motors on the front truck are in one circuit and all motors on the rear truck are on another circuit. When a 2-position switch is open or off, the corresponding motors are cut out. The nameplate of the rotary type switch indicates which motors are cut out. To cut out a motor:

A. Return the throttle and reverse lever to their off positions. Do not throw or turn a cut-out swich under load.

B. Open the traction motor cut-out switch.

C. Operate in the usual manner with the remaining motors, except that Load Ammeter readings should not exceed half (½) the value listed on the Load Limit table.

IX. Stopping the Locomotive:

A. Retard the throttle to first notch. When load ammeter shows that the current has dropped, the throttle may be moved off. Do not apply brakes under any condition which will cause an overload.

Note: If power ever fails to shut off when throttle is retarded, open control switch.

B. Apply the brakes. Do not use the independent brake to stop a heavy train; use the automatic brake.

C. If locomotive is to be left standing temporarily, remove the reverse lever and apply the hand brake.

X. Reversing the Locomotive:

The reverse lever determines the position of the large reverser in the equipment cabinet, which in turn controls the direction of travel of the locomotive. Reversing the field circuit in the traction motors changes their direction of rotation.

CAUTION: Never move the reverse lever while the locomotive is still in motion, as this may cause serious damage to the electrical equipment. Do not drift in one direction with the reverse lever set in the opposite direction.

To reverse the locomotive:

A. Move throttle off.

B. Apply brakes to come to full stop.

C. Change reverse lever to opposite direction.

D. Release brakes.

E. Advance throttle slowly.

XI. Stopping the Diesel Engine:

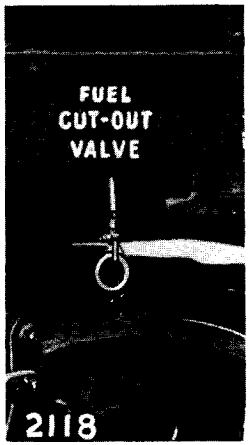
A. Normal procedure:

1. Let the engine idle ten (10) minutes to dissipate heat.
2. Open the control switch (on control stand).
3. If locomotives are connected in multiple, and it is desired to stop only one engine, set the engine control switch on that unit in accord with its nameplate designations. Opening the control switch on the control stand will stop all engines. Locomotives in multiple may be controlled from the cab of a leading unit which is idled or stopped by the engine control switch.

B. Emergency procedure:

1. Open control switch.
2. In case of fire, collision or other hazard from fuel oil, pull the red emergency fuel cut-off device in the rear corner of the cab, or outside the locomotive under the cab.

To start engine after tripping the cut-off valve, check that throttle and reverse lever are off, and manually reset the fuel cut-off valve at the tank.



OUTSIDE FUEL OIL CUT-OFF PULL RING

FIGURE 7

XII. Shutting Down the Locomotive:

A. Stop diesel engine in the normal manner, just described.

B. Open the auxiliary generator field switch.

C. Open battery switch.

D. Set the hand brake and release the air brakes.

E. Remove reverse lever.

F. Turn off lights.

G. If locomotive will be exposed to freezing temperature, take necessary precautions as outlined in the section on the Cooling Water System.

XIII. Pusher or Double Heading Service:

In such service, power is controlled on each locomotive in the usual manner, but service brakes are controlled by the leading locomotive only. However, brake pipes can be so set that the non-controlling locomotive can release its own brakes only, to avoid sliding or overheating the wheels. Conform to standard practice of the railroad in your area.

On a pusher locomotive with 6-SL brake equipment, close the brake valve 2-position cutout cock and place both brake valve handles in running position. With 24-RL brake equipment, place the Rotair valve in Pass or Frt position, depending on the service required, place dead-engine cock in live position, and close the double heading cock. Place automatic brake valve in Running position and independent brake valve in Release position.

XIV. Towing Dead Locomotive:

To tow a locomotive dead in a train, the reverse lever should be removed to eliminate any likelihood of connecting the main power circuits, and the brakes should be set to operate like those in the train.

For 6-SL Equipment:

A. Place double heading cock in "dead" position.

B. Place both brake valves in Running position and remove handles.

C. Open charging cock on the dead-engine feature.

D. If it is desired to keep the maximum braking power below standard, reduce the adjustment of the safety valve on the distributing valve so it opens at 25 pounds.

For 24-RL Equipment:

A. Close double heading cock.

B. Place automatic brake valve in Running position and independent brake valve in Release position and remove handles.

C. Place Rotair valve in Pass position.

D. Place dead engine cock in Dead position.

XV. Alarms and Protective Devices:

Protective devices function as follows. Except for the stack switch, which is always connected to the bell, the devices are usually connected to the alarm in multiple unit locomotives only. Some equipment (such as train control when installed) has an independent alarm. Dynamic brake alarms are connected to the standard bell, but are described in the braking section. A separate list of operating difficulties gives clues to all troubles, but the following directions concerning the alarm may help locate certain troubles more quickly and definitely.

Stack Switch Closes. Due to high exhaust temperature.

Remedy—Determine whether this is the cause by pressing the stack switch cut-out button on the control panel to see whether the alarm ceases. If so, operate at reduced throttle.

Ground Relay Closes. Due to defective high voltage circuit such as insulation breakdown. Sluggish or dirty electrical equipment may cause temporary short circuits. The engine idles and a ground light burns. (On multiple unit equipment, the alarm rings also.)

Remedy—The grounded condition should be rectified. Some grounds clear themselves. Pressing the ground relay reset button will restore circuits to normal in such instances. If the ground alarm persists after pressing this button, and it is necessary to pull into the clear or operate to a terminal point, open the ground relay cut-out switch in the cabinet. Don't operate for a prolonged period with this switch open, be governed by local operating rules.

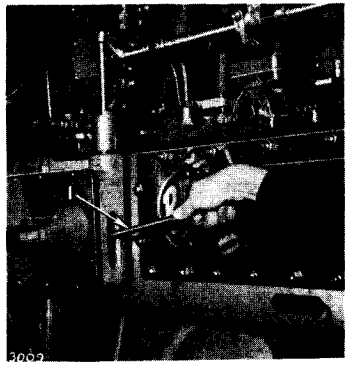
Water Temperature Switch Closes. Due to hot engine. It idles the engine.

Remedy—Check cooling system. See separate description.

Engine Shutdown Device Actuated. Due to low lube oil pressure (see operating difficulties), or to lack of fuel because of an empty tank or tripped safety device.

Remedy—Rectify any faults in the lube oil or fuel oil systems, or reset overspeed stop (see next item).

Engine Overspeed Control. The engine is prevented from exceeding a specific safe RPM through action of an overspeed stop. This appliance, situated on the front of the camshaft casing at the generator end of the engine, is a spring loaded tripping device, set to trip at a predetermined camshaft speed. The tripping operation actuates a plunger which moves the fuel control shaft to the no-fuel position and stops the engine. Before starting engine again, the overspeed stop must be reset.



RESETTING OVERSPEED STOP

FIGURE 8

1. RESET BAR. (Pull down to reset overspeed stop.)

XVI. Miscellaneous Operations:

Some items of equipment in the following operations are special modifications which are installed only when specified by purchaser.

1. **Running Through Water.** If necessary to operate through water, keep speed low enough to avoid splashing the motors, and avoid water more than 3 inches above the top of rail.
2. **Operating Over Cross-overs.** Reduce throttle at cross-overs to avoid excessive jarring of gears, and electrical pitting of commutators.
3. **Rerailing Locomotive.** Do not try to rerail a locomotive under its own power, as serious damage may result to the traction motor from spinning the wheels. However, if only one pair of wheels is derailed it is possible to rerail the locomotive under its own power by cutting out the motor driving the derailed wheels.
4. **Dual Control Stands.** Each control stand is provided with a control switch. The control switch must be closed at the controlling stand, and open at the other stand. The throttle is operative only at the stand where the switch is closed, because a master control valve, MCV, controlling the pneumatic lines to the throttle is set by the control switch. When changing from one stand to the other, it is necessary to throw the control switches as nearly simultaneously as possible, if the engine is to be kept running. Any prolonged delay will interfere with the fuel supply by de-energizing the engine shutdown valve and the fuel pump. Change-over of reverse lever and brake valve handles, and cutting out the non-operating brake valve is done in routine manner. (A control cut-out valve, CCV, is connected to the M.U. switch so that the throttle does not function on any trailing unit in multiple unit operation. The action of MCV and CCV is automatic, provided the manually operated switches are set properly.)

5. **Overspeed Control.** Check the maximum recommended speed (about 65 miles per hour). When a slightly higher speed is reached, overspeed control initiates a service application of the air brakes. The diesel engines are automatically idled when such an application occurs. The engineer is first given a whistle warning, and a 6-second delay feature enables him to reduce speed and thus suppress the automatic application.

6. **Deadman Pedal.** The deadman foot pedal is a safety device which must be depressed at all times when the locomotive is in operation. A release of the deadman pedal causes a warning whistle to sound for approximately 5 seconds after which the brakes are automatically applied and the engines brought to idling speed. If the deadman pedal is depressed within the warning period, however, no action takes place.

7. **Recovery After Penalty, or Emergency, Brake Application.** Following any emergency, speed control, train control, deadman, or similar extra-ordinary brake application, move the throttle to the off position. In many instances, the interlocking is such that traction motors are automatically disconnected to avoid overloading them. However, further interlocking prevents restoration of the electrical circuits until the throttle is in the off position. On 24-RL brake equipment place the automatic brake in Lap position until the brake system recovers.

MULTIPLE UNIT OPERATION

Locomotives equipped for multiple unit operation may be handled as a single locomotive after connections are properly made. In addition to the conventional coupling of locomotives and air lines, the electrical control circuits of the two locomotives must be connected. A jumper for this purpose must be firmly plugged into the receptacles at the end of the locomotives. The controls are then set so that both the power and brakes are controlled from only one cab. The locomotive from which operation is controlled is called the leading unit, and any coupled locomotives are trailing units. Certain alarm and protective circuits, and certain auxiliary controls, such as sanding, are connected through the jumper, but the power plants and heavy duty circuits of the coupled units remain entirely independent of each other.

Connecting Units in Multiple (6-SL Equipment):

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives: throttle line, main reservoir line, equalizing pipe and brake pipe.

C. On trailing or non-controlling unit:
   1. Place the double heading cock on the brake pedestal in "trailing" position.
   2. Remove the automatic brake valve handle (lap position).
   3. Remove the independent brake valve handle (running position).
   4. Check that the throttle is off.
   5. Put the reverse lever in the "off" position and remove the handle.
   6. Close the multiple unit switch in the equipment cabinet to the "M.U." (Multiple Unit) position.
   7. Close the main battery switch in the equipment cabinet.

8. Open control switch.
9. Release the hand brake.

D. On the leading or controlling unit:
1. Make sure the multiple unit switch is closed in the "S" (Single Unit) position.
2. Close main battery switch.
3. Place double heading cock in "lead" position.
4. Close control switch.

E. Start the engines as previously outlined on page 16. It will be necessary to start the engine in the trailing unit from the trailing cab. However, in the trailing unit, leave the control switch open.

F. Close the auxiliary generator field switches.

G. The locomotives may now be operated in the same manner as a single unit. The sander foot switch will apply sand to the front or rear of both trucks on both units as determined by the position of the reverser.

Connecting Units in Multiple (24-RL Equipment):

A. Couple the units together and connect the air lines and jumpers, making sure that each plug is pushed all the way into the receptacle and locked in place.

B. Open the cocks at the end of the air lines on both locomotives.

C. On the unit which will be controlling:
1. Make sure that the battery switch and control switch are closed, and that the multiple-unit switch is in "S" (single unit) position.
2. Place the Rotair valve in Pass or Frt, depending on the service required.
3. Open the double heading cock.

D. On trailing or non-controlling unit:
1. Close the double heading cock.
2. Place Rotair valve in Pass Lap, or Frt Lap, depending on C-2 above.

3. Put the automatic brake in Running position, and remove handle.
4. Put the independent brake in Release position, and remove handle.
5. Put the throttle in the "idle" position.
6. Put the reverse lever in the "off" position and remove the handle.
7. Move the multiple-unit switch in the equipment cabinet to the "M.U." (multiple unit) position.
8. Check that battery switch is closed.
9. Open the control switch.

E. Start the engines as previously outlined on page 16. It will be necessary to start the engine in the trailing unit from the trailing cab. However, in the trailing unit, leave the control switch open.

F. Close the auxiliary generator field switches.

G. The locomotives may now be operated in the same manner as a single unit. The sander valve will apply sand to the front or rear of both trucks on both units as determined by the position of the reverser.

Procedure for Changing Operating Cab (6-SL Equipment):

A. In the cab which has been controlling:
1. Make at least a 20 pound reduction with automatic brake valve.
2. Place double heading cock in "trailing" position.
3. Remove automatic brake valve handle (lap position), and independent brake valve handle (running position).

B. In the cab which will be controlling:
1. Insert brake valve handles. Move independent brake valve handle to full application position, and automatic brake valve handle to running position.
2. Place double heading cock in "lead" position.
3. Close control switch.

4. Change multiple unit switch from "M.U." to "S" position.

C. Return to the former controlling cab:
1. Change multiple unit switch from "S" to "M.U." position.
2. Open control switch.
The units are now ready for multiple operation.

Procedure for Changing Operating Cab (24-RL Equipment):

A. In the cab which has been controlling:
1. Make at least a 20 pound reduction with automatic brake valve.
2. Move automatic brake valve handle to lap position and independent brake to release position.
3. Place double heading cock in closed (cut-out) position.
4. Move K-2-A Rotair valve to Pass Lap, or Frt Lap, as required (or K-2 Rotair valve to Lap position).
5. Move automatic brake valve handle to running position, and remove both the automatic and independent brake valve handles.

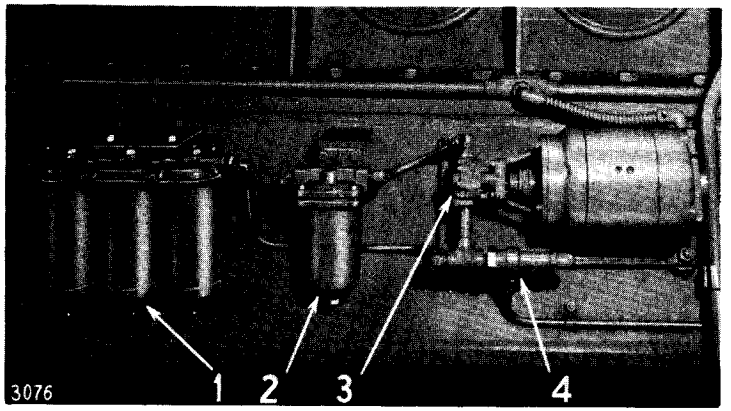
B. In the cab which will be controlling:
1. Put Rotair valve in Pass or Frt position, as required.
2. Move independent brake valve to full application position.
3. Open the double heading cock.
4. Close control switch.
5. Change multiple unit switch from "M.U." to "S" position.

C. Return to the former controlling cab:
1. Change the multiple unit switch from "S" to "M.U." position.
2. Open control switch.

The units are now ready for multiple operation.

FUEL OIL SYSTEM

Fuel is supplied to the engine by a motor driven supply pump which draws fuel from the tank through a suction



FUEL OIL SUPPLY PUMP

FIGURE 9

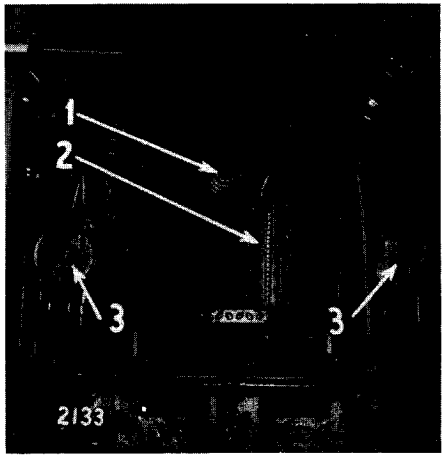
1. CARTRIDGE-TYPE FILTER
2. METAL EDGE STRAINER
3. MOTOR DRIVEN SUPPLY PUMP
4. DISCHARGE RELIEF VALVE

strainer and forces it through a pressure filter into the fuel oil header, where it supplies the injection pumps. There is a gravity return line from the header to the tank. A pressure relief valve limits fuel pressure in the header to 25 psi, by-passing excess fuel back to the tank. The supply pump is protected against pressure by a relief valve connected to its discharge. The suction strainer and filter cartridges should be cleaned or renewed periodically.

The fuel storage tank, tank filler and gauge are located at the rear of the locomotive. A center tank is added on the AS-616 models. Fill the tank slowly, observing level gauge to avoid overflow.

LOW LUBE OIL PRESSURE SHUTDOWN DEVICE

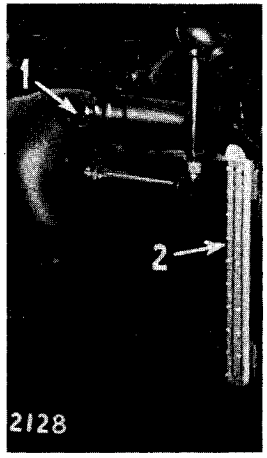
A safety device is incorporated in the fuel system to shut down the engine if lube oil pressure is too low. An electrically controlled engine shutdown valve is fed through a lube oil



REAR FUEL TANK and MULTIPLE UNIT END RECEPTACLES

FIGURE 10

1. FUEL OIL FILL
2. FUEL GAGE
3. TRAIN-LINE RECEPTACLES (Multiple Unit)

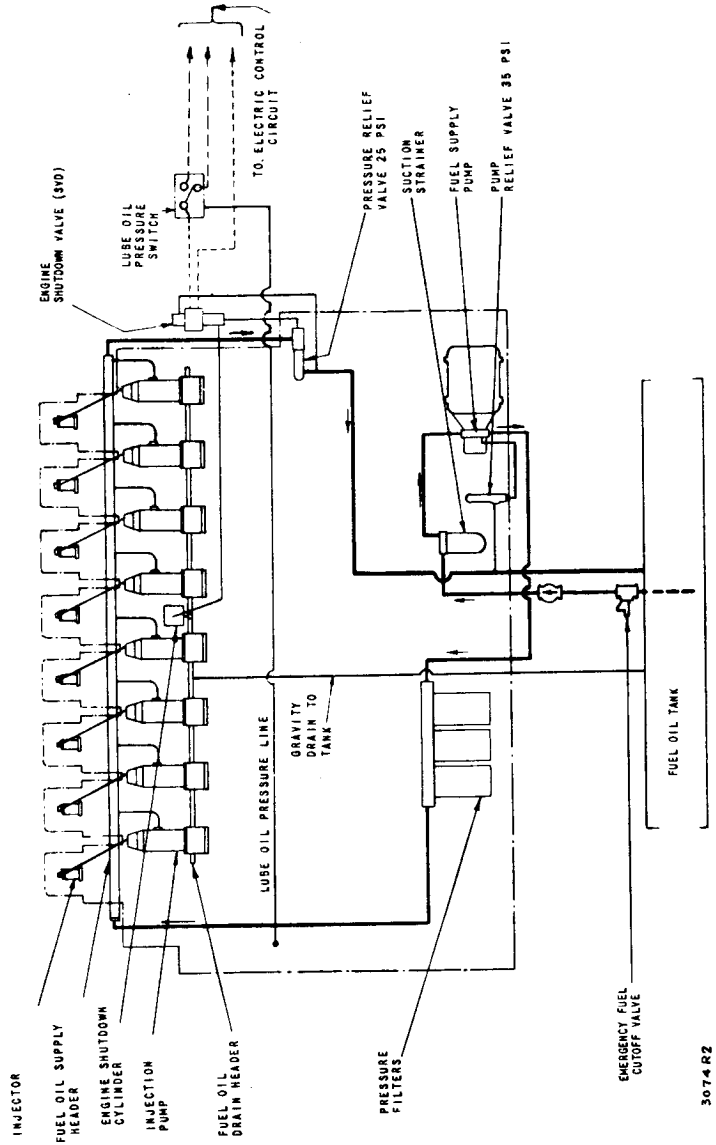


CENTER FUEL TANK

FIGURE 11

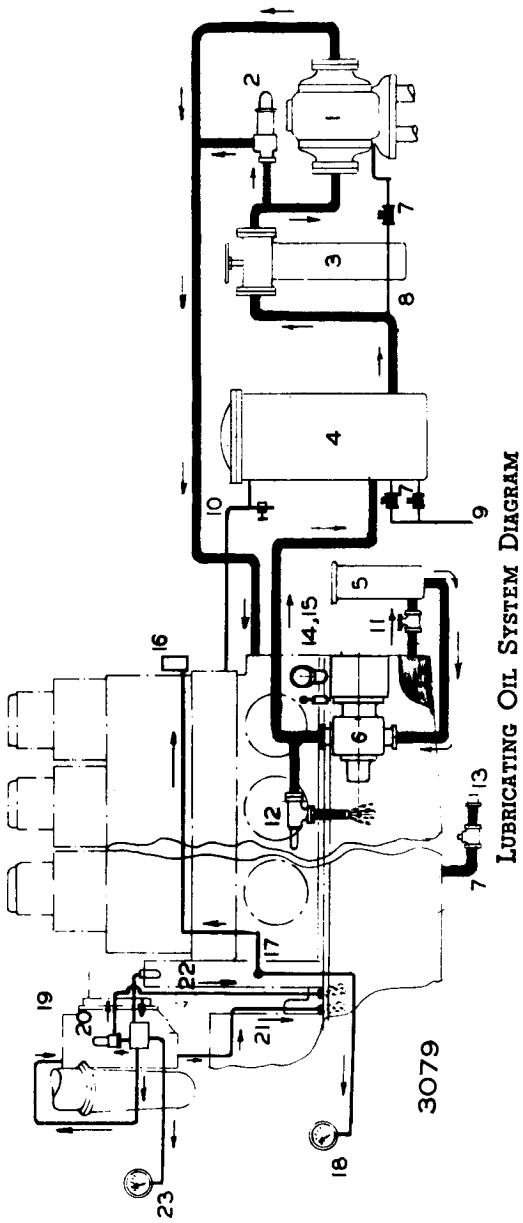
1. FUEL OIL FILL
2. FUEL GAGE

pressure switch which is kept closed by lube oil pressure. When the shutdown valve is energized, the fuel control shaft is free to act according to the demands of the governor. When lube oil pressure drops, the switch opens, the shutdown valve is de-energized, and its piston forces the fuel control shaft to the stop (no fuel) position. When the engine is being started, the engine start button energizes the shutdown valve (by-passing the lube oil switch), thereby maintaining the fuel supply until the lube oil pressure builds up to normal. Possible causes of low lube oil pressure are given under Operating Difficulties at the rear of this book.



FUEL OIL SYSTEM DIAGRAM

FIGURE 12



LUBRICATING OIL SYSTEM DIAGRAM

FIGURE 13

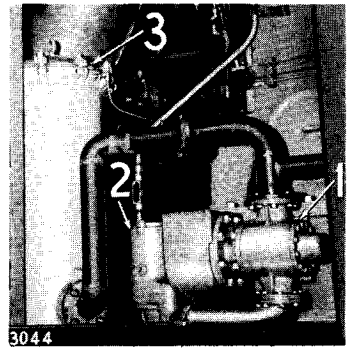
1. LUBE OIL HEAT EXCHANGER
2. RELIEF VALVE 25 PSI
3. METAL EDGE STRAINER (if installed)
4. LUBE OIL FILTER
5. SUCTION STRAINER
6. LUBE OIL PUMP (Engine driven)*
7. LOCK COCKS
8. HEAT EXCHANGER DRAIN
9. FILTER AND PIPING DRAIN
10. VENT AND DRAIN
11. CHECK VALVE
12. RELIEF VALVE 125 PSI
13. CRANKCASE DRAIN
14. LUBE OIL FILLER CAP**
15. LUBE OIL BAYONET GAUGE**
16. LUBE OIL PRESSURE SWITCH
17. LUBE OIL PRESSURE CONNECTION
18. LUBE OIL PRESSURE GAUGE
19. TURBOCHARGER
20. RELIEF VALVE
21. RETURN LINE
22. BY-PASS LINE
23. LUBE OIL PRESSURE GAUGE (at Turbo)

*Located at exhaust side of engine.
**Located on Fuel Pump side of engine.

LUBRICATING OIL SYSTEM

The lubricating oil is drawn from the sump, formed by the bedplate of the engine, through a suction strainer by the engine driven pump. The pump forces the oil through an oil filter, a metal edge type strainer, and a heat exchanger. The oil is then delivered to the engine header, which distributes the oil to all parts of engine requiring lubrication. The pressure gauge in the cab should read between 50 lb. and 55 lb. (This is equivalent to 65 lb. at the header.) Should pressure become excessive, a relief valve will spill the pump output back to the engine base. Another relief valve by-passes the heat exchanger if its pressure drop is excessive. The water connections of the heat exchanger are shown in the Cooling System Diagram.

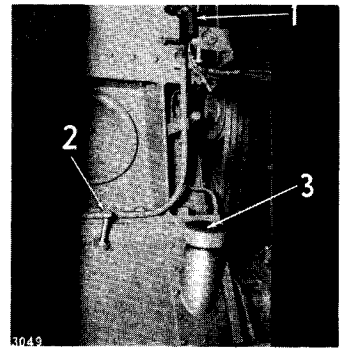
The oil level in the sump should be checked daily and must be maintained above the "low" mark. To fill the crankcase, pour the proper type of oil through the filler pipe. Fill to the "full" mark on the bayonet gauge. To drain oil from the engine, open the drain valve and remove the plugs from the bottom of the camshaft trough. Also, be sure to drain the strainers, the filter and the heat exchanger, when changing crankcase oil.



LUBE OIL PUMP AND STRAINER

FIGURE 14

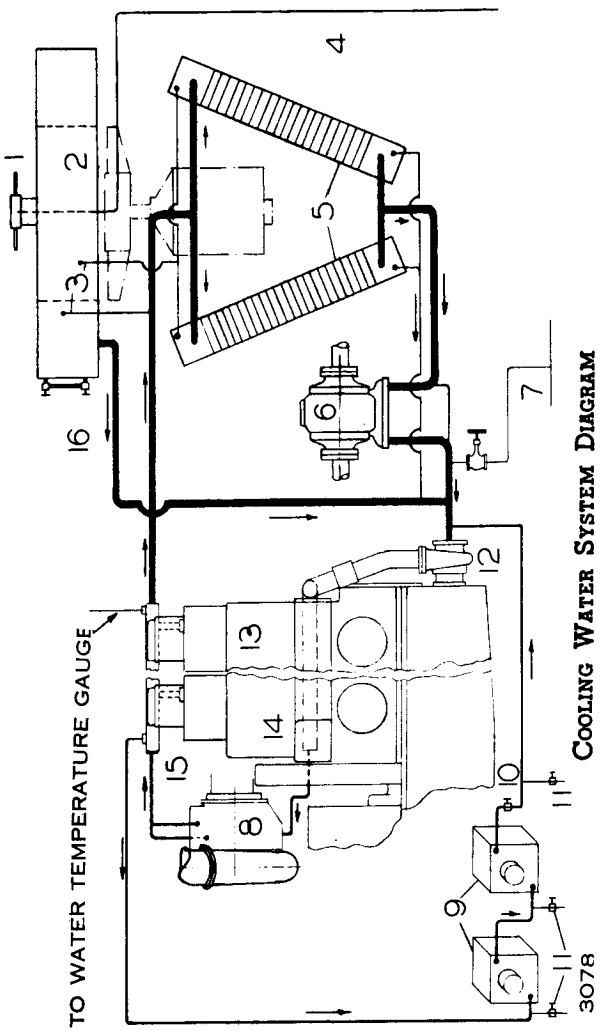
1. PUMP
2. SUCTION STRAINER
3. FULL FLOW FILTER



LUBE OIL FILL AND GAUGE

FIGURE 15

1. ENGINE SHUT-DOWN VALVE
2. LEVEL GAUGE
3. FILL



Cooling Water System Diagram

Figure 16

1. WATER FILLER
2. EXPANSION TANK
3. VENT LINES
4. OVERFLOW AND VENT
5. RADIATORS
6. LUBE OIL HEAT EXCHANGER
7. DRAIN AND FILL LINE
8. TURBOCHARGER
9. CAB HEATER
10. SHUT-OFF VALVE
11. DRAIN VALVE
12. WATER PUMP
13. DIESEL ENGINE
14. WATER INLET HEADER
15. WATER OUTLET HEADER
16. WATER LEVEL GAUGE

COOLING WATER SYSTEM

Water is circulated through the engine, heat exchanger and cooling radiator by an engine driven pump. An expansion tank vented to the atmosphere through an overflow pipe acts as a reservoir for maintaining a full system. The water level in the expansion tank must be maintained above the bottom of the gauge. This gauge is on the radiator compartment bulkhead above the temperature control equipment at the front of the engine compartment. If leaks are suspected, the crew should endeavor to locate them while engine is warm, and report to maintainer. However, the packing gland of the water pump is adjusted to leak about 3 or 4 drops per minute normally.

To fill the system, add water through the connection located over No. 1 truck on right side of the locomotive. The system can be filled through the filler on the roof near the front, but it is not recommended because of the danger of trapping air in the system. If the engine overheats because of low water level, idle the engine and add hot water if possible. If it is necessary to use cold water, it should be added very slowly.

DRAINAGE

If the locomotive is to be left standing exposed to freezing temperature, it will be necessary to drain the cooling system or use an outside source of steam to prevent freezing. If a steam source is available, connect it to the drain pipe through a check valve so that the water can not back up into the steam line. Open the drain valve enough to allow steam to enter the system. To drain the system, open the drain valve (Figure 16). Also drain the heat exchanger, the cab heaters, and the turbo-charger cooling system. Condensed water may accumulate in the turbine casing which has a separate drain valve.

FAN SWITCH

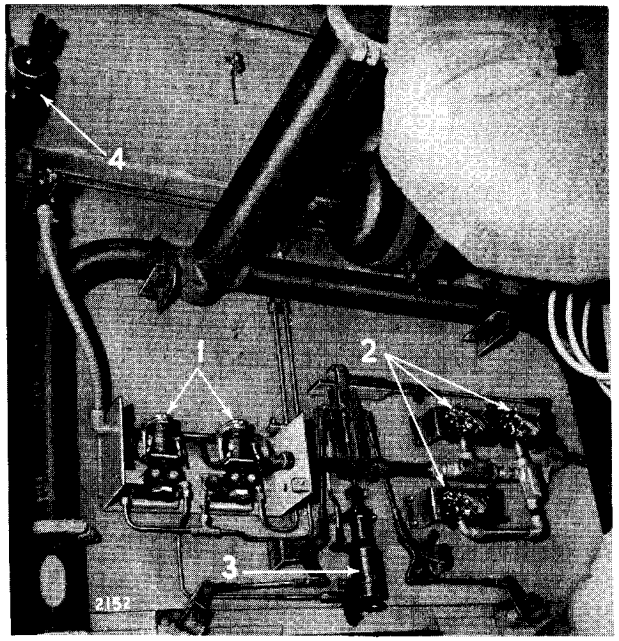
The fan switch is a small double-pole double-throw manually operated switch on the panel on the front wall of the

cab. It has three positions. The fan contactors are connected as follows:

Off Position—Fans will not operate.

Automatic Position—Fan speed is automatically regulated.

On Position—Fans operate at intermediate speed if automatic temperature control fails. Shutters are provided with dynamic braking to determine the path, but not volume, of air flow. They are not part of the water temperature controls.



EQUIPMENT ON RADIATOR BULKHEAD

Dynamically Braked Locomotives

FIGURE 17

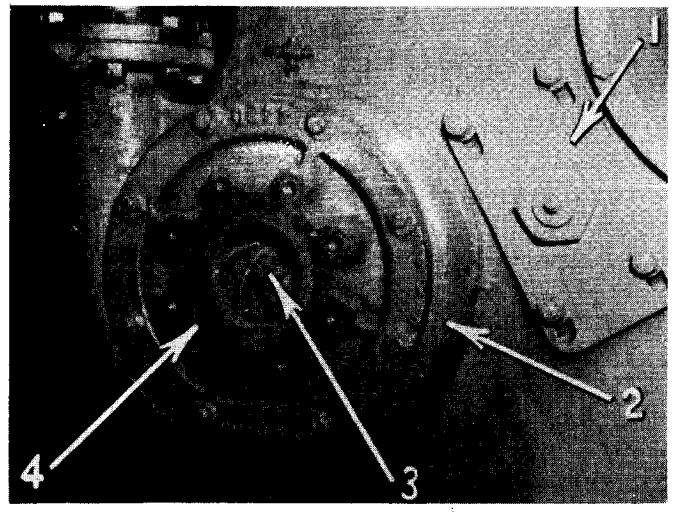
1. SHUTTER MAGNET VALVES
2. SHUTTER LIMIT SWITCHES
3. SHUTTER OPERATING CYLINDER (for lower flaps)
4. SHUTTER OPERATING CYLINDER (for top side shutters)

AUTOMATIC TEMPERATURE CONTROL

When the fan switch is in "auto" position, radiator fans are driven by electric motors whose speed is varied by thermostatic control of the fan motor contactors. When water temperature rises moderately, a fan contactor closes which operates fans at low voltage. A further rise in temperature closes a contactor which connects full generator voltage to the fans, thereby increasing their speed. Further increase in temperature closes a contactor which shunts the fan motor fields for still faster operation. As the water cools, the fan speed automatically decreases.

MANUAL CONTROL

When the automatic system does not function properly, check fan motor breaker if fans are not running. Non-automatic cooling may be had by moving the 3-position fan switch to the "on" position. The fans will run at intermediate speed. If the



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WATER PUMP AND IDLER BRACKET

FIGURE 18

1. CHAIN IDLER ADJUSTMENT BRACKET
2. PUMP CASING
3. IMPELLER NUT (Left Hand Thread)
4. PUMP SUCTION HEAD

temperature gauge indicates excessive cooling, set fan switch to "off" position briefly, or shift from "on" to "off" as required.

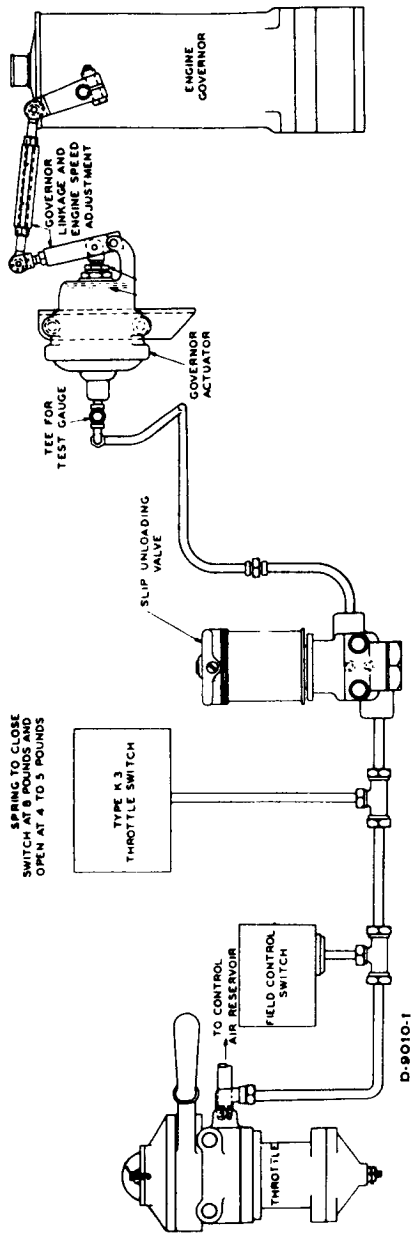
HOT WATER SWITCH

An automatic hot water temperature switch (if installed) idles the engine if the cooling water temperature becomes excessive. This switch is connected to the throttle valve. It also rings the alarm when tripped. Operators of single-unit locomotives should watch their temperature gauge, but the switch is normally supplied on multiple unit locomotives to give adequate protection for trailing units. It will, of course, function in any leading unit so equipped.

PNEUMATIC CONTROLS

Pneumatic control lines, at a pressure of 70 psi, are fed from the high pressure lines through a reducing valve. Equipment actuated by the 70 pound control pressure includes the reverser, power switches, sanders and horn (also shutter cylinders on dynamic brake installations). The throttle is essentially a variable reducing valve connected to the 140 pound line controlling pressure to the governor actuator. On D-1 controllers a throttle switch and field control switch are operated pneumatically. On CE-100 controllers, the function of these switches is performed by contacts in the controller or load regulator. A wheel slip valve in the throttle control air line is automatically operated by an electric relay to reduce power momentarily if wheel slip occurs.

A thermostat in the temperature control system operates at about 17 psi. Air from the 140 psi supply is connected through reducing valves to the thermostat which responds to changes in the cooling water temperatures, thereby varying temperature switches in the fan control circuits and automatically regulating the fan speed. Electrically operated shutter valves control the air lines to the shutter cylinder on dynamic brake installations.



NOTE: 1. ADDITIONAL MAGNET VALVES ARE REQUIRED TO ISOLATE THE NON-OPERATING THROTTLES WHEN MULTIPLE UNIT, OR DUAL CONTROL EQUIPMENT IS INSTALLED.

NOTE: 2. IF CE-100 CONTROLLER IS USED, AS WITH DYNAMIC BRAKING, NO K-3 THROTTLE SWITCH IS USED.

NOTE: 3. THIS DIAGRAM APPLIES TO ENGINES EQUIPPED WITH WOODWARD UG-8 GOVERNOR ONLY. IF WOODWARD PG PNEUMATIC-HYDRAULIC GOVERNOR IS INSTALLED ON THE ENGINE, THE ACTUATOR AND ITS LINKAGE IS NOT INSTALLED AND THE THROTTLE AIR LINE IS CONNECTED DIRECTLY TO THE GOVERNOR. IF WOODWARD PG ELECTRO-HYDRAULIC GOVERNOR IS INSTALLED, THIS DIAGRAM SHOULD BE DISREGARDED.

TYPICAL PNEUMATIC THROTTLE CONTROL SYSTEM
(Standard D-1 Controller)
FIGURE 19

ELECTRICAL SYSTEM

An electrical drive is the most practical means of transmitting diesel engine power to the driving wheels, and electro-pneumatic controls provide the simplest means of handling both the propulsion motors and the auxiliary equipment. Normal operations are controlled by a throttle, a reverser lever, and a standard braking system. After the manually operated switches are set for normal operation, and the engine started as previously described, power is controlled by the throttle and Auto-Load control. Field shunting, engine cooling, etc., are controlled automatically.

Operating men should have some fundamental knowledge of the electrical system. They are then more competent to handle the controls, watch indicating instruments for prevention of trouble, and meet non-routine operating conditions when they arise.

Most of the instruments and routine controls are mounted on panels in front of the engineer. An illustration of the inside of the equipment cabinet near the front of this book shows most of the other electrical control equipment on the locomotive. These controls should be thoroughly understood before investigating or repairing any trouble. There is high voltage on much of this equipment and no attempt should be made to enter the cabinet without taking proper safety precautions. Some equipment is mounted on the engine room side of the cabinet frame (see Figure 21).

A diagram of the principal equipment in the control system is shown in Figure 22. Many details are purposely omitted so that the essential relationships are more easily understood. The master controller consists principally of a

throttle and a reverse lever. The main generator supplies high voltage power to the traction motors and fan motors. The auxiliary generator charges the battery and supplies low voltage power (about 75 volts) to the lighting and control circuits and the 4-pole exciter field circuit. When more than one diesel engine is controlled from one controller, the only electrical connections between units are low voltage control circuits.

The principal types of control equipment function as follows:

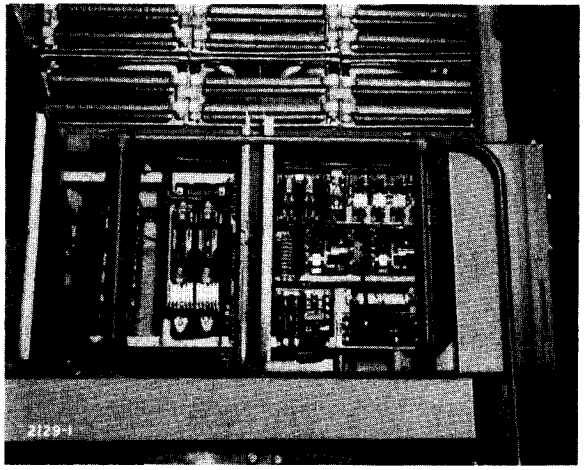
Relays—A relay is a coil which opens or closes a set of comparatively light-duty contacts (generally in a controlling circuit). The coil may be in either the high or low voltage circuit and may be adjusted to pick-up or drop-out at various voltages, and calibrated to respond to varying operating conditions. As the name implies, it relays an impulse to other equipment (mostly contactors), and more than one contactor may be controlled by a single relay.

Contactors—A contactor is a coil-operated set of contacts (generally heavy-duty, and in the circuit being controlled). Its closed or open positions generally depend on whether it is energized or de-energized. There is usually no adjustment for intermediate voltages or currents, because the more sensitive relays are used for such purposes. Light-duty contacts on a contactor are called interlocks which are described in the next paragraph.

Interlocks—An interlock is an auxiliary switch mounted on, and controlled by, another switch, contactor, valve or similar control equipment. It is operated by a cam or mechanical linkage which is so connected that the opening and closing of the auxiliary circuit is dependent on the operation of equipment in the main circuit. They are used to control the sequence of operation, or to permit making or breaking related circuits only when proper conditions exist. The chief concern to the operator is that sluggish or faulty interlocking can cause faulty locomotive operation.

Electro-pneumatic Valve—An electro-pneumatic valve (or magnet valve) consists of an electrical coil in a controlling circuit which controls valves for the pneumatic operation of certain equipment. For example the reverser and the power switches are pneumatically operated by a valve which is built into the equipment. Control air pressure is maintained from the main air reservoir, but at a lower pressure.

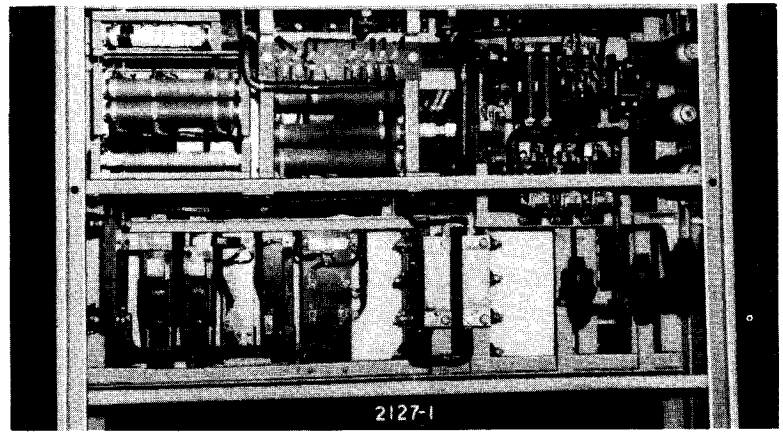
Voltage Regulator and Battery Protection—A voltage regulator holds the auxiliary generator voltage constant over the normal speed range of the diesel engine. It is set slightly above battery voltage so the battery will receive a charge if necessary. A reverse current relay protects the battery against discharge through an idle or defective auxiliary generator. The relay opens a contactor in the circuits whenever a reverse current flows. This contactor closes automatically any time auxiliary generator voltage exceeds battery voltage. Operators should not change the adjustment or setting of this equipment.



DYNAMIC BRAKING RESISTORS AND AUXILIARY EQUIPMENT

Showing Typical Arrangement of Braking Relays, Contactors, Pneumatic Unit Switches, Cam Switch, etc.

FIGURE 20



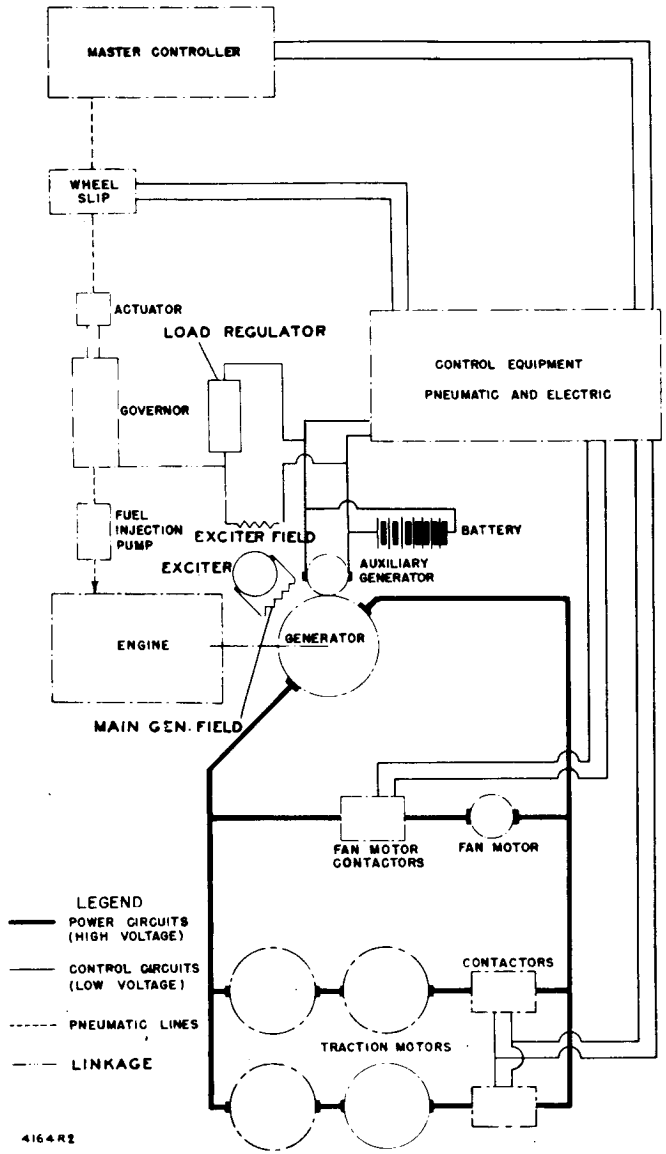
REAR VIEW OF TYPICAL ELECTRICAL EQUIPMENT CABINET
(With Dynamic Braking)

FIGURE 21

The principal items of equipment on the rear of the cabinet are the Wheel Slip Relay, Signal (Alarm) Relay, Ground Relay, Time Delay Air Relay, the K 3 Pneumatic Switch and Throttle Valve on standard locomotives, also the Power Knockout Contactor if installed, and, on dynamically braked locomotives, the Motoring Selector Valve and Braking Selector Valve.

CONDENSED SEQUENCE OF OPERATION

Stage of Operation	*Electrical Action*	*Pneumatic Action*
Starting	Main generator is connected to battery (wires not shown in diagram). It acts as motor to turn or crank the engine. Other generator connections are open.	None.
Engine Idling	After starting and closing auxiliary generator field switch, auxiliary generator is connected to battery. Main generator field and exciter field energized by automatic closing of field contactors.	None.
Engine Cooling	Fan motor contactors (F) close and fans operate whenever radiators are hot enough. Fan speed is automatically changed by temperature switches which energize various combinations of fan motor contactors.	A magnet valve controls the shutters.
Reverse Lever set to change direction.	Reverser magnet valve connections established but not energized until throttle is advanced in next step.	Operating cylinder moves reverser when reverser valves are energized (after the throttle is advanced).
Throttle Advance	Magnet valves in reverser and traction motor contactors (P switches) are energized.	Fuel supply increased and engine speeds up. See pneumatic lines on diagram. Power switches close when their magnet valves are energized.
Running at high speed.	Traction motor fields are shunted by the closing of field shunting contactors (M), in 4 steps, by the field shunting sequence controller. This controller responds to varying generator voltages as speed changes.	Same as above, but no additional action.
Throttle retard.	Reverse of above.	Reverse of above.
Wheels slip.	Wheel slip relays pickup. They are sensitive to unbalanced voltage conditions at the traction motors. They close a circuit which energizes a valve in throttle line.	Throttle line air pressure is reduced. Fuel supply reduced. Pressure automatically restored when slip stops.



CONTROL SYSTEM DIAGRAM

FIGURE 22

DYNAMIC BRAKING

GENERAL DESCRIPTION

Locomotives are sometimes equipped with a dynamic braking system in addition to the standard air braking equipment. Dynamic braking is controlled entirely by the throttle and reverse lever. The energy involved in retarding the train by dynamic brakes is dissipated in the electrical equipment instead of in the brake shoes. At such times, the traction motors act as generators driven by the locomotive. This reduces wear and tear on brake shoes and, on long descending grades, eliminates delays which may otherwise be necessary for cooling wheels and shoes. Applications of the automatic brakes on the cars of a train are possible at all times, regardless of the setting of dynamic braking controls. However, the air system is interlocked with the electrical circuits so that it is impossible to make an automatic application of brakes on the locomotive during dynamic braking. Emergency applications may be made by the automatic brake at any time (although in some cases, a power knock-out device must first automatically interrupt the dynamic braking circuits).

OPERATION

Dynamic braking will not function unless the dynamic braking cut-out switch is in dynamic braking position (closed), and it is generally left in that position. If there is no dynamic braking cut-out switch, it is incorporated in a fan relay cut-out switch. A separate set of electrically driven fans cools the braking resistors. They operate automatically, but if the circuit is defective the braking circuits are automatically kept inoperative. The usual braking procedure may be summarized as follows:

1. Reduce throttle to "off". Wait about 10 seconds before setting controls for dynamic braking.
2. Move reverse lever to dynamic braking position. If there is more than one such position, use the one corresponding to the direction of travel. (Trip a small latch under the lever if necessary to release it.)
3. Place the throttle in the first notch until an ammeter reading is obtained, then advance gradually until the desired amount of dynamic braking is obtained, but keep the ammeter within the normal operating range. A dynamic braking overload light will give indication when braking current becomes excessive. The throttle should be retarded sufficiently to extinguish the light.
4. If additional braking effort is needed, the usual automatic air application may be made simultaneously. (If the dynamic brakes do not function at all, the air brakes alone can be used in the usual manner.)
5. To resume normal operation, first move the throttle to "off", next move the reverse lever to the position corresponding to the direction of travel, then use the air brakes or throttle with due regard to the conditions set forth in the following important paragraph.

NOTE: Dynamic braking differs greatly from air braking and therefore requires special attention by the operator in order to handle the train smoothly. The feel of the train is best obtained only from experience, but the principal fact to remember is that the train is bunched in dynamic braking. At very low speeds, the dynamic braking effort fades out and air brakes must be used to come to a complete stop. Whenever dynamic braking ceases, either because of the low-speed fade out, or because the engineer no longer desires to brake, be careful to avoid a quick run-out of the head end which may have sufficient force to damage drawbars.

Dynamic braking is not effective above certain maximum speeds. Check what that speed is for your locomotive (as posted in the cab), and if braking is needed at high speed, use the air brakes until the speed falls within the dynamic braking range.

SUPPLEMENTARY INFORMATION

The following miscellaneous information may be useful to operating personnel at times, especially if they must investigate some irregularity in operation.

The changes in electrical connections are controlled by a system of relays which function automatically when the foregoing manual controls are operated. The action is mainly as follows:

(a) The traction motor fields are disconnected from their armatures. The armatures are connected to dissipating resistors, and the fields alone are connected to the generator.

(b) The fans which cool the braking resistors are automatically connected to the traction motor armatures. A fan relay prevents complete changeover to dynamic braking circuits if these fans don't operate properly.

(c) After braking circuits are established, advancing the throttle increases the braking effort by acting on both engine speed and generator field strength. Increasing either, or both, of these variables will increase the generator output to the traction motor fields. As traction motor field strength is increased, dynamic braking effort is increased.

(d) The locomotive wheels would frequently slide if subjected to both dynamic braking and air braking at the same time. A brake interlocking valve functions automatically to prevent simultaneous application of dynamic brakes and automatic air brakes on the locomotive.

(e) Other protective devices may be installed according to individual specifications. If an alarm is connected to indicate operating failure in the fans on the dissipating resistors, avoid dynamic braking until the trouble is rectified. Do not use the dynamic brakes if the wheel slip buzzer sounds continuously, but intermittent sounding may be disregarded.

(f) If throttle has been advanced too soon during changeover into or out of braking, it may be necessary to again return it to its off position momentarily to clear all protective interlocking devices.

If there is no dynamic braking effort:

1. Check that the dynamic braking cut-out switch or fan relay cut-out switch, depending on the installation, is in the correct position.
2. Check that the traction motor cut-out switch is in correct position.
3. Check braking-resistor fans, breaker or relay.

OPERATING DIFFICULTIES AND CAUSES

(*Denotes items usually in multiple unit equipment only.)

I. Engine Does Not Turn When Starting Button Is Pressed

A. Battery switch open.
B. Control switch open (except M.U. locomotives).
C. Engine control switch in wrong position.*
D. Multiple unit switch in wrong position.*

II. Engine Turns But Does Not Fire, or Does Not Continue Running After Releasing the Starting Button

A. Fuel tank empty.
B. Emergency fuel cut-out valve is tripped. Reset.
C. Overspeed stop has been tripped. Reset.
D. Releasing start button before lubricating oil pressure has built up to 19 lb.
E. Low fuel oil pressure.
F. Insufficient oil supply in the governor.
G. Multiple unit switch not in the correct position.*
H. Engine control switch in wrong position.*

III. Engine Does Not Respond to Throttle Setting

A. Low control air pressure.
   1. Low main reservoir air pressure.
   2. Control air cut-out cock closed.
   3. Control air pressure reducing valve sticking. Try tapping it.
B. Governor linkage disconnected.
C. Ground relay closed.
D. Hot engine has tripped temperature switch.*

IV. Locomotive Does Not Move

A. Reverser not in the forward or reverse position.
B. Auxiliary generator field switch open.
C. All traction motors cut-out. (Check cut-out switch.)
D. Hand brake still set.
E. Pneumatic throttle switch open.
F. Starting contactors stuck in closed position.
G. Control-Lighting Breaker in cabinet open.

V. Engine Stops

A. Overspeed stop has tripped. Reset (Fig. 8). Notify maintainer if it continues to trip.
B. Low lubricating oil pressure, causing the engine shutdown device to operate.
C. Emergency fuel cut-out valve has been tripped. Reset.
D. Fuel tank empty.
E. Engine control switch in wrong position.*

VI. Low Fuel Oil Pressure

A. Fuel tank empty.
B. Emergency fuel cut-out valve tripped. Reset.
C. Sticking relief valves. Try tapping them.
D. Faulty pump.

VII. Low Lubricating Oil Pressure

A. Low oil level.
B. Clogged pressure strainer. Turn the handle on top of the strainer two revolutions in the clockwise direction.
C. Sticking relief valves. Try tapping them.
D. Hot or diluted oil.
E. Faulty pump or leaking lines.
F. Clogged heat exchanger.

VIII. Engine Overheats

A. Low water level.
B. Faulty radiator shutter control.
C. Radiator fans not functioning properly. (See page 41.)
D. Water Pump not functioning properly.

IX. Air Pressure Too High or Too Low

A. Compressor governor cut-out cock closed.
B. Compressor governor sticking. Try tapping it.

X. Battery Ammeter Shows Discharge (Engine Running)

A. Auxiliary Generator Field Switch open.
B. Auxiliary Generator Power Switch open.
C. Poor contacts on battery contactor or reverse current relay, or voltage regulator.

NOTE: Always notify maintainer when any operating difficulty is experienced, even if the trouble has been corrected by the above suggestions.

HUMPING CONTROLS (IF INSTALLED)

The locomotive is equipped with auxiliary controls when designed for humping service. It is necessary to operate the diesel engine at top speed (i.e., full throttle) to insure ample cooling for the traction motors while heavily loaded at the low speeds prevailing in humping.

A variable rheostat beside the master controller is used to regulate the tractive effort and locomotive speed while the throttle is advanced to meet the foregoing requirements. It is connected in the exciter field circuit. Increasing or decreasing the exciter field strength by means of this rheostat results in a corresponding increase or decrease in locomotive speed or power.

For Humping Operation:

1. Set the rheostat so that proper resistance is added to the field circuit. This varies with different operations, and is best determined by experience. It is desirable to obtain the maximum possible tractive effort without causing the wheels to slip.
2. With the reverse lever in the position for the desired direction of travel, advance the throttle to full engine speed.
3. Leave the throttle wide open, and regulate power with the rheostat.
4. To resume regular service, place the rheostat in its "off" position.

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