THE RAILWAY EDUCATIONAL BUREAU

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INSTRUCTION PAPER

UNIT N. 22A

SUBJECT:

DIESEL LOCOMOTIVE OPERATION

THE POWER PLANTS OF ALCO - G. E. 660 AND 1000 HORSEPOWER DIESEL LOCOMOTIVES

OMAHA——POSTAL ZONE 2——NEBRASKA

THE POWER PLANTS OF ALCO - G. E.

600 AND 1000 HORSEPOWER DIESEL LOCOMOTIVES

Fig. 1

Fig. 2

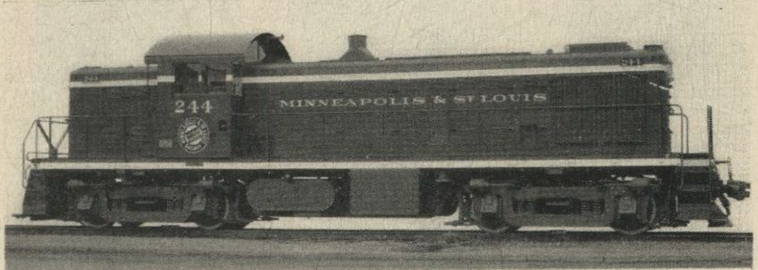

Fig. 3

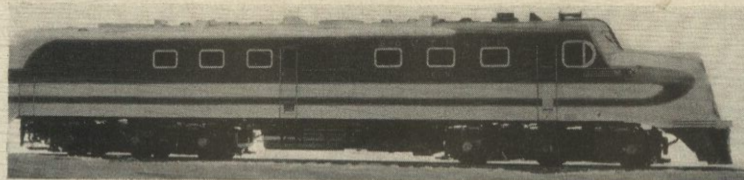

Fig. 4

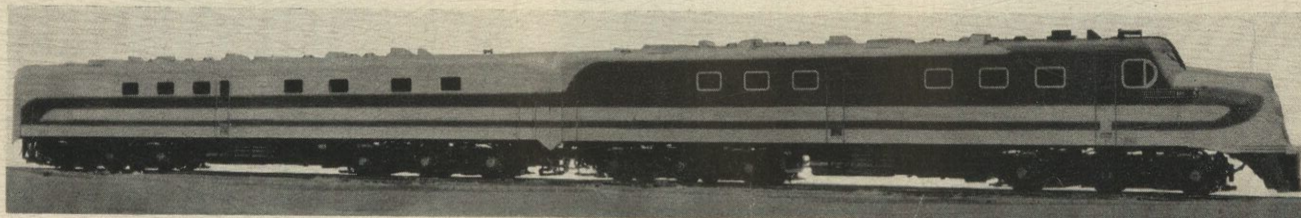

Fig. 5

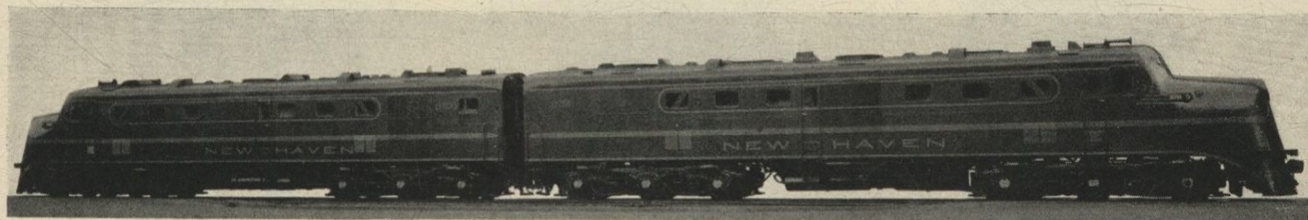

Fig. 6

DIESEL LOCOMOTIVE OPERATION

THE POWER PLANTS OF ALCO—G. E. 660 AND 1000 HORSEPOWER DIESEL LOCOMOTIVES

General

1. The American Locomotive Company manufactures 660 horsepower and 1000 horsepower switching locomotives and a "road switcher" of 1000 horsepower. Also, it manufactures regular Diesel road locomotives of 1500 and 2000 horsepower for both freight and passenger service. These units can be used in multiple combinations as desired. Fig. 1 illustrates a 660 horsepower switcher, Fig. 2 illustrates a 1000 horsepower switcher, Fig. 3 illustrates a road switcher, Fig. 4 illustrates a single-unit, 2000 horsepower road locomotive, and Fig. 5, a two-unit, 4000 horsepower road locomotive. Two of the 2000 horsepower locomotives can be coupled end to end as shown in Fig. 6 to make a 4000 horsepower double-end locomotive. The road locomotives are the same for either freight or passenger service except for a possible change in the gear ratio of the driving motors. The electrical equipment for these various locomotives is manufactured by the General Electric Company.

2. The power plant of the 1000 horsepower switcher will be described. Differences between the power plant of this switcher and that of the 660 horsepower switcher, as well as differences in the power plants of the road switchers and regular road locomotives, will be pointed out.

3. The power plant of a 1000 horsepower switcher is described because the crew of a switcher usually is responsible for the operation of the power plant and auxiliary equipment, as well as for the operation of the locomotive itself.

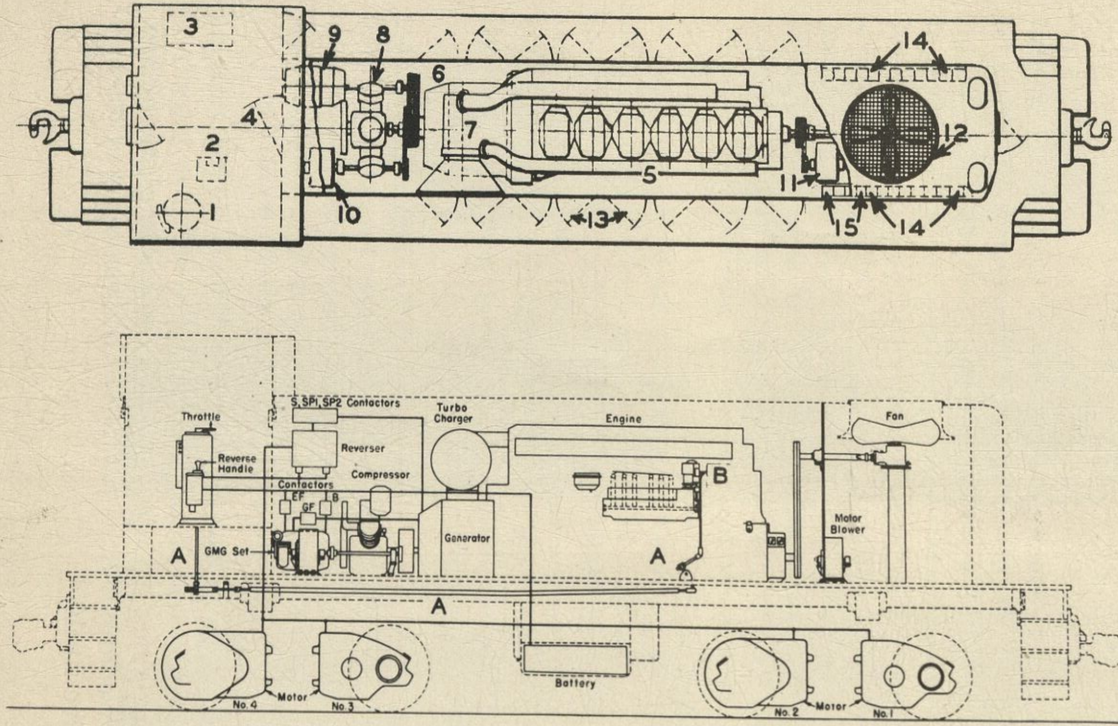

Fig. 7

1—Engineer's seat

2—Control stand

3—Fireman's seat

4—Door to electrical cabinet

5—Diesel engine

6—Generator

7—Turbo-charger

8—Air compressor

9—Combined auxiliary generator-exciter

10—Blower for rear traction motors

11—Blower for front traction motors

12—Cooling fan

13—Doors to engine compartment

14—Water sections of radiators

15—Oil sections of radiator

A-A-A—Mechanical throttle linkage

B—Engine governor

4. Figure 7 shows a floor plan and a cut-away sketch of a side view of the 1000 horsepower switcher illustrated in Fig. 2. The arrangement and the names of the principal parts are shown.

5. The arrangement of the road switcher is much the same as that of the regular 1000 horsepower switcher except that an extension at the back of the cab (see Fig. 3) provides space for a steam generator. There is provision, also, for coupling two of these road switchers together and operating the two units from the control station of either cab.

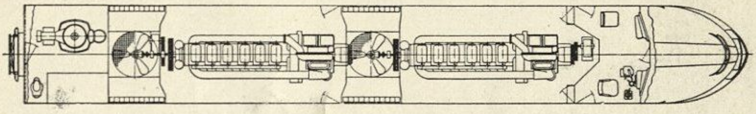

Fig. 8

6. Figure 8 is a floor plan which shows the arrangement of the cab and engines of the single-unit road locomotive illustrated in Fig. 4.

7. The power plant of the 1000 horsepower switcher is illustrated in Figs. 9 and 10. When this power plant is in place, the side of the engine shown in Fig. 9 is at the left side of the locomotive and the side shown in Fig. 10 is at the right side of the locomotive. Certain parts of the engine are numbered and named in the figures.

8. The Diesel engine has six cylinders and operates on the four-stroke cycle principle. The bore of the cylinders is 12½ inches and the stroke of the pistons, 13 inches. The normal operating speed is 740 revolutions per minute. The engine is directly connected to a direct current generator by a solid coupling. The 660 horsepower switcher has an engine of exactly the same type, but without the turbo-charger, and with a smaller generator. The power plants of the older road locomotives are the same as the power plant of the 1000 horsepower switcher, with the addition of the necessary electrical equipment for the

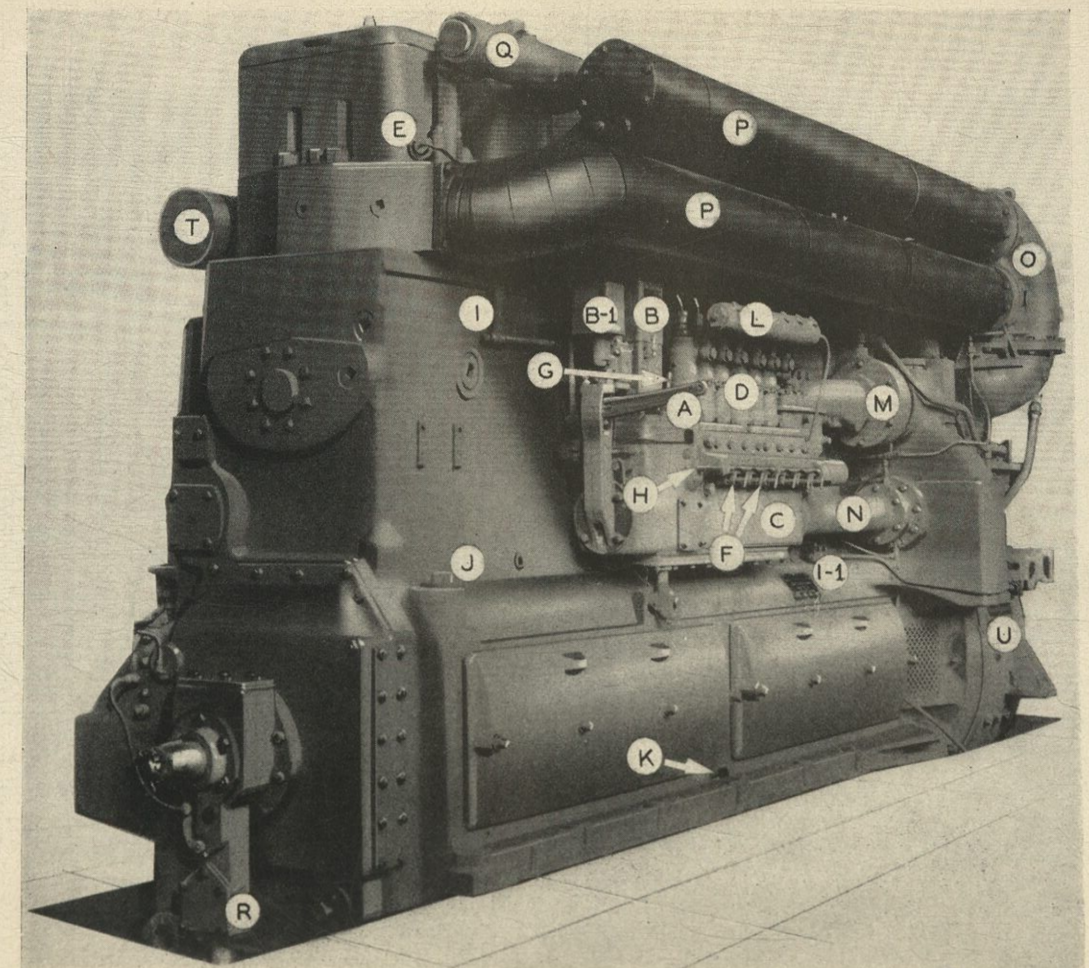

Fig. 9

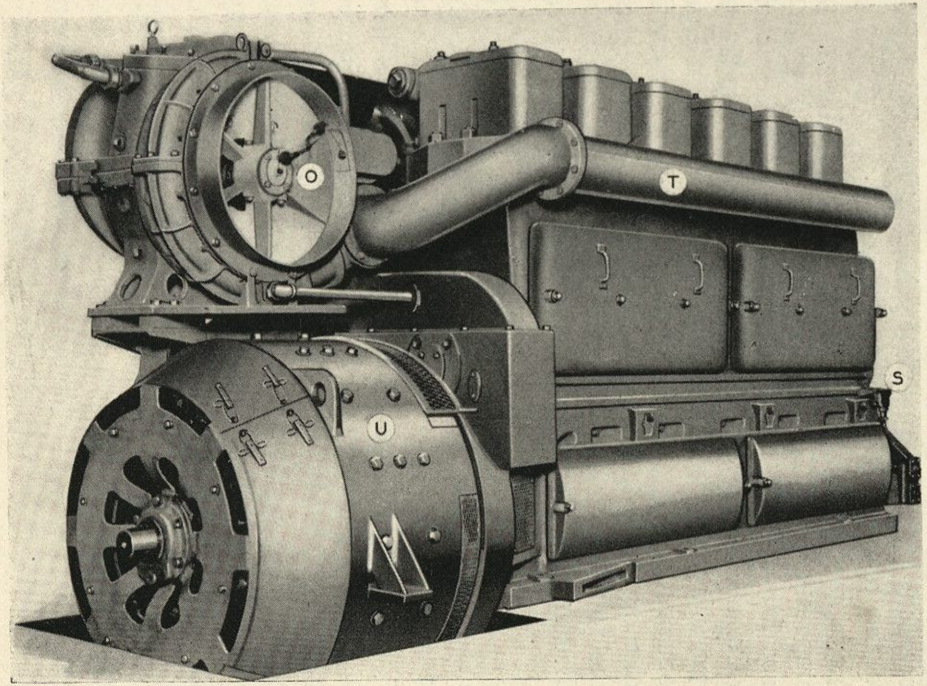

Fig. 10

A—Throttle linkage connection
B—Governor
B-1—Solenoid shutdown valve
C—Bosch fuel oil injection assembly
D—Fuel oil plunger pumps
E—Return drip pipe from fuel oil injector nozzle
F—Plunger pump cutout pin handles and fingers
G—Engine shutdown lever
H—Fuel plunger pump reset lever
I—Drip box (one of three)
I-1—Main drip box
J —Lubricating oil filler opening
K—Lubricating oil bayonet gage
L—Header of fuel oil plunger pumps
M—Water pump
N—Bosch injection assembly drive shaft
O—Turbo-charger
P—Exhaust manifolds
Q—Engine cooling water header
R—Lubricating oil pump
S—Lubricating oil low pressure stop switch (Fig. 10)
T—Air inlet manifold
U—Generator

remote control of all engines from the cab. A new type V-engine has been designed for road switchers and road locomotives.

PRINCIPLE OF OPERATION

9. As has been stated, many Diesel engines are designed to operate on the four-stroke cycle principle. The operation is practically the same as with a gasoline engine except that *air only* is admitted above the piston during the first or admission stroke. During the second or compression stroke, the charge of air is compressed to about 450 pounds per square inch, a much higher pressure than is necessary with a gasoline engine. When the piston nears the top of the second or compression stroke, a charge of fuel oil is sprayed by pressure into the charge of compressed air. The temperature of this highly compressed air is about 1000 degrees. This is high enough to ignite the fuel oil as it is sprayed into the cylinder. *No spark is necessary.* The burning of the fuel and the consequent explosive expansion of the fuel and air in the cylinder causes the third or power stroke of the piston. On the fourth or exhaust stroke, the burned gases are expelled from the cylinder through the exhaust valves.

10. When a turbo-charger or supercharger is used, air under pressure is forced from the turbo-charger into the cylinder during the exhaust stroke. This helps to clear (scavenge) the cylinder of exhaust gases. Then, on the admission stroke the charge of air for the power stroke is forced into the cylinder under pressure from the turbo-charger. Thus, a greater amount of air is compressed in the cylinder than is possible with the ordinary admission valve arrangement.

11. The amount of fuel which can be burned on any firing stroke is limited by the amount of air which can be compressed in the cylinder. The additional amount of air compressed in the cylinder by the use of the turbo-charger allows more fuel to be burned on each firing stroke. This accounts for the increase in power of an engine equipped with a turbo-charger, although there is no increase in the size of the cylinders or the speed of the engine.*

12. The power that drives a Diesel locomotive is developed by one or more Diesel engines mounted on the bed or framework of the locomotive. No practical mechanical device has been developed to transmit the power from the crankshaft of the Diesel engine directly to the driving wheels of a large locomotive. A device, such as the clutch and the transmission used on the automobile, is not practicable in large sizes or for starting and accelerating very heavy loads. The desired flexible control of the power developed by the Diesel engine is obtained by the use of electric transmission.

13. Power is transmitted electrically from the crankshaft of the engine to the wheels of a Diesel locomotive. The mechanical energy delivered at the crankshaft of the engine is converted into electrical energy by means of a direct-driven, direct-current generator. The electrical energy is delivered from the generator to the traction motors which are mounted on the trucks of the locomotive and are connected to the driving wheels by means of reduction gears.

14. The engineer of a Diesel locomotive moves the cab throttle to increase or decrease the power output of the Diesel *engine*. Each movement of the throttle away from the idling position results in a corresponding increase in the amount of fuel oil supplied to the cylinders of the Diesel engine and a consequent increase in the speed or power output of the *engine*.

15. Variation in the electrical power supplied by the generator to the traction motors is accomplished by a

*This is explained in more detail in paragraphs 99, 100, and 101.

combination of manual and electrical controls. This combination of controls makes possible great flexibility in the transmission of the power of the Diesel engine to the driving wheels of the locomotive.

OPERATING THE POWER PLANT

16. Figure 11* is a view from the engineer's position in the cab of a 1000 horsepower Diesel switcher. The names of the parts are shown. Fig. 12* is a view of the corner of the cab at the right of the view shown in Fig. 11. Fig. 12 shows the handle of the battery switch, *K*, the emergency fuel oil cutoff pull knob, *M*, and the fan shutter operating lever, *N*, none of which are visible in Fig. 11. The valves at the lower right of Fig. 12 are the reducing valve and the feed valve of the air brake system. The door, *J*, which is shown in both Figs. 11 and 12, opens into the electrical apparatus cabinet.

17. The instruction in this text will be presented under the following six general headings:

(1) Preliminary checkup required before starting the engine.†

(2) Starting and warming up the engine.

(3) Checkup if the engine will not turn over.

(4) Checkup if the engine turns over, but fails to fire.

(5) Moving and stopping the locomotive.

(6) Shutting down the power plant.

18. The locomotive crew called for duty on one of these switchers may encounter any one of three conditions. First, the locomotive may be standing after a number of hours of shutdown. Second, the locomotive may have been serviced by the roundhouse forces and the

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*Figures 11 and 12 will be referred to frequently. For convenience they are placed on a folded insert at the back of the text.

†The term engine in these texts refers to the Diesel engine of the power plant, not to the locomotive as a whole.

engine may be running and warmed up. Third, one crew may simply relieve another crew, in which case the engine will be running.

19. If the locomotive has been serviced and the engine is running when the new crew takes charge, about the only checkup necessary is to inspect the fuel oil gage, the water glass of the expansion tank of the cooling system, and the bayonet gage which shows the height of lubricating oil in the crankcase of the engine. The gages and indicators on the instrument panel should be checked to see that there is proper air pressure for the operation of the brakes and the controls and to see that the storage battery is charging. The fuel pressure gage should show about 35 pounds, the lubricating oil gage should show between 35 and 45 pounds, and the temperature of the cooling water should be between 150 and 170 degrees.

20. The new crew, of course, is responsible for knowing that there are proper supplies and flagging equipment on the locomotive. This includes the proper signaling equipment, in accordance with the rules of the road. It is against the rules to carry waste on a Diesel locomotive, other than oil soaked wool waste for repacking axle bearings. The lint from wiping waste is likely to clog up oil lines or interfere with the proper working of the electrical equipment. Wiping rags are furnished for use on Diesel locomotives and a supply should be on hand on the locomotive.

21. When a crew arrives at a locomotive which has been standing *shut down* for several hours, a thorough and systematic checkup should be made. Such a checkup is described in the following paragraphs.

PRELIMINARY CHECKUP OF POWER PLANT

22. Necessary preliminary checks before starting the Diesel engine are as follows:

(a) Check to see that emergency fuel oil valve is open.

(b) Check fuel oil supply.

(c) Check engine cooling water supply.

(d) Check lubricating oil supply.

(e) Check for anything loose or under repair in the engine compartment.

(f) Check position of all shutters.

(g) Check fuse panels to make sure that all fuses are in place.

Each of these items will be discussed separately.

23. CHECK POSITION OF EMERGENCY FUEL OIL VALVE. The fuel oil tank is underneath the floor of the cab. A pipe leads from this tank forward to the fuel pump. The emergency fuel oil valve is located in this pipe between the tank and the fuel pump. It can be inspected by opening the door to the electrical cabinet. When the valve is open, the stem of the valve is in its upper position and latched; when closed, it is unlatched and down. This valve must be open, otherwise, oil cannot flow from the fuel oil tank to the fuel pump.

24. It is well, before climbing up on the locomotive, to check the angle cocks at the ends of the brake pipe of the locomotive to see that they are closed. The main reservoir drain valves should be checked also, to see that they are closed. There are other valves which must be checked later in connection with the checkup of the lubricating oil and cooling systems.

25. CHECK FUEL OIL SUPPLY. On switchers, the gage which indicates the amount of fuel oil in the main fuel tank is located inside of a small door directly below the engineer's window, outside of the back of the cab. The gage is like an old-fashioned water glass on a boiler. The first inspection of the fuel oil system is to check this sight-glass gage so that the operator can decide whether there is sufficient fuel for the trick or run. Some-

times a very clear grade of white fuel oil is used; close inspection may be necessary to determine the height of such fuel oil in the glass. The filler pipe usually is located just outside this door.

26. The fuel oil tank of this locomotive, when filled, holds 635 gallons. Fuel oil is added to the tank through the filler pipe just mentioned. The indication of the sight-

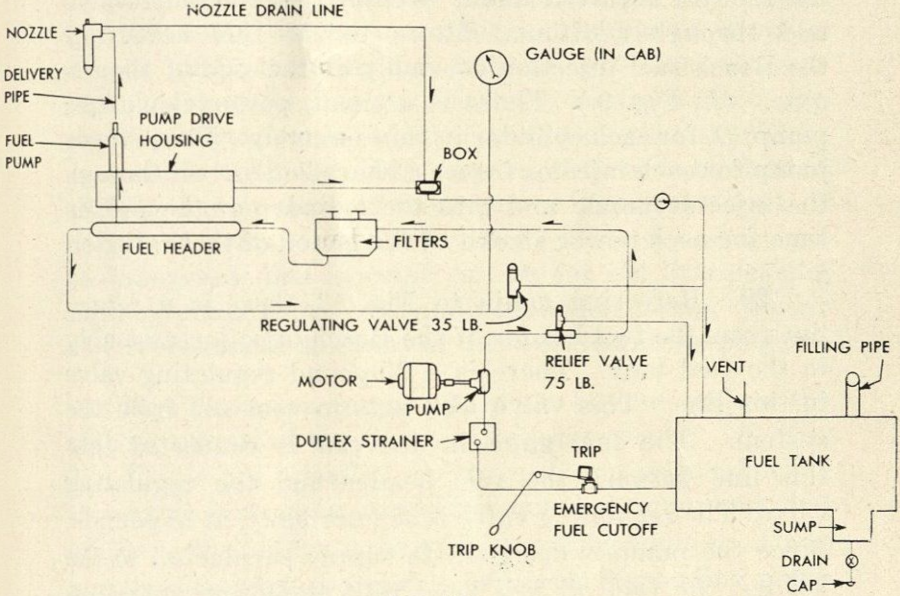


Fig. 13

glass gage will show the approach of the oil to the top of the tank. There is a vent pipe at the top of the tank. This vent pipe contains a flame arrester.

27. The fuel oil circuit is shown in Fig. 13. This sketch is known as a schematic diagram, that is, it shows the various parts and pipes without much reference to piping details or to the actual size or location of each part. There is a sump at the bottom of the fuel oil tank into which water, dirt, or sludge can sink. There is a drain valve below this sump, but the drain pipe is capped to prevent a loss of fuel should an unauthorized person open this valve. The cap must be removed with a pipe wrench if the sump is to be cleared of water or if the fuel system is to be drained.

28. A pipe leads from near the bottom of the fuel oil tank through a duplex strainer and the emergency cutoff valve to the main fuel oil pump.* This pump is driven by its own motor. When the pump is operating, the fuel oil is forced under pressure past a relief valve and through additional filters to the fuel header of the Bosch fuel injection assembly at the side of the engine. (*L*, Fig. 9.) There is a small, powerful plunger pump, *D*, for each cylinder in this assembly. The plunger pump for each injector forces a charge of fuel oil through the injector nozzle and into the cylinder at the proper time for each power stroke of the piston of that cylinder.

29. Referring again to Fig. 13, there is a return line from the fuel header of the Bosch injection assembly to the fuel tank. There is a 35-pound regulating valve in this line. This valve also acts to vent air from the system. The fuel gage in the cab is connected into this line between the fuel header and the regulating valve. The regulating valve is set, normally, at 35 pounds. Since the pump is designed to supply surplus oil to the header, the fuel oil will keep this regulating valve unseated as it flows through it back to the tank. The fuel gage in the cab indicates the setting of this valve. The 75-pound relief valve near the pump has a pipe from its discharge port to the fuel tank.

30. The moving parts at the plunger pumps and injection nozzles of the Bosch injection assembly are lubricated by a part of the fuel oil which passes through the assembly. Fuel oil that seeps past each nozzle spindle is piped to an open box or receptacle on the side of the

*On some locomotives the duplex strainer is beyond the emergency cutoff valve, as shown in Fig. 13.

engine. There are three of these boxes. (One can be seen at *I,* Fig. 9.) Each box receives the drain from two nozzles. These three boxes in turn drain into a main drain box, *I-1,* Fig. 9. (Only the main drain box is indicated in Fig. 13.) Another drain pipe leads from the plunger pump section of the Bosch assembly to this main drain box. The main drain box drains directly into the fuel oil tank.

31. The leakage at the drip pipe from any nozzle spindle should not be more than a couple of drops a minute. More than this may indicate dirt under the seat of the valve of the injector nozzle, excessive wear of the needle plunger, or some other condition that should be reported to the maintainer. Again, if there is no drip at all from one or more of these pipes, it indicates lack of proper lubrication at that injector. Should such a case be discovered, that injector can be cut out by releasing the stop pin of the corresponding plunger pump. Under no circumstances must any of these drain lines be plugged.

32. There is a cutout pin at the base of each of the plunger pumps of the Bosch injection assembly (*F*, Fig. 9). If this pin is pulled out, turned, and released while the engine is running, it will cut out that pump and shut off the fuel injection to the corresponding cylinder. These pins must be latched properly or the corresponding pump will not operate.

33. There is a shutdown lever, *G*, Fig. 9, alongside the plunger pumps that can be operated by hand or automatically by the overspeed safety device to shut down all of these plunger pumps and thus stop the engine. In case of such a shutdown, each stop pin must be pulled out and latched by hand before the engine can be restarted. Resetting requires two operations. First, the pins must be pulled out and turned until the finger of each pin rests on top of the cutout rack. This is so that the spring will not pull the pin back in again. When all pins have been given this first adjustment, the reset lever is pulled out; this in turn, moves the cutout rack to its starting position. If any cutout pin finger does not slip into its proper notch, the cutout pin handle must be turned again. When in proper position, the handles of the pins will be close to vertical. The overspeed trip will not function again, after it has been tripped, until the reset lever has been pulled out and the pins have been properly reset. The pins are not properly reset until each finger is in its proper notch.

34. Usually, there is a bleeder above the plunger of each oil pump at the Bosch injection assembly and a second bleeder at each injector nozzle. If air gets into the fuel oil pipes leading to the fuel injectors, these bleeders may have to be opened and the engine will have to be cranked by means of the battery to clear the pipes of air. No fuel will reach the cylinders and the engine will not fire until this has been done. A case where this may be necessary is when the main fuel tank has run dry and then is refilled.

35. The fuel oil is filtered once before it reaches the main fuel pump and again before it reaches the fuel header of the Bosch injection assembly. It is filtered again at each injector. Filters are of different types. Duplex filters have a three-position handle so that the oil can be directed, first, through one side of the filter, and then, when that becomes dirty, through the other side which should be clean. If the duplex filter handle is kept in mid-position, both sides become dirty at the same time, thus the advantage of having a clean filter in reserve is lost. Some other types of filters have a *cleaning handle.* The handle should be turned every few hours in order to scrape the accumulated sludge from the filtering surfaces. Filters are serviced by the terminal forces.

36. The emergency fuel oil cutoff valve, as the name implies, is for emergency use to shut off the fuel oil supply close to the fuel tank in case of accident or danger of fire. It can be operated by pulling an emergency knob in the cab. A similar knob is located under the running board ahead of the cab on either side of the locomotive. If the emergency fuel oil cutoff valve has been tripped, it must be reset by pulling up the stem and adjusting the latch to hold the stem up.

37. There are two tanks on road switchers. One tank is used for water storage if the road switcher is equipped with a steam generator. If there is no steam generator, a valve in the pipe which connects the tanks can be opened and both tanks used for fuel oil. The regular fuel oil tank of the road switcher is under the floor of the cab. Its gage glass and filler pipe are on the right side of the locomotive. The second tank is under the bed of the locomotive, between the trucks. It, also, has a gage glass and filler pipe which can be reached from the right side of the locomotive. Road switchers also have two "remote" gages in the cab which show the amount of liquid in these two tanks.

38. CHECK ENGINE COOLING WATER SUPPLY. Figure 14 is a schematic diagram of the engine cooling system of a 1000 horsepower switcher. The water simply circulates around and around. It is heated as it passes through the engine block and cooled as it passes through the radiators. There is an expansion tank at the top of the engine compartment just back of the radiators. This expansion tank takes care of fluctuations in the height of water as the temperature of the water changes. The system should be filled so that the water is within an inch or an inch and a half of the top of the expansion tank as shown by the water glass on this tank.

39. The path of the engine cooling water is as follows: Water from the expansion tank keeps the radiators full. Water from the bottom of the radiators flows through a return line to the engine block and through a passage inside the engine block to the water pump. (*M*, Fig. 9.) The water pump is driven by gears from the crankshaft of the engine. The pump forces water under pressure around the cylinders and cylinder heads of the engine. The water, after cooling the engine, is discharged from a water header at the top of the cylinders to a pipe which leads to the radiators. This pipe has a branch to the expansion tank.

40. The thermometer on the instrument panel in the cab is connected to the water header. Consequently, it indicates the temperature of the water after it has circulated through the cooling spaces of the engine.

41. The cooling water system also has a connection from the water pump to the turbo-charger (see Fig. 9). The turbo-charger is driven by exhaust gases from the engine. The gas turbine end of the turbo-charger has to be cooled. The water which flows through the cooling passages of the turbo-charger is piped back to the engine block and flows with the cooling water through the engine cooling spaces.

42. There is a pipe from the water header that leads through the cab heater and back through a return line to the suction side of the water pump. There are drain lines and valves so that the cooling cavities of the turbo-charger can be drained and so that the cooling cavities in the engine block can be drained. *These drain valves must be closed while the engine is running.* The cab heater is cut into the drain line as well as the radiators, expansion tank, and all other parts of the cooling system. The system can be filled by connecting a hose at the drain line or by running water into the opening of the expansion tank on the roof of the engine hood.

43. There is a fan in the roof of the hood that exhausts air from the engine compartment so that cooling air will be drawn through the radiators. Shutters to regulate the amount of air exhausted by this fan can be adjusted by means of a shutter operating lever in the cab. There is a hand-operated shutter outside of each radiator. These are adjusted from the running board by loosening a wing nut and moving a lever to give the opening desired. The wing nut must be tightened after the adjustment is made. The combined adjustment of the shutters at the radiators and the shutters at the fan

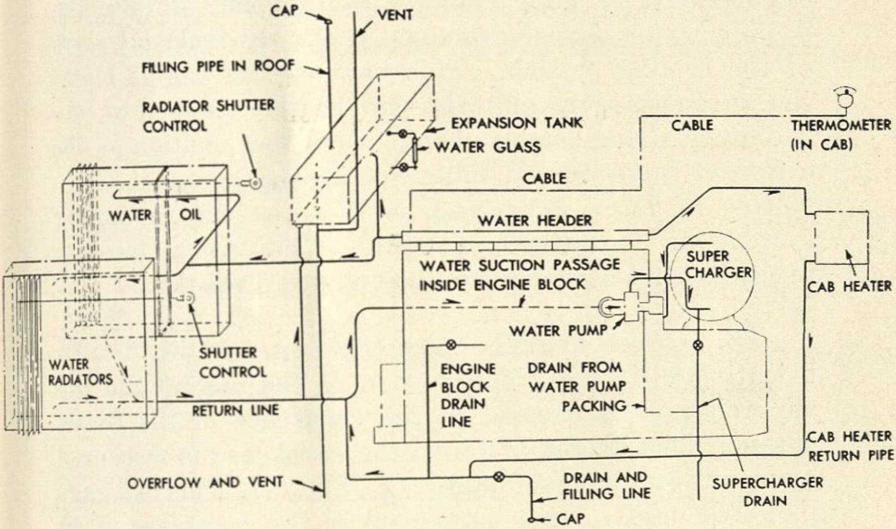


Fig. 14

should enable the operator to keep the cooling water temperature between 150 and 170 degrees in all kinds of weather. In warm weather the shutter at the oil section of the radiator should be kept open and the other shutters adjusted as necessary to maintain the desired temperature. In cold weather the shutter at the oil section is kept shut and the adjustment made with the other shutters.

44. Several sections at the rear of the radiator on the right side of the locomotive are used to cool the lubricating oil. The shutter at the oil sections of the radiator should be kept closed except in warm weather. In cold weather the oil which passes through these sections will become chilled if the shutter is left open. This might make the oil so stiff that it would not circulate through the radiator properly.

45. On switchers there is no provision, other than the circulation of water through the engine block, to keep the water from freezing during cold weather. Consequently, if the locomotive is to stand out-of-doors, the engine must be kept running continuously or else the cooling water must be drained promptly from *all parts* of the cooling system. This includes the engine block, the turbo-charger, and the cab heater, as well as the radiators. Enginemen should learn the position of the different valves in the water cooling system *on the locomotive they are operating* so that the engine cooling system can be drained promptly to prevent a freeze-up in case of an emergency shutdown in cold weather.

46. CHECK ENGINE LUBRICATING OIL SUPPLY. The lubricating oil for the lubrication of the engine and the supercharger is carried in the crankcase of the Diesel engine. The height of oil in the crankcase is measured by means of a bayonet gage. (*K*, Fig. 9.) This is a gage like that used for measuring oil in the crankcase of an automobile engine. The crankcase holds 85 gallons of oil when the system is filled to the proper height. This height is indicated by a mark on the bayonet gage. The height of oil in the crankcase should be examined *before* starting the engine and the oil should be brought to the proper level if necessary. Oil is added to the crankcase at a filling hole which can be seen at *J*, Fig. 9.

47. After the engine has been started and has run for a few minutes, the gage will show about an inch less oil than before. This is because it takes a certain number of gallons to circulate through the system. When the engine is shut down, this oil drains back into the crankcase.

48. Figure 15 is a schematic diagram of the lubricating oil system. The oil supply is shown in the crank-

case. The lubricating oil pump is located at the base of the engine on the end opposite the generator. (See *R*, Fig. 9.) The pump is driven by gears from the crankshaft. The pump forces oil from the crankcase through a pipe to the top of the cooling tubes in the oil units of the radiator. It is cooled as it passes down through the tubes of these units. It travels from the bottom of these units of the radiator back to the engine. It passes through Cuno oil strainers on its way back to the engine.

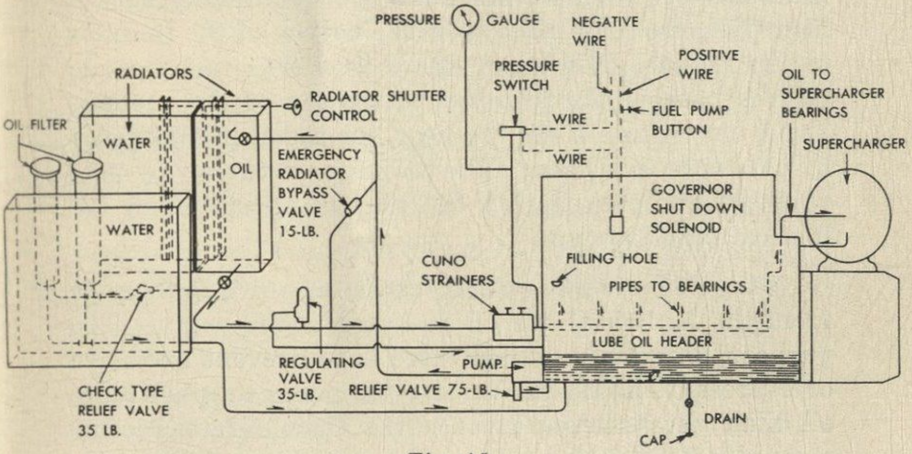


Fig. 15

49. At the engine, the lubricating oil is forced through various pipes and passages to lubricate the crankshaft, pistons, and other engine bearings. A branch pipe leads to the turbo-charger. The turbo-charger shaft bearings are pressure lubricated by the engine lubricating system, as are the drive shaft and cams of the Bosch injection assembly. The oil from the various engine bearings drains back to the oil reservoir at the bottom of the crankcase.

50. Referring again to Fig. 15, there is a 75-pound relief valve at the oil pump. A pipe leads from this relief valve back to the crankcase. This relief valve operates if the lubricating oil pipe line becomes closed for any reason. Oil from the pump is forced through the tubes of the radiator where it is cooled before it returns to the engine and is distributed to the bearings. Normally, this pipe line from the pump to the radiator and back to the engine carries about 35 pounds of pressure. A radiator emergency by-pass valve is located across this pipe line. It is set for 15 pounds. If the oil tubes in the radiator should become clogged on a cold day so that the oil could not pass through them freely, pressure would accumulate in the pipe between the pump and the top of the radiator. When this occurs, there would be but little pressure in the pipe from the bottom of the radiator to the engine. Whenever there is a *differential* of 15 pounds between the pressure at the top of the radiator and at the bottom of the radiator, the radiator emergency by-pass valve will open. The radiator emergency by-pass valve never opens during the normal operation of the lubricating oil system.

51. There is a 35-pound regulating valve in the pipe from the bottom of the oil radiator to the engine. The purpose of this regulating valve is to prevent excessive over-pressure in the line in case the pump supplies more oil than necessary or in case the Cuno filters become clogged. The relief line from this regulating valve leads directly to the oil space at the bottom of the engine crankcase.

52. Usually, the lubricating oil pump delivers a surplus of oil, that is, more than is required to be forced through the oil passages of the engine. When the pressure in the oil line exceeds 35 pounds, the 35-pound regulating valve by-passes *a part* of the surplus oil back to the crankcase. Any additional surplus oil passes through a check-type relief valve, which also is set at 35 pounds. This second by-pass valve line leads through one or two large oil filters and from there back to the crankcase of the engine.

53. The crankcase can be drained of oil or cleared of any accumulation of water by opening a globe valve in the drain pipe. This drain is on the left side of the locomotive below the bed. The use of a cap at the end of the drain pipe protects against loss of oil by the unauthorized or accidental opening of this valve.

54. The lubricating oil pressure gage on the instrument panel indicates the pressure in the lubricating oil line between the Cuno strainers and the engine. This same pipe leads to an oil pressure switch which is connected electrically with the engine governor shutdown solenoid. The oil pressure switch operates if the oil pressure drops below 20 pounds. The operation of this switch opens an electrical circuit which causes the governor to shut down the engine.

55. It is desirable that the handles of the Cuno filters be turned every few hours to keep the filter surfaces clear of any sludge that may accumulate from the oil.

56. Check for anything loose or under repair. A careful operator will check the last work report to find out what repairs, if any, were listed and what work, if any, was done on the power plant or the locomotive during the layover. With this information, a special inspection of the engine and trucks can be made to insure that the work listed has been completed.

57. Serious damage may result if tools, blocking, or anything else has been left loose in the engine compartment or if the engine is started before repairs have been completed. Before pushing the starting button to start the engine, inspection should be made to see that the cylinder head covers are in place, that belts, belt guards, etc., are in place, and that there are no loose tools lying on the engine or the auxiliary equipment.

58. If the inspection cover over the opening above the brushes of any of the traction motors is not in place,

it is likely that that motor will heat. Cooling air delivered to that motor by its traction motor blower will escape without properly serving its purpose. A *loose* cover would allow moisture and dirt to enter the motor case. This might cause the ground relay to trip.

59. CHECK POSITION OF VENTILATORS AND SHUTTERS. Before starting the engine, a check should be made to see that the shutter at the oil section side of the radiators is in proper position. The shutter at the other side of the locomotive (left side) should be adjusted in accordance with the weather and operating requirements. The shutter lever in the cab regulates the shutter opening at the fan in the roof of the hood of the engine. The fan shutters are open when the lever is forward and closed when the lever is back. The shutters must be adjusted to maintain the cooling water temperature between 150 and 170 degrees.

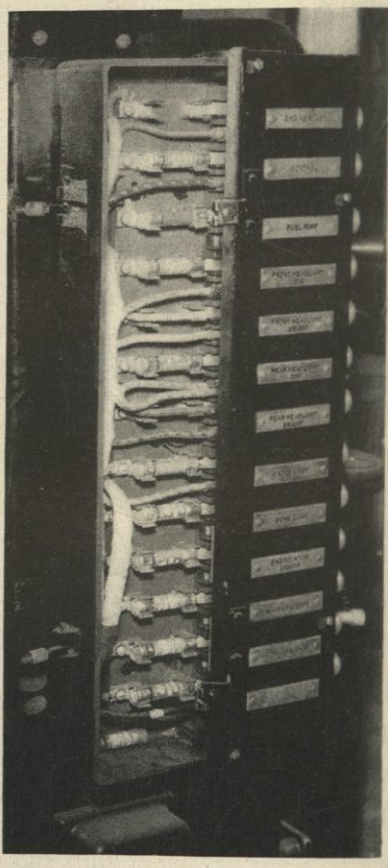


Fig. 16

60. The shutters of the radiators can be left closed in cold weather until the engine warms up. In such a case, the engine cooling water temperature gage in the cab must be watched closely.

61. Check fuse panel to make sure that all fuses are in place. The main fuse panel is in the switch box at the side of the instrument panel. The door (*E-15*, Fig. 11) leading to these fuses is shown open in Fig. 16. Each fuse is opposite its corresponding switch.

62. There are four other fuses to be checked. These are to the left of the door in the electrical cabinet. (Three of them can be seen in Fig. 17.) These four, from top to bottom, are the compartment light fuse, the auxiliary generator field fuse, the auxiliary generator fuse, and the main battery fuse.

63. The fuse positions should be inspected to see that all fuses are in place. A supply of extra fuses of each different type should be on hand in some suitable storage receptacle. The inspection of the fuse panels should include a check to make certain that there are extra fuses of all needed sizes on hand.

64. It is not required to turn the Alco Diesel engine over by hand to check for an accumulation of water or oil in the cylinders. Such an accumulation seldom occurs. Should there be any noise when first cranking the engine, that might indicate water or oil in the cylinders, the cranking should be stopped instantly. There is a plug near the bottom of the head of each cylinder that can be removed to clear the cylinder.

Starting The Engine

65. To start the engine. Refer to Figs. 11 and 12 on the folded insert at the back of the text.

(1) See that the hand brake is set, unless there is pressure in the air brake system.

(2) See that the throttle, *A*, is latched in the idling position against the forward stop, as shown in Fig. 11.

(3) See that the reverser handle, *B*, is in its

mid or neutral position as it stands in Fig. 11.

(4) Close the main battery switch, handle *K*, Fig. 12. This switch is closed when the handle is clear forward; it is open when the handle is pulled clear back.

(5) Push in control switch, *E-2*.

(6) Push in fuel pump switch, *E-3*.

When the fuel pump has started and run sufficiently so that the hand on the fuel oil pressure gage, *F-4*, shows about 35 pounds, the engine is ready to start.

66. Now, *but not until now,* press in on the engine start switch, *E-1, and hold it in.* The engine should turn over immediately. It may fire during the first revolution if it is warm. In any event it should fire by the time the engine reaches approximately 200 revolutions per minute; this should be within 3 or 4 seconds.

67. When the engine fires, *do not release* the starting switch. This switch must be held in until the hand on the lubricating oil gage, *F-6,* shows a little more than 20 pounds pressure, otherwise, the engine will be shut down automatically by the action of the low oil pressure switch.

68. If the lubricating oil pressure does not build up promptly, that is, within a very few seconds after the engine fires, the starting switch should be released so that the low oil pressure switch will stop the engine. Then, the reason why the oil pressure does not build up must be discovered and corrected.

69. If the engine does not fire before the cranking speed reaches 200 revolutions per minute (within 3 or 4 seconds) the starting switch should be released. The cranking should be stopped until the cause of the failure to start is ascertained.

70. The engine start switch should not be pressed in, then released, and then pressed in again, as is done at times when starting an automobile. This would cause arcing of the electrical contacts, that might melt and weld them and cause an engine failure. The starting switch should be pushed in *and held in* until the engine fires and has built up the proper lubricating oil pressure or until it is apparent that there is some difficulty which must be corrected before the engine will fire.

71. THE ENGINE FAILS TO START. Failure of the engine to start may be because the engine does not turn over or because it turns over but will not fire.

72. THE ENGINE DOES NOT TURN OVER. This means that power from the battery is not reaching the generator in sufficient force to cause it to run as a motor and to crank the engine. In trying to locate the cause for this trouble, start all over again to see that the reverser handle, throttle, and switches are in the correct position. Something may have been overlooked or forgotten.

73. If the main battery switch is closed, see that the battery fuse in the electrical cabinet is in place. It may be that this fuse is blown. Try another one from spare stock, but do not throw away the one removed; it may be all right; something else may be wrong. Check the control switch fuse, *E-2,* and the engine start switch fuse, *E-1.* Replace them with spares to see if they are blown.

74. If the fuses are all right, it may be that the battery is too weak to turn the engine over. Open the door of the electrical cabinet and watch the starting contactors,* while someone pushes in on the engine start switch. Have the electrical cabinet and engine compartment lights turned on when you make this test. If the contactors pull in, but the lights get so dim that they can hardly be seen, it indicates that the battery is too weak.

*Shown at 28 and 29, Fig. 18.

75. If the starting contactors do not pull in when making this test, the battery may be all right. If so, take two sticks of wood, such as hammer handles or flagstaffs, and place one against each contactor. These contactors carry only battery voltage, 64 volts. There is no danger. Push in hard on both contactors and hold them in firmly. If the engine cranks, continue to hold in on the contactors until the engine fires and the oil pressure builds up to 20 pounds. If you hold the contactors with only a light pressure, arcing may occur which will be bright enough to hurt your eyes. Keep your eyes closed or turn your head away. When you let go, do so with both sticks at once and do it with a quick movement so as not to draw an arc. These contactors contain a magnetic blowout that will always cause a loud pop when the contacts are opened quickly.

76. There is another possibility. Someone at the shop may have put wedges of wood in the starting contactors to prevent the accidental starting of the engine while it was being worked on. These wedges may have been forgotten and left in the contactors. If so, they will show sticking out of the arc chutes at the top of the contactors. The remedy, of course, is to remove them. (Pull the battery switch open first. Do not forget to close it again.) In this case, be very sure that all work has been completed on the engine so that it may be started without damage.

77. THE ENGINE ROTATES, BUT DOES NOT FIRE. There are two things to keep in mind about the firing of a Diesel engine: (1) Atomized fuel must reach the cylinders, (2) there must be sufficient compression so that the air compressed above the piston will be hot enough to ignite the fuel.

78. CHECK THE FUEL PRESSURE. If no pressure shows on the fuel oil gage, *F-4*, see if the main fuel pump motor is running. If it is, see if the coupling between the motor and the pump is all right. If the motor is not running,

check the fuel pump switch fuse, *E-3*. Try another fuse. Next, recheck the fuel supply in the fuel oil tank and recheck the position of the emergency fuel cutoff valve. If this valve is closed, it has to be reset and latched by hand.

79. If the trouble has not been found, check the engine overspeed trip to make sure that it is in running position. There might be trouble with the electric circuit at the governor or the solenoid might be stuck so that the governor piston would not rise. If so, no fuel would be supplied to the injectors. A *light* tap on the solenoid case might correct the difficulty. Also, there might be air in the fuel oil pipes at the plunger pumps or at the injectors. Cranking the engine may clear the fuel oil lines of air. If not, the air will have to be bled out before fuel can reach the cylinders.

80. With a mechanical throttle linkage there is a possibility that a pin may have dropped out, that the linkage may have become jammed, or that the linkage may be icebound in winter weather.

81. LOW COMPRESSION. About the only thing that might lower the compression in an engine that otherwise is all right, would be the removal of the cylinder test plugs. Any escape of air from test plug openings will be heard when the engine is being cranked. These plugs should be replaced if they are out.

BEFORE MOVING THE LOCOMOTIVE

82. *After the engine has been started and the lubricating oil pressure has built up satisfactorily, the following checks are necessary before the locomotive is moved:*

(a) Check air supply in main reservoirs and in the control reservoir. Main reservoir pressure is indicated by the red hand on gage, *F-1*, Fig. 11. Control air reservoir pressure is indicated by the hand on the control air gage, *F-5*, Fig. 11. There must be sufficient main reservoir pressure to operate the brakes. If the control reservoir pressure is less than 70 pounds, the contactors will not operate properly. Time should be allowed for the air compressor to raise the pressure to 70 pounds.

(b) Check engine cooling water temperature gage. It should indicate at least 125 degrees before any attempt is made to move a heavy load.

83. The locomotive cannot be moved if the ground protective relay contacts are open. This relay is shown at *21* in Fig. 18. There is a red fiber latch at the top of this relay. The relay is reset by lifting this latch. When the latch is lifted, the contacts will close; then the locomotive can be started. However, the ground relay may trip again when the locomotive is started. The circuit will be broken a second time if the ground still exists. When making the routine inspection prior to starting the locomotive, it is well to make certain that the armature of the ground relay is not latched with its contacts open.

84. There are certain safety precautions that always should be taken before moving any locomotive that has been shut down and has been standing for any length of time. The first precaution is to make sure that there is no one working underneath the locomotive and that it is not blocked in any manner. It is of equal importance to test the air brakes to make certain that there is sufficient air pressure and that the brakes operate properly. If the engine has been out of service for some time, the operator should make certain that the bell and whistle both operate, that the sanders work properly, that the headlight will light, etc.

85. TO MOVE THE LOCOMOTIVE. Complete instructions for operating Alco-G. E. switching locomotives are contained in Unit N. 23-A.

86. TO STOP THE LOCOMOTIVE. Return the throttle to idling position and apply the air brakes gradually, unless emergency action is necessary. *Do not move the reverser handle until the locomotive has come to a full stop.*

SHUTTING DOWN THE POWER PLANT

87. The proper way to shut down the power plant is to open the fuel pump switch in the cab. This will cause the fuel pump to stop. Opening this switch also opens the circuit to the governor solenoid so that the solenoid will dump the oil pressure at the governor and shut off the supply of fuel oil from the Bosch plunger pumps to the fuel injector nozzles.

88. If the engine has been working hard just before time to shut it down, it should be allowed to idle for about five minutes to let the temperatures equalize throughout the engine block and cylinder heads. In cold weather all shutters can be closed when the engine is shut down. Of course, the water must be drained from the cooling system if the engine is shut down out-of-doors in freezing weather.

89. If the crew is to leave the locomotive after shutting down the engine, the air brakes should be released and the hand brake set. All switches should be open including the main battery switch. The reverser handle should be removed from the stand but left on the locomotive.

90. STARTING AND STOPPING THE ENGINE OF OLDER ALCO-G. E. SWITCHING LOCOMOTIVES. On some of the early Alco-G. E. switching locomotives a three-way valve located at the right side of the control stand is used for starting and stopping the Diesel engine. This valve is exactly like a sander valve. To start the Diesel engine the handle of this valve is placed in its vertical position, after which the engine starting button is pressed and held in. When the engine fires and the lubricating oil pressure has built up to 30 pounds, the handle of this three-way valve should be moved to its running position.

91. *The handle of this valve never should be left in the starting position while the engine is running* because the low lubricating oil automatic shutdown is inoperative in this position. *The Diesel engine always must be stopped by moving the handle of the three-way valve to its stop position.* An engine equipped with this valve *never* should be shut down by opening the fuel pump switch. Should this be done, the engine would not stop until the fuel lines were pumped dry of oil.

MISCELLANEOUS

92. The proper idling speed of the engine is 275 revolutions per minute. Terminal maintainers have an instrument for measuring engine speed. If the engine sounds as though it were idling too slowly or too fast, the information should be noted in the work report. The operator usually can count the revolutions by holding a finger at a bend in one of the pipes from the plunger pumps to the fuel nozzles. There will be one pulse for every *two revolutions* of the crankshaft of the engine. The engine speed will be *twice* the number of pulses per minute.

93. The reverser handle shaft is interlocked electrically by the throttle when the control switch is closed. The electrical connections which cause the traction motors to reverse cannot be changed by movement of the reverser handle while the throttle is open.

94. If the throttle is pulled away from its idling position to move the locomotive and the locomotive does not start to move immediately for any reason, the throttle should be moved back to idling position. If the throttle is left out and current flows to the motors without movement of the locomotive, the motors will heat and may be badly damaged in a short time.

95. The field circuits of the Alco-G. E. Diesel generator are energized by an exciter. The exciter is combined with the auxiliary generator. This is explained further in the sections on Electrical Action of other texts.

96. The traction motors of these locomotives are cooled by passing a current of air through suitable passages in the motors. This current of air is supplied by two traction motor blowers. These auxiliaries are located in the engine compartment of the locomotive. There is one for each truck.

97. There are individual sets of "V" belt drives from the engine to the auxiliary generator and exciter, to the two traction motor blowers, and to the gear set that turns the radiator cooling fan. Each set of belts should have sufficient tension to drive its auxiliary properly. Belt covers, which are safety guards, should be in place.

98. A dump valve on the governor power cylinder is held closed by an electric solenoid. If the circuit to the solenoid is opened, as happens when the fuel pump switch in the cab is opened, the dump valve of the governor is opened and the lubricating oil pressure on the under side of the governor power piston is released. The spring of the governor then operates to force the plunger pump control shaft of the Bosch injection assembly into shutdown position so as to stop the engine.

99. The turbo-charger application used on the Alco Diesel engine is named "Buchi" for its inventor. It consists of a small gas turbine which is directly connected to a centrifugal blower. After the Diesel engine is started, the exhaust gases pass through and drive the turbine of the turbo-charger on their way to the atmosphere. The operation of the turbine causes the cen-

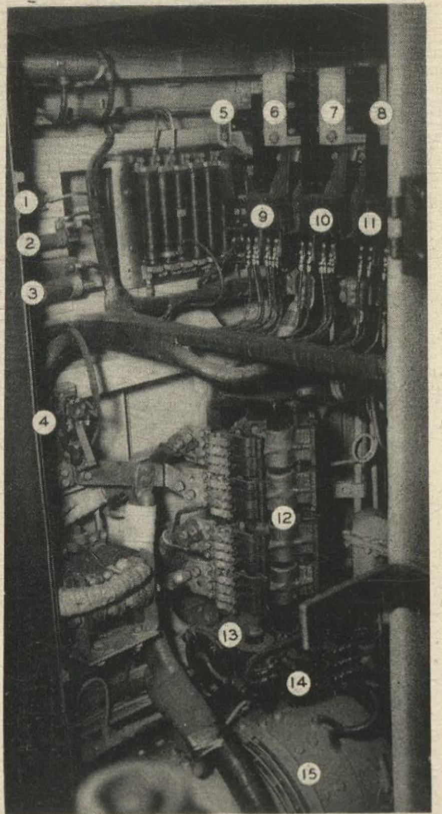


Fig. 17

1—Auxiliary generator field fuse

2—Auxiliary generator fuse

3—Main battery fuse

4—Overload relay

5—One of two traction motor field shunting contactors

6—Series-parallel contactor (SP-1)

7—Series contactor (S)

8—Series-parallel contactor (SP-2)

9—Interlock on series-parallel contactor

10—Interlock on series contactor

11—Interlock on series-parallel contactor

12—Reverser drum

13—Reverser drum electro-pneumatic valve and cylinder

14—Reverser drum interlock

15—Combined auxiliary generator and exciter

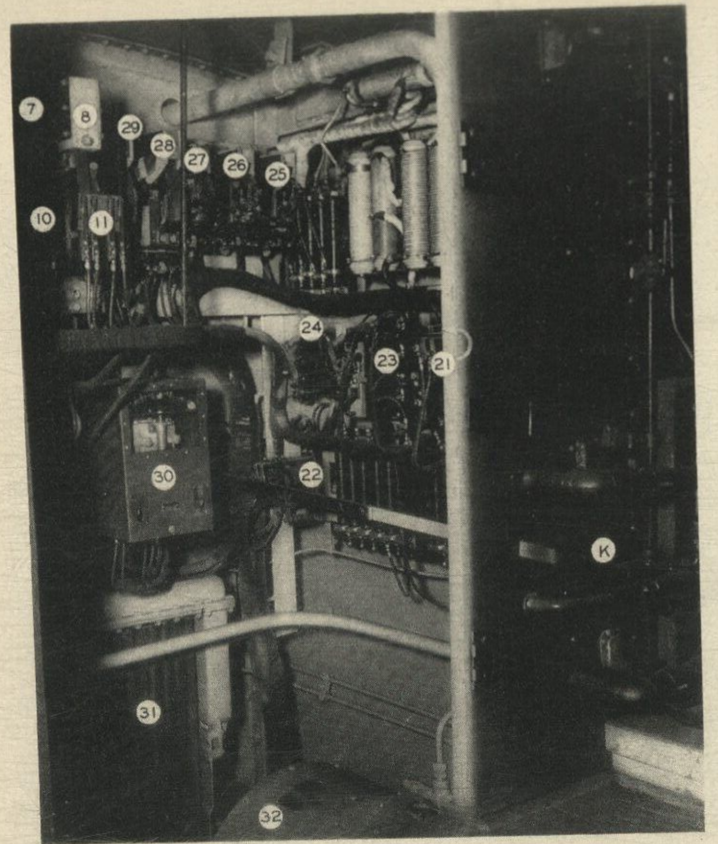


Fig. 18

7—Location of series contactor shown in Fig. 17

8—Series-parallel contactor (same as shown in Fig. 17)

10—Location of interlock on series contactor shown in Fig. 17

11—Interlock on series-parallel contactor (same as shown in Fig. 17)

21—Ground relay (arrow indicates reset handle)

22—Control relay

23—Transition relay

24—Wheel-slip relays

25—Exciter field contactor (EF)

26—Main generator field contactor (GF)

27—Battery charging contactor (B)

28—Engine starting contactor (GS-1)

29—Engine starting contactor (GS-2)

30—Voltage regulating relay

31—Intercooler for air compressor

32—Traction motor blower

K—Battery switch handle and rod

trifugal blower to supply air to the intake manifold of the Diesel engine at a pressure of around 5 pounds per square inch. As has been stated, this compressed air is used to help scavenge the exhaust gases from the cylinders of the Diesel engine and to supercharge the cylinders with air on each compression stroke.

100. The addition of a turbo-charger to a Diesel engine requires a very careful readjustment of the timing of both the exhaust and the admission valves of the engine. The admission valves are opened during the exhaust stroke to help scavenge the cylinders. The exhaust valves are not closed until the piston has reached the top of the exhaust stroke and has started down again. The intake valves are not closed until the piston reaches the bottom of its admission stroke.

101. If any unusual noise should develop in the turbo-charger for any reason, the engine should be shut down at once. There is a way of blocking the turbo-charger unit if it has to be kept from turning. If the turbo-charger unit is blocked, the Diesel engine can be restarted and operated, but the power of the engine will be reduced because of the elimination of the turbo-charger feature. Locomotive engineers assigned to run a Diesel locomotive which is equipped with a turbo-charger should find out from the maintenance forces how the turbo-charger may be blocked.

ELECTRIC CABINET

102. Figures 17 and 18 are two views looking into the electric cabinet from different angles. The doors of the cabinet were removed for the purpose of taking the photographs. The names of some of the items of electrical equipment are listed beside the illustrations. The location of three of the four fuses in the electric cabinet is shown in Fig. 17. The starting contactors are shown in Fig. 18. The location of the ground relay also is shown in Fig. 18. Explanations of the electrical apparatus and their circuits are given in later texts.

THE 660 HORSEPOWER SWITCHER

103. As has been stated, there is practically no difference in the operation of the power plant of the 660 horsepower switcher and of the 1000 horsepower switcher. The absence of the turbo-charger on the 660 horsepower switcher makes no difference in starting, running, or shutting down the power plant.

THE ROAD SWITCHER

104. There is little apparent difference in starting, running, or shutting down the power plant of the road switcher from what already has been described. On some road switchers the reverser handle is at the top of the instrument panel alongside the throttle. This change makes no difference in operating the power plant. There are notches on the throttle of some road switchers and corresponding electrical controls on the engine. Again, however, this has no practical effect on the method of starting, running, or shutting down the power plant.

EXAMINATION QUESTIONS

1. . . Where is the fuel oil tank filler opening?
2. . . How can the height of fuel oil in the tank be checked?
3. . . What valve must be opened before any fuel oil can be pumped from the tank to the cylinders of the engine?
4. . . How is this valve reset if it is closed?
5. . . How can the amount of water in the engine cooling system be checked?
6. . . How is the oil level in the crankcase checked?
7. . . Describe the different checks that should be made before the engine is started if the locomotive has been standing inoperative for several hours.
8. . . After the preliminary checks have been made, describe the step by step procedure to start the Diesel engine.

9....How long should the starting button be held in if the engine cranks but does not fire immediately?

10....How long should the starting button be held in after the engine fires? Explain the reason for your answer.

11....When the engine has been started and is warmed up, what should be the temperature of the cooling water?

12....What pressure should be shown on the fuel oil gage?

13....When the engine has been started and is warmed up, what pressure should be shown on the lubricating oil gage?

14....How can the fuel supply be shut off in case of accident or danger of fire?

15....If the engine rotates when the engine starting button is pressed in but does not fire in a few seconds, what should be done and how would you preceed to check for the trouble?

16....What will happen if the engine speeds up considerably above its normal working limit of 740 revolutions per minute?

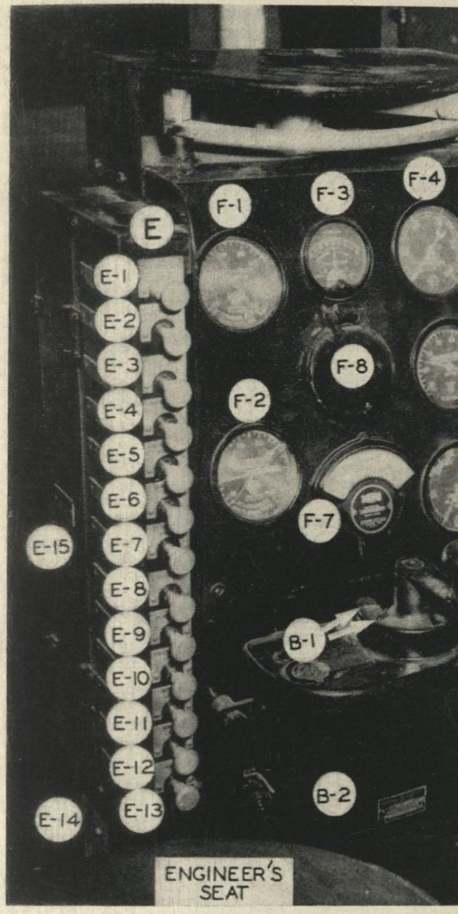
17....What will happen if the lubricating oil pressure drops below 20 pounds?

18....Describe how to restart the engine if it has been shut down by the tripping of the overspeed lever.

19....What valves must be opened to drain the water cooling system in case the engine has to be shut down in freezing weather?

20....Tell the purposes of the three-way valve on the duplex strainer and of the handles on some other types of strainers.

R.E.B.—5-48-17.5



A —Throttle
B —Reverser handle
B1 —Transition notch marks
B2 —Controller case
C —Automatic brake valve
D —Independent brake valve
E —Switch panel
E1 —Engine start switch
E2 —Control switch
E3 —Fuel pump switch
E4 —Front headlight dim switch
E5 —Front headlight bright switch
E6 —Rear headlight dim switch
E7 —Rear headlight bright switch
E8 —Gage light switch
E9 —Dome light switch

E10—E
E11—N
E12—M
E13—H
E14—W
E15—D
F —In
F1 —D
F2 —D
F3 —B
F4 —F

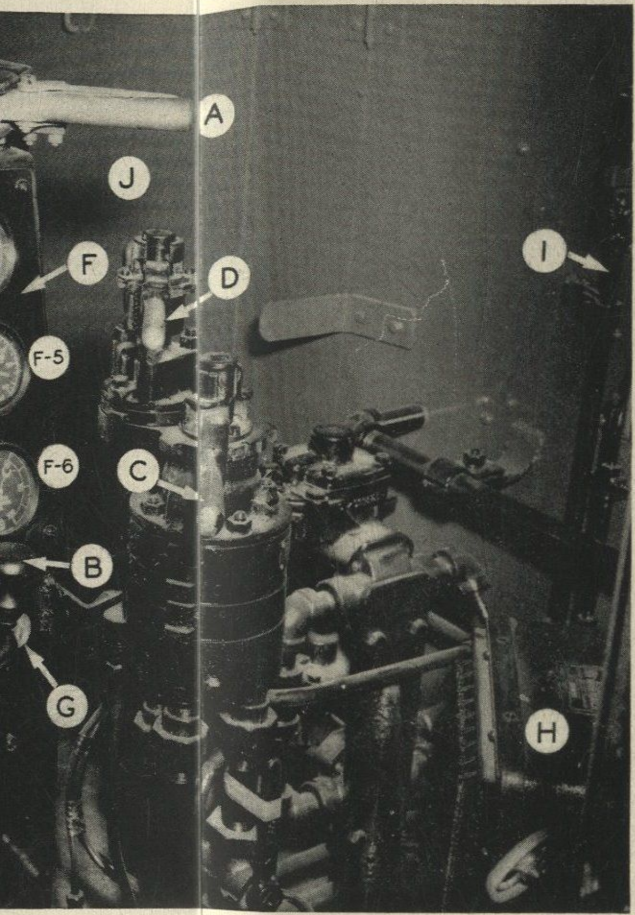


Fig. 11

- ngine compartment lights switch
- umber lights switch
- Iarker lights switch
- eater fan switch
- Vheel-slip buzzer
- oor to fuse panel
- nstrument panel
- uplex air gage—
  Red hand—main reservoir
  White hand—equalizing reservoir
- uplex air gage—
  Red hand—brake cylinder pressure
  White hand—brake pipe pressure
- attery charging ammeter
- uel oil pressure

F5 —Control air pressure
F6 —Lubricating oil pressure
F7 —Engine cooling water thermometer
G —Generator overload warning light
H —Cab heater
I —Air pipe to horn
J —Door to electrical cabinet
K —Battery switch handle
L —Windshield wiper
M —Emergency fuel oil valve cutoff knob
N —Radiator cooling fan shutter lever
O —Back of instrument panel F
P —Front cab window—engineer's side

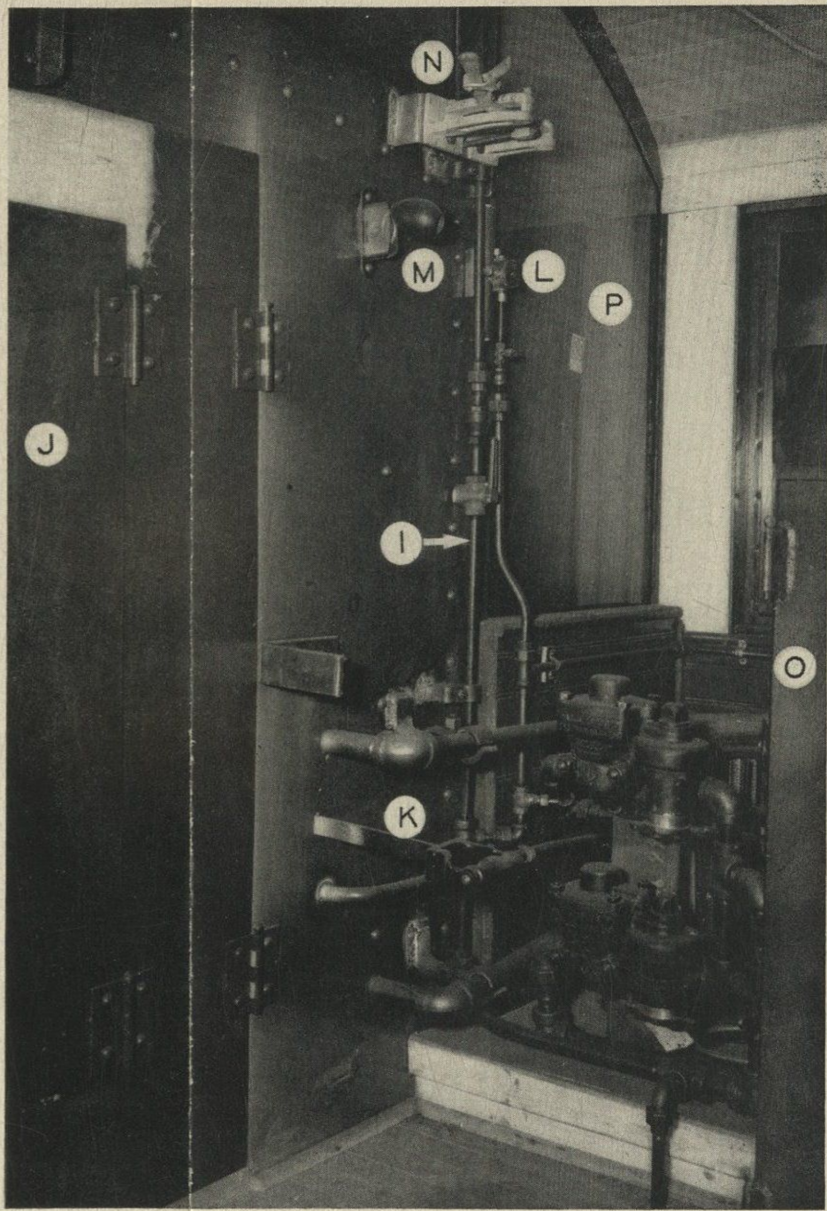


Fig. 12

Sander valve and bellringer valve are on the right-hand wall of the cab.

Horn cord is above engineer's seat.

These last three are not shown in the illustration.