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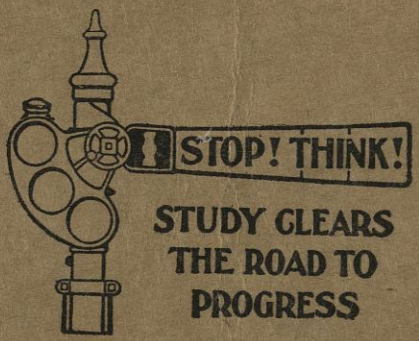

INSTRUCTION PAPER

UNIT N. 27

SUBJECT:

DIESEL LOCOMOTIVE OPERATION

THE STEAM GENERATOR

OMAHA—POSTAL ZONE 2—NEBRASKA

Around 1945, the Vapor Car Heating Company put out a new model generator known as the DK 4516 or the DK 4530, depending upon its capacity. This generator has a constant speed motor instead of a variable speed motor. The controls are through automatic regulators and by-passes instead of through motor speed changes.

The DK model did not prove entirely satisfactory in service. A modified design known as the DRK quickly superseded the DK models. Practically all of the DK models have been modified to change them to the new DRK design. The principal change was the replacement of a back-pressure steamline control of the DK model with a control that is very similar to the model described in this text.

Another type of generator, known as the OK model, also has been developed. About the only practical difference between the OK model and the DRK model is a rearrangement of the controls so that they are grouped in a single cabinet alongside of the generator.

The CFK generators described in this text are standard on most of the present Diesel locomotives and still are being applied to new locomotives. All of these types of generators are very similar in principle. The DRK and the OK models are described in a supplement to this text.

The Superheater Company has brought out an entirely new design of steam generator for use on Diesel locomotives. Only a few are in service as yet. Students who require information on these generators will be furnished such information on request.

April 1948

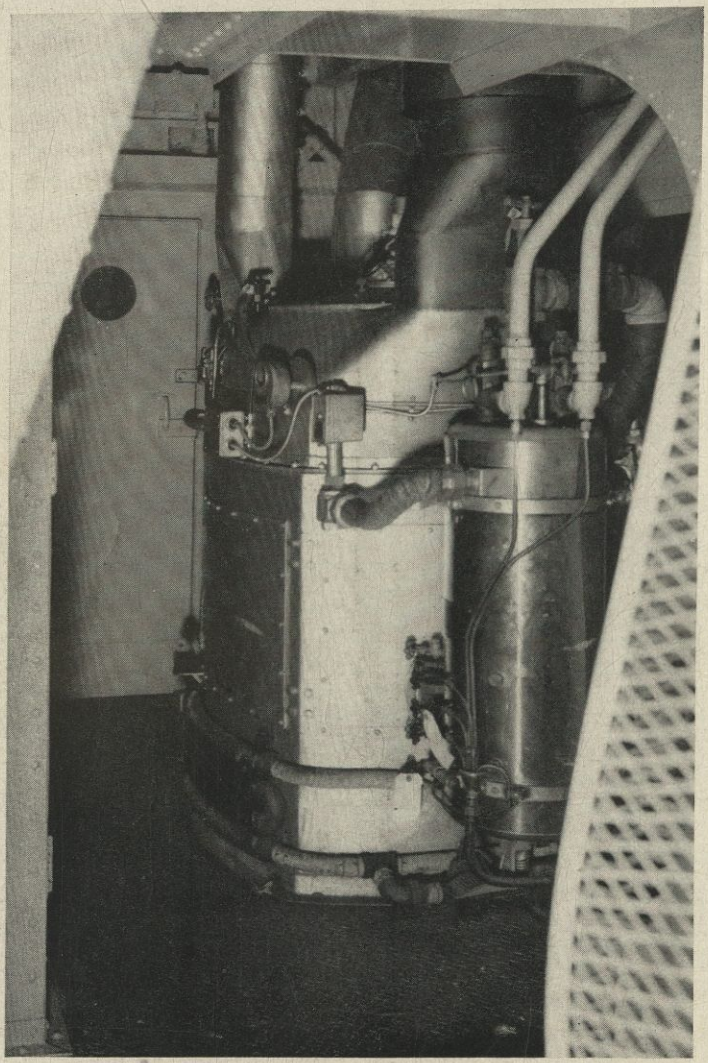

Fig. 1

DIESEL LOCOMOTIVE OPERATION

THE STEAM GENERATOR

General

1. The steam generators used on Diesel locomotives are made by the Vapor Car Heating Company. Fig. 1 is a view of one of these generators in place inside the rear door of an Alco-G. E. Diesel road locomotive. The generator is an oil fired flash boiler, designed for continuous automatic operation while in service.

2. The steam generator is designed to furnish whatever amount of steam is needed *as it is used.* There is no reserve of hot water or steam. Since the amount of steam required fluctuates continuously, the generator is provided with numerous controls to maintain and safeguard its automatic operation.

3. A flash boiler, in principle, consists of a long length of tubing wound into the form of a fairly tight coil. The coil is located in a fire box or furnace compartment. Water is forced into one end of the coil by means of a heavy duty pump. An oil burner in the furnace is lighted and the heat is regulated in proportion to the flow of water through the coil. The water, in its passage through the coil, is changed into steam. The steam flows from the coils through a separator to the steam line of the train.

4. While a flash boiler is simple in principle, it requires a number of automatic controls to keep it operating continuously. The basic requirement of its operation is the automatic control of the pump, so that it will force through the coils the exact amount of water required to meet the fluctuating demands for steam. Since the steam making is a continuous process, the amount of

fuel burned in the furnace must be in exact proportion to the amount of water being forced through the coils.

5. There is a fuel control device in the water line between the water pump and the coils in the furnace. The *rate of flow* of the *water* through this fuel control device automatically regulates the supply of fuel to the furnace. The air supply to the furnace also is regulated automatically in accordance with the amount of fuel to be burned.

6. If the pump should force considerably more water through the coils than the heat of the flame converts into steam, the unit will not function efficiently. If the heat of the furnace should be too great, the temperature of the steam will be excessive. Then, safety devices will operate to shut off the fuel supply to the furnace, thus shutting down the generator before harm is done.

7. The Vapor Car Heating Company has made many changes and improvements while developing its steam generator. Eight or ten types have been sold for installation on Diesel locomotives. Each new type has embodied improvements in the automatic controls or of some other feature. The type of generator that will be described in this text is known as the CFK 4225-2A. The type CFK 4225-2A has been rearranged for the application of remote control. This latest change is classed as CFK 4225-3A.* The earlier types of generators do not differ from the later types in principle. However, they do differ in various details, such as, the kind and arrangement of automatic controls, the piping arrangement, the arrangement of air ducts to the furnace, etc. A student who masters this text should be able to trace the piping and understand the purpose and operation of the controls of all models.

8. These steam generators can supply a full head of steam for train heating and other steam needs at a pres-

*The Vapor Car Heating Company also manufactures a generator for use on Diesel road switching locomotives as well as a standby generator for Diesel freight locomotives.

sure of two hundred pounds per square inch within two or three minutes after the fire is lighted. This may seem rather startling to a steam locomotive man. However, when properly adjusted, these steam generators are not difficult to start and they require comparatively little attention on the road.

9. The parts and controls of the steam generator will be described briefly. Then, the operation of the generator will be explained by tracing the flow of water and steam, fuel oil, air, and electricity, separately. After the operation has been explained, full instructions will be given on how to start and use the generator.

10. Figure 2, which is on a folded insert at the back of the text, is a schematic diagram of the generator assembly. It shows all of the various parts, including the piping and controls, that make the generator a complete and efficient operating unit. However, a schematic diagram is laid out without any attempt to show the parts in their actual location. Figs. 3 and 4, which are printed on the *back* of the folded insert, are views of a completed generator ready for installation in a Diesel locomotive. The names corresponding to the reference numbers of Figs. 3 and 4 appear beside the figures.

11. Figure 2 should be used to follow the explanation of the operation of the generator. Figs. 3 and 4 should be used to determine the appearance and actual location of the various parts of the assembly. Fig. 1 shows a type CFK 4225-2A generator, that is, a generator without the remote control feature. Fig. 2 is a diagram of this assembly. Figs. 3 and 4 show how this assembly is rearranged for the application of the remote controls; that is, Figs. 3 and 4 illustrate the type CFK 4225-3A generator. Since Figs. 3 and 4 illustrate a generator before it is installed, not all of the parts are shown; for example, the water treatment tank is missing, the stack temperature switch and its connection are missing, etc.

THE PARTS OF THE STEAM GENERATOR ASSEMBLY

12. The principal parts of the generator assembly are defined briefly as follows:

WATER TREATMENT TANK. It is particularly important to keep the inner surface of the coils of a flash boiler clear of scale. The feed water is treated continuously as it passes through a small water treatment tank.

THE MOTOR. A 5 horsepower motor drives a combination water pump, fuel oil pump, and magneto through one set of "V" belts. It drives a separate air blower through another set of belts.

THE WATER PUMP. This is a heavy duty pump which can supply water against a pressure of several hundred pounds.

THE FUEL PUMP. The fuel pump is a part of the same assembly as the water pump. It forces fuel oil to the fuel control manifold at pressures up to about 40 pounds.

THE MAGNETO. The magneto, when used, is a part of the water pump assembly. It furnishes high tension current to a spark plug. This ignites the fuel as it is sprayed into the furnace. In some installations the magneto is replaced by a rotary converter and transformer.

ROTARY CONVERTER. This is a small electric motor-generator set which converts battery current into alternating current for ignition.

TRANSFORMER. There is a transformer in the motor-generator circuit. The voltage of the alternating current is stepped up sufficiently in the transformer to supply a continuous spark for igniting the fuel.

FUEL CONTROL. This is a two-part device; there is a water compartment and a fuel oil valve. The rate of flow of the water through the water compartment on its way to the furnace coils regulates the rate at which fuel can flow through the fuel valve to the burner.

HEAT EXCHANGER. This is a drum in which is located a coil of small sized tubing. The cold water that passes through the exchanger circulates around the outside surfaces of this exchanger coil. Hot water, which is drained automatically from the steam separator, flows through the *coil in the exchanger* on its way back to the water supply tank. Heat is transferred from the hot water as it passes through the exchanger coil to preheat the cold water which is on its way to the furnace coils.

STEAM SEPARATOR. The adjustment of the generator controls is such that a certain amount of water will be carried over into the separator with the steam. The steam flows from the separator to the train steam line. The water which is separated from the steam is returned through the coil of the heat exchanger to the water tank for re-use.

STEAM TRAP. This is an automatic valve in the return line from the separator to the heat exchanger that controls the water level in the separator. It prevents steam from blowing from the separator through the return line while the water level is being reduced.

FUEL CONTROL MANIFOLD. This manifold contains a relief valve, a hand operated by-pass valve, and a fuel metering valve. The hand operated by-pass valve is provided so that fuel can be prevented from entering the burner while the pump is being operated to fill the coils with water. The metering valve has a key that allows hand regulation of the pressure in the fuel line to the fuel control device. Final adjustment of the fuel supply with this key will give as nearly perfect combustion as is practical.

FUEL SPRAY HEAD. Compressed air pressure of about 22 pounds per square inch enters the fuel spray head and atomizes the fuel as it enters the furnace.

IGNITION. Spark plugs operate continuously while the generator is operating, to insure continuous firing of the fuel.

PHOTO-ELECTRIC CELL. Some generators are equipped with a photo-electric cell which is directed into the combustion chamber. If the fire goes out, the cell responds and shuts down the generator in from 10 to 20 seconds.

BLOWER. An air blower furnishes the necessary supply of air to the combustion chamber of the furnace to insure proper combustion of the fuel. The blower is driven by the water and fuel pump motor, so that its speed is in proportion to the rate of flow of the water and fuel. Admission of air to the blower is through a fan housing that has two air intakes.

CONTROLS

13. The following controls are a part of the assembly:

ELECTRIC SWITCHES. There is a main switch that must be closed to bring battery current to the electric circuits of the steam generator. Also, there is an ignition switch which must be closed to start the ignition devices.

STEAM PRESSURE SWITCH. This is the control switch that is set by hand to the pressure at which it is desired to have the generator deliver steam. The generator will shut down automatically when this pressure is reached. Then, when the pressure has dropped about 15 or 20 pounds, the switch will operate to start the generator again.

OPERATING SWITCH. The operating switch has four positions—TEST, OFF, START, and RUN. This switch is used to fill the coils with water, to light the fire, and to put the generator in operation.

KEY AT WATER TREATMENT TANK. Turning this key regulates the amount of treating compound supplied to the feed water. It should be set by the railroad chemist or generator maintainer.

SAFETY FEATURE OF FUEL CONTROL DEVICE. The fuel control device will shut off the supply of fuel oil to the burner

should there be any interruption of the flow of water through the device.

SAFETY FEATURE OF COIL BLOWDOWN VALVE. The coil blowdown valve contains a switch which will prevent the operation of the generator if the coil blowdown valve has been left open.

HIGH TEMPERATURE SWITCH. This is a switch in the steam line between the furnace and the steam separator. It opens automatically when the steam temperature reaches 620 degrees. When it opens, it shuts down the generator.

SAFETY VALVES. There are two safety valves on the steam separator. Usually, one is set at 245 pounds and the other at 250 pounds.

STACK SWITCH. This is an automatic device which shuts down the generator if the temperature of the stack gases reaches 900 degrees. This device also operates as a low stack temperature switch to close the fuel solenoid valve and shut down the motor when the fire goes out or does not light promptly.

FUEL SOLENOID VALVE. There is a solenoid valve above the fuel spray head which operates automatically to shut off the fuel supply when its coil is de-energized by any of the various safety devices.

ATOMIZING AIR CONTROL SWITCH. This switch prevents the opening of the solenoid valve unless there is sufficient pressure in the air line for the proper atomization of the fuel.

MOTOR OVERLOAD SWITCH. This is an automatic electrical cutout that prevents the overloading of the motor.

THE WATER AND STEAM LINE

14. COLD WATER. *Refer to Fig. 2.* The cold water system starts at the water tank. When the pump is running, water flows from the supply tank through a strainer, a stop valve, a check valve, and the treatment tank to

the intake valves of the pump. The water then is forced past a water relief valve and through a fuel control device to a heat exchanger.

15. WARM WATER. The cold water is preheated in its passage through the heat exchanger. From the heat exchanger, the warm water passes through a steam generator feed check valve and a coil shutoff valve to a connection with the outer end of the tube which forms the outer coil of the generator.

16. Three separate coils of tubing are connected to form a continuous path for the passage of the water through the furnace. The outer coil is a tube of comparatively small diameter, the middle coil is a tube of larger size, and the inner coil is a tube of still larger diameter. The water winds around through the outer and intermediate coils to the bottom of the inner coil and then up through the inner coil to its outlet.

17. The flame of the burner is directed toward the inside of the inner coil. The draft created by the blower forces the hot gasses of combustion around the inner coil, past the intermediate coil, and to the outside of the outer coil where they enter the ducts which lead to the smokestack of the furnace.

18. STEAM. The water is converted into steam during its passage through the coils of the furnace. A pipe leads from the end of the inner coil to a steam separator. A high temperature switch is screwed into a fitting in this pipe.

19. The steam separator is designed to remove as much condensation as is practical from the steam before the steam enters the steam heat train line. It serves somewhat the same purpose as the steam dome on a locomotive boiler. There are two safety valves which screw into the steam space of the separator. It is the usual practice to set one of these safety valves to blow at 245 pounds and the second one to blow at 250 pounds.

20. Other steam pipes from the separator lead to soot blower valves, to the steam gage on the instrument panel of the generator, and to the steam pressure switch.

21. The pump has sufficient power to force the water into the coils at a pressure up to 600 pounds. This insures the continuous flow of water to the coils that is required for steam making.

22. HOT WATER RETURN. Any water that is carried into the separator with the steam drains to the bottom of the separator. The height of water in the separator is indicated by gage cocks and a water glass. Either a float valve, similar to the float valve in the water tank of a toilet, or a steam trap operates so that the level of the water in the steam separator will be maintained at about the level of the second gage cock.

23. The hot water, that escapes from the steam separator as the steam trap operates, is forced back to the water tank for re-use. However, during its return, it passes through the coil in the heat exchanger. There, much of its heat is extracted by the cold water surrounding the coil. Thus, the cold water is preheated on its way to the furnace coils and the hot water from the separator is cooled sufficiently before it reaches the water tank. This explains the name, heat exchanger.

THE FUEL OIL LINE

24. *Refer to Fig. 2.* The fuel line starts at the fuel oil tank. The fuel oil is drawn from the bottom of this tank, through an emergency fuel cutoff valve, to an oil filter, and from the filter to the fuel oil pump.

25. The fuel oil pump forces the fuel oil through another filter to a fuel control manifold. This manifold contains a relief valve which is set to 60 or 70 pounds. If the pressure rises above that amount, the valve will open and by-pass some of the fuel oil back to the fuel tank. The fuel control manifold also contains a hand operated

by-pass valve. This can be used to by-pass all of the fuel oil back to the fuel tank when it is necessary to pump *water* to fill the coils of the generator before lighting the fire. The fuel is by-passed back to the tank through this valve when the valve is *opened by hand.* Also, there is a metering valve in this manifold. The use of the key of this valve will be explained in connection with the operation of the generator.

26. The fuel passes from the fuel control manifold to the fuel control device which is in the *water line.* The fuel control device contains a fuel metering valve which is operated by the *water* which flows through the water compartment of the device on its way to the coils in the furnace. The movement of the fuel metering valve varies according to the rate at which the *water* flows through the water compartment. The fuel oil must pass through the metering valve to reach the burner. Fuel oil can pass the valve only in proportion to the rate of flow of the water on its way to the furnace coils. The design and purpose of the device is to regulate the flow of fuel oil to the spray nozzle in exact proportion to the rate at which water is flowing to the coils of the furnace.

27. The fuel control device will not allow *any* fuel oil to flow to the furnace if no water is passing through the water compartment of the device. This provides a further automatic safeguard to prevent the burning of the coils should there be a failure of the water supply. There is a hand wheel adjustment on the fuel control device which is set by the maintenance forces. Its adjustment should not be changed on the road.

28. The fuel metering key at the fuel control manifold can be turned to increase or decrease the flow of fuel oil to the fuel control device. When the furnace is operating, slight adjustments of this key can be made to clear the stack, that is, to give the best practical combustion of the fuel.

29. After the fuel oil passes through the metering device, it flows to a strainer at the fuel spray head. There is a fuel solenoid valve at the top of the spray head. This fuel solenoid valve is one of the safety devices that will be explained later.

30. The fuel oil, after it passes the solenoid valve, is sprayed into the furnace by air pressure. The fuel, when it passes the spray nozzle, is thoroughly atomized for burning.

THE AIR PRESSURE LINE

31. The compressed air which atomizes the fuel oil comes from the air brake system. There is an atomizing air shutoff valve, an air reducing valve, and a low air pressure switch in the line. The low air pressure switch is another of the various control devices. It must be held open by sufficient air pressure before fuel can flow past the solenoid valve to the spray nozzle. Usually, the air enters the fuel spray head at a pressure of about 22 pounds.

THE ELECTRIC CIRCUITS

32. The fuel oil, on issuing from the spray nozzle, is ignited by electrical sparks. Either a magneto, a transformer, or a combination of both furnish high voltage alternating current to two separate spark igniters which are suitably located near the spray nozzle. The magneto spark, when used, operates continuously while the water pump is running; the transformer spark operates continually while the converter is running.*

33. The fuel solenoid valve is held open when its coil is energized. Any interruption of the coil circuit, because of the operation of other control devices, causes this solenoid valve to close and shut off the supply of fuel oil to the furnace.

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*The spark igniters serve the same purpose as spark plugs but are different in construction.

34. The electric circuits also include the necessary wiring for the operation of the various automatic controls and alarms which are a part of the installation.

THE AIR BLOWER

35. The belt driven air blower is located near the top of the steam generator. Two separate air ducts from the roof lead to the fan housing. There are damper plates in each of the air intakes. Air from the blower is led to openings in a "centralizing cone" at the top of the fire pot and to other openings which are in an air ring that surrounds the fire pot, somewhat below the centralizing cone. Air from the air pressure line atomizes the fuel oil and sprays it into the fire pot. The blower furnishes the additional air required for the complete combustion of the atomized fuel oil.

STARTING THE STEAM GENERATOR

36. When a steam generator that has been shut down is to be started, the first thing that must be done is to fill the coils with water. There must be a steady flow of water through the coils before the fuel is ignited. *The indication of the water glass at the separator gives no information as to whether there is water in the coils in the furnace.*

37. TO START THE GENERATOR:

(1) Close the main generator switch. Usually, this is located on the wall of the engine room somewhere near the steam generator.

(2) Open the hand operated fuel by-pass valve at the fuel manifold.*

(3) Move the operating switch at the instrument panel to TEST position. The motor should start in about two or three seconds. There will be this slight delay due to the action of the oil dashpot of the steam pressure switch.

(4) Open the separator blowdown valve and

*This is a double precaution. The solenoid valve, normally, will prevent entrance of fuel to the furnace at this time.

keep it open until all the water in the separator drains out. Then, close this valve and wait until the pump forces water through the coils and into the separator so that water shows at the opened lower try cock.* While waiting, it is well to check to see that the motor is running and to open the water pump test valve for a moment to make sure that the pump has primed and is pumping water.

(5) As soon as water shows up again at the try cock, close the cock and move the control switch from the TEST position to the OFF position. Then, *close* the fuel by-pass valve at the fuel manifold and open the atomizing air shutoff valve in the air line.

(6) Turn on the ignition switch. This will start the converter set so that the ignition devices below the fuel spray nozzle will start sparking. (If there is a magneto, it will be running whenever the pump is running.) The sparking devices must be operating so that the fuel will be ignited when it is sprayed into the furnace.

(7) Turn the control switch from the OFF position to the START position. When this is done, the fuel will be sprayed into the combustion chamber of the furnace within a couple of seconds. The fuel should be ignited by the sparks as it enters the combustion chamber. There is a peephole at the top of the furnace through which the flame can be observed. The furnace will warm up on this setting of the control switch and make steam at a limited rate.

(8) As soon as the furnace is lighted, the separator blowdown valve should be latched in the *open* position. This is done to let the water, which passes through the coil and into the separator, drain out. Otherwise, there is the probability that the separator will fill with water and that some water will be carried over into the steam train line.

*The open try cock prevents pressure building up in the separator if the train line stop valve is closed.

(9) After the fuel has been ignited and the furnace has had about two minutes to heat, the control switch should be moved from START position to RUN position. This puts the generator in full operation.

(10) Close the separator blowdown valve and then watch the water glass. The water should rise in the glass until there is about half a glassful in the separator. If it fills above half a glass, keep blowing it down at intervals until the automatic action of the steam trap or float valve will maintain it at about that level.

38. The steam pressure switch should be set by turning the knobbed handle to the number which corresponds with the steam pressure it is desired to carry. Speaking generally, it is not desirable to have the setting of this valve less than 150 pounds.

39. The generator will have to be watched for a few minutes after it is running. After about five minutes, the check valve in the pipe between the heat exchanger and the furnace coils ("the boiler check valve") should be felt with the hand.* This valve should be at just about the temperature of the hand, that is, the valve should not feel either hot or cold. If it feels cold, the fuel pressure to the nozzle should be *reduced* about 5 pounds. The hand should be held on the check valve until it begins to feel warm. If the valve gets hot in a few minutes, the fuel pressure should be increased a little. The adjustment of the fuel valve should be continued until the check valve temperature is just right. When this has been done, the generator will be running at its best rate. It then may be left unattended except for the regular flash blowdown of the separator and the operation of the soot blowers from time to time.

*If the check valve is not within convenient reach, the same test can be made by feeling the pipe leading from the heat exchanger to the furnace coils.

40. The flash blowdown of the separator is accomplished by pressing down for about ten seconds on the foot pedal below the separator. When the foot is lifted from the pedal, the spring will close the valve again. The separator should be blown down about once an hour.

41. The soot blowers are operated by two hand valves which usually are located close to the separator. These valves blow steam against the furnace coils to dislodge the soot. The soot blowers should be used about once an hour. Each valve should be operated separately by pressing it in for about three seconds and then releasing it. This should be repeated two or three times. Usually, there is a globe valve in the steam line to the soot blowers which must be opened before using the soot blowers. This valve must be left open if the soot blower valves are to be operated by remote control. This valve should be closed while the boiler is not in use.

42. Many railroads have their own definite rules about when and how to use the separator blowdown and the soot blowers. Local rules, when in effect, always should be followed.

43. When the generator is operating properly under automatic controls, it is not necessary to shut it down if the train line stop valve has to be closed when a car is to be switched out or picked up. The automatic controls will take care of the operation during any ordinary stop of this kind.

REMOTE CONTROLS

44. Many passenger locomotives are equipped with remote controls so that the separator can be blown down and the soot blowers operated from the cab. The remote control switches and indicator lights are in a case, located below the cab window in front of the fireman's seat.

45. There is a toggle switch on the panel of the remote control device in the cab. This switch must be

moved to its ON position in order to make the remote controls operative. When this switch is in the ON position, the panel is illuminated.

46. There are three signal lights on this remote control panel. When they glow, they indicate steam generator shutdown, low oil, or hot engine, the same as the corresponding lights on the individual engine panels of the different locomotive units.

47. Remote control panels are of several different designs. Some are equipped with toggle switches. A simpler design is equipped with push buttons. On one design, there is one rotary switch on the panel for the steam generator of each of the different locomotive units. Each rotary switch has four positions, (1) OFF, (2) SEPARATOR BLOWDOWN, (3) FIRST SOOT BLOWER, (4) SECOND SOOT BLOWER. When any one switch is turned in a clockwise direction, it will produce the effects indicated above on the generator that that switch controls. These effects will occur in the order listed above. The switches always should be left in the OFF position except when being used.

48. Usually, there is a steam gage on the remote control panel. This gage shows the pressure in the steam line of the locomotive, not the pressure at any one generator.

49. The remote control panel in the cab also may contain a steam train line shutoff switch. The fireman can operate this one switch to close the stop valve in the steam line at each generator. However, once these valves have been shut off by remote control, they have to be reset by hand.

THE INSTRUMENT PANEL

50. There is a gage at the top of the instrument panel of each steam generator that shows the pressure of the steam as it issues from the separator. The generator "cycles" when operating automatically. In other words, the steam pressure will rise to the setting of the steam

pressure switch and then the switch will shut off the generator and keep it shut off until the pressure drops about 20 pounds. Then the automatic controls will start the generator operating again.

51. There may be a steam gage in the steam line beyond the stop valve at the separator. The gage beyond the stop valve may show less pressure than the gage on the panel if the train line stop valve is throttled.

52. The small gage at the left of the panel is the atomizing air pressure gage. The pressure on this gage will correspond with the setting of the atomizing air reducing valve if the air shutoff valve is wide open.

53. The small gage at the right of the panel shows the fuel pressure at the fuel spray head. This pressure will vary in accordance with the setting of the fuel key metering valve and the rate at which water is being pumped. The maximum pressure carried should correspond with the top limit of the capacity of the generator to make steam. This pressure may vary with different generators from about 25 pounds up to 32 pounds.

54. The small gage at the bottom of the panel indicates the pressure at the fuel manifold. It is useful only in showing that there is sufficient pressure at the manifold. It may indicate anywhere from a few pounds up to about 40 pounds pressure.

55. The purpose and method of using the operating switch below the gages has been described.

56. There is a water pressure gage at the top of the fuel control device in the water line. This gage hand should show a steady pressure but not over a maximum of 400 pounds.

SAFETY DEVICES

57. In order that the steam generator may be protected from injury or unnecessary running, several safety devices are provided, any one of which will shut down the

generator or prevent it from being started. These safety devices are:

(1) Fuel control device
(2) Coil blowdown valve switch
(3) High steam temperature switch
(4) Photo-electric cell (when used)
(5) Low air atomizing pressure switch
(6) Stack switch

58. Some of these controls, when they operate, set off an alarm bell in addition to lighting an "out-fire" signal on the engine or remote control panel. If the generator alarm starts to ring, the first thing to do is to locate the generator that is causing the alarm. Then its control switch should be moved to the OFF position. This will stop the alarm. Then, the control switch can be turned back to the START or RUN position while the cause of the difficulty is being located.

59. The control devices which operate electrically either break the circuit of the fuel solenoid valve so that no fuel will flow to the spray nozzle or else they operate the out-fire relay which shuts down the motor. The motor usually does not shut down until about 45 seconds after the fire goes out because of a time-delay feature of the out-fire relay.

60. FUEL CONTROL DEVICE SAFETY FEATURE. If no water or too little water should flow from the water pump for any reason whatever, the fuel control device will not allow fuel to pass to the furnace. If the flow of water stops while the furnace is operating, the flow of fuel will be shut off. When the fire goes out, the stack temperature switch or the photo-electric cell (if used) will function to de-energize the out-fire relay and thus stop the motor.

61. COIL BLOWDOWN VALVE SWITCH. The coil blowdown valve switch guards against the possibility of starting the boiler in case someone may have left the blow-

down valve open after blowing down the coil. The generator will not operate until this valve has been closed.

62. HIGH STEAM-TEMPERATURE SWITCH. The high steam-temperature switch, in the steam line between the coil and the separator, opens when the temperature of the steam reaches 620 degrees. When this switch opens, it opens an electric circuit which shuts down the generator. After the condition which caused the shut down has been corrected, the high steam-temperature switch must be reset by pushing in the reset button. The generator can not be fired until this switch is reset.

63. PHOTO-ELECTRIC CELL. The Photo-electric cell still is used on some of the older equipment. The Photo-electric cell is an electronic device which is sensitive to changes in light intensity and to color changes. It is mounted in such a way that the window of the cell faces a sight glass on the boiler. The one in use on these generators is sensitive to the yellowish-red light band and not to any other color or shade. Therefore, it permits an electric current to flow when the flame is burning normally. Should the fire go out or turn blue or smoky dark, the photo cell will open the out-fire relay and the motor will shut down in about 20 seconds. This will shut down the generator and cause the alarm to sound. The current set up by the photo cell is too small to operate a relay directly. First, the current passes through an amplifier which operates a very sensitive relay. This relay, in turn, operates the out-fire relay.

64. LOW PRESSURE AIR ATOMIZING SWITCH. There is a low pressure air switch in the air line. It is connected into the electrical control circuits in such a way that the supply of fuel to the furnace will be shut off at the fuel solenoid valve unless there is sufficient air pressure to atomize the fuel. Its purpose is to prevent unatomized fuel from entering the furnace.

65. STACK TEMPERATURE SWITCH. When the generator is operating properly, most of the heat generated in

the furnace is transferred to the water in the coils. However, this is true only if the coils are clean, both inside and outside. As soon as any considerable amount of scale accumulates inside of the coils or when soot accumulates on the outside of the coils, the temperature of the exhaust gases will start to increase.

66. To prevent excessive stack temperatures, a stack temperature switch is inserted in the side of the stack. When the stack temperature reaches 900 degrees, the switch will open, thereby shutting down the generator.

67. The stack temperature switch also has a low temperature feature which takes the place of the Photoelectric cell. The low temperature or out-fire indication operates to break the circuit of the out-fire relay if the stack temperature drops below 240 degrees.

ADDITIONAL SAFETY FEATURES

68. Five other safeguards are provided in addition to those mentioned. These are:

(1) The two steam safety valves mounted on the steam separator.

(2) A water relief valve in the line between the pump and the furnace coils. This relief valve is set to open at between 500 and 600 pounds. Its purpose is to protect against possible overpressure in the water line should the coils become clogged with scale.

(3) A fuel relief valve in the fuel manifold. This relief valve is set at from 70 to 80 pounds. Its purpose is to protect against possible overpressure in the fuel pump and fuel supply line.

(4) An overload switch on the electrical panel of the generator. This switch will trip in case there is an overload on the motor. When tripped, it has to be reset by hand.

(5) A fuse in the control circuit on the same panel as the overload switch. This fuse protects

against excessive current in any of the generator control circuits.

OPERATING DEVICES

69. ELECTRIC SWITCHES. There is a main switch in the circuit from the battery to the electrical devices of the generator. There is a control switch in addition to the main switch. This control switch on the panel starts the motor that operates the pumps, blowers, etc. There is an ignition switch that starts the converter set which supplies alternating current for the ignition device. Other electrical devices in the control circuits are automatic.

STEAM PRESSURE SWITCH

70. This is the main control switch. It regulates the speed of the motor which drives the pumps in accordance with the demand for steam, that is, in accordance with the rate at which steam is being used. The valve is set by hand so that its dial finger will point to the pressure at which it is desired to have the generator furnish steam to the train.

71. A small pipe from the steam separator leads to the underside of a spring-loaded diaphram in the pressure switch. The tension of this spring is varied by turning the handwheel of the switch to the pressure desired. Movement of the diaphragm in turn operates contact fingers which are connected electrically to five heavy duty contactors in a small electrical cabinet. If the demand for steam is light and the pressure rises, the operation of the diaphragm will slow down the motor. If the pressure drops, the motor speed will be increased. When the pressure reaches the amount at which the valve is set, the contact fingers will move to shut off the motor. When the pressure has dropped about 20 pounds below this setting, the contact fingers will move to start the motor again.

RESETTING HIGH STEAM-TEMPERATURE SWITCH

72. When the high steam-temperature switch trips, the little black button on the front of the box pops out about an inch; also, the alarm begins to ring and a green light shows at all of the engine control stations. To stop the alarm, the control switch must be moved to the TEST position. This restarts the motor and, therefore, the water pump. The usual procedure then is followed to be sure that the furnace coils are refilled with water. The water will have to be circulated through the coils until the high steam-temperature switch has cooled down sufficiently so that it can be reset by pushing the little black button back into place. Then, the control switch can be moved to the RUN position to restart the generator. Remember! *Never attempt to reset the high steam-temperature switch until the furnace coils have been filled.*

WATER TREATMENT TANK

73. With few exceptions, the water available for use in the generator must be treated before it is permitted to enter the coils. The coils of the generator are, in fact, one long tube. Scale formation in the coils interferes with the proper operation of the generator; this is why a treatment tank is provided. Either of two treatment compounds are recommended for use, namely, Dearborn No. 301 or Bird-Archer No. 404. These come in ¾-pound sticks for this purpose.

74. To place a compound stick in the water treatment tank, proceed as follows:

(1) Shut down the generator.

(2) Close the water suction stop valve in the pipe between the supply tank and the treatment tank. This is to prevent water from gushing out when the cover is removed from the tank (there is some pressure in the water tank when the generator is operating).

(3) Unscrew the crossbolt at the top of the treatment tank cover about four or five turns.

(4) Use the crossbolt as a handle and lift up to pull the cover off. This cover may stick due to the use of rubber sealing rings.

(5) Pull out the strainer screen. Clean it, if dirty, and replace it.

(6) Now, put one stick of compound into the inner can. Do not break up the stick. It will fit just as it is.

(7) Replace the cover after having made certain that the treatment tank is nearly full of water. The cover may have to be worked back into place, especially if the rubber sealing rings are loose or enlarged. If some powdered graphite is at hand, use some on the rings. It will make the replacement of the cover much easier. Now screw the crossbolt down tight and open the water suction stop valve.

75. A small copper tube runs from the inlet water pipe to the treatment tank. In this pipe is a key operated valve. The key is used to regulate the amount of treatment solution added to the water. The key adjustment should be made by the railroad chemist or by someone in charge of generator maintenance.

BLOWING DOWN THE COIL AND SEPARATOR

76. Scale will form in the coils in the furnace if untreated water is used or if the water treatment device is not adjusted properly. If there is an indication of excessive scaling, it may be necessary to interrupt the operation of the generator long enough to blow out the coils. Scaling in the coils may cause an excessive rise in the pressure in the water line.

77. The method of blowing out the coils is as follows:

(1) Close the trainline stop valve.

(2) Build up the steam pressure to the safety valve limit by turning the steam pressure switch to its highest position.

(3) Turn the control switch at the front of the gage panel to its OFF position.

(4) Open the coil blowdown valve and leave it open until the steam pressure has dropped to 100 pounds. The latch on this valve must be pulled out before it can be opened.

(5) Open the foot operated blowdown valve under the steam separator and latch it in the open position. This will rid the coils and separator of all steam and water and will flush out all loose mud and scale.

(6) Now, close the coil blowdown valve—it latches automatically when closed.

(7) Turn the control switch to TEST position. The pump will fill the coils with water but the generator will not fire with this setting of the switch. The manual fuel by-pass valve on the fuel manifold may be opened, while pumping water, to make doubly sure that no fuel gets to the spray head.

(8) Close the separator blowdown valve and watch for water to show up in the bottom of the water glass or at the bottom try cock.

(9) When water shows up again, it indicates that the coils are filled. Then the fuel by-pass valve can be closed and the control switch turned to RUN position.

MISCELLANEOUS OPERATING INFORMATION

78. Any water which flows from the coils with the steam settles to the bottom of the steam separator. When the water in the separator reaches the top of the separator drain pipe, the float valve (or steam trap) opens, allowing the water to escape into the return line. This water is boiling hot. If boiling water was permitted to return to the supply tank, the supply water soon would become too hot for the water pump to handle. A vapor lock would form. The heat exchanger solves this prob-

lem. The hot water, while returning to the supply tank, gives up much of its heat in the heat exchanger by preheating the feed water as has been described.

79. The purpose and use of the steam separator blowdown valve, at the bottom of the steam separator, and of the coil blowdown valve, below the coil shutoff valve, have been described. One other feature of the assembly is a pair of "solution valves". One of these is between the fuel control device and the heat exchanger; the other is in a branch line from the separator blowdown pipe. These valves are used by maintenance men, periodically, to circulate an acid solution through the hot water and steam portions of the generator assembly in order to clear the scale from the interior surfaces of the coils and separator. A check valve prevents the solution from reaching the fuel control device or the pump.

80. There are a number of drain valves throughout the water and steam line. Diesel men should learn the actual position of these various drain valves on the locomotives to which they may be assigned. Parts of the system have to be blown out with air pressure to clear them of water. Maintenance men should be consulted for definite instructions about any particular generator. There might be an emergency in cold weather when it would be necessary to drain the generator quickly to prevent freezing.

81. FURNACE AIR SUPPLY. A plentiful supply of air for combustion can be supplied by the air blower. Adjustable air scoops sometimes are provided on the roof of the locomotive to insure an adequate supply of air to the blower while the train is in motion.

82. If not enough air is delivered to the furnace, it will be indicated by black smoke at the stack. If too much air is being delivered, the smoke will have a whitish tinge. There are adjustable damper plates in the air ducts. These

dampers ordinarily are adjusted and locked in place by the maintenance forces and should not be altered on the road. If it is impossible to clear up a stack by adjusting the fuel key metering valve, proper report should be made so that the maintainers can readjust the dampers. The trouble may be due to the blower belt slipping or to a V-belt being broken. In winter, the intakes may be plugged with snow.

83. THE IGNITION SYSTEM. The early generators were equipped with a magneto for ignition. Later a dual ignition system was used. This consisted of a rotary converter and transformer, in addition to the magneto. Generators now being built use only the rotary converter and transformer.

84. In all cases, the spark is produced at a special spark plug assembly, which has two separate points or electrodes. The air gap at the points should be $\frac{3}{16}$ of an inch. If the spark plugs are dirty, the spark may crawl up along the electrodes to the porcelains. This will interfere with the ignition. Should it occur, the assembly should be removed and cleaned and the spark gap reset.

85. The rotary converter changes direct current from the battery into alternating current. The transformer steps up this alternating current to the high voltage required to produce the sparks at the spark plugs. Contact with the high tension spark plug wires will give one a severe shock and possibly a painful burn. The ignition always should be shut off before doing any work around the spark plugs.

86. THE WATER PUMP. The water pump is of the three-cylinder piston type. It is belt driven by the motor. It is lubricated with a mineral oil of the same grade as is used for the Diesel engine. The oil in the crankcase of the pump should be up to the "full" mark on its bayonet gage. Sometimes a "water hammer" occurs while the pump is operating. This usually is caused by air in the pump. The air can be bled off by opening the hexagon

shaped test valves located on the suction valve caps. These should be backed off with the fingers. They should not be tightened with a wrench.

87. If the hand of the water gage is "jumpy", it is an indication that one of the suction valves is not seating properly. The one that causes the trouble usually can be found by opening the test valves, one after the other, and noting whether any air comes out or if the pressure seems weaker than from the other two. Sometimes dirt under the valve will be washed out when the test valve is opened.

SHUTTING DOWN THE GENERATOR

88. When a generator is to be shut down at the end of a run, the coils and separator should be blown down as has been previously explained (Paragraph 77). Then, the coils should be refilled with water and all controls shut off.

OPERATING DIFFICULTIES

89. There are a number of different things that can happen enroute that may cause a generator to give trouble. The best advice that can be given to a fireman about the operation of the generator is that he should study the principle of its operation and understand enough about each part of the apparatus so that he can THINK OUT the cause of any trouble. When the cause is determined, the remedy will suggest itself.

90. One of the best ways for a student to make certain that he understands the principle of operation of the generator is to practice tracing the flow of water, steam, oil, etc., on the chart which appears as Fig. 2 in this text. When the student is certain that he understands the principle thoroughly, he can test his knowledge by taking colored pencils and coloring the chart.

91. A loose copy of the chart, Fig. 2, is included with the text and is to be used in answering some of the exam-

ination questions. A standard way of coloring this chart is to use solid blue lines to indicate cold water and dotted blue lines to indicate hot water. The line from the heat exchanger to the furnace coils and the return line from the separator to the heat exchanger both are hot water lines. Full yellow lines should be used to indicate steam, and full red lines to indicate fuel oil. A green line can be used to show the air pressure line if desired, although the three colors, blue, yellow, and red, will be sufficient.

92. Should the generator fail to operate properly, a routine checkup might be as follows:

(1) If short of steam, check the train line steam pressure against the generator steam pressure. If the generator pressure is more than 30 pounds lower than the pressure switch setting, check to see if the pump is working at full speed. If not, look at the control switch on the front panel. Maybe this switch has been left in the START position. If it is in the RUN position, open the contact box and see if all the contactors on the steam pressure switch circuits are closed. If they are and the motor seems to be running at full speed, then:

(2) Check the temperature of the coil check valve again. It should feel neither hot nor cold, that is, it should be at about body temperature. If the check feels hot, look at the water glass to see if the water has risen above normal height. If so, blow the separator down. As soon as all of the water has been blown out of the separator, feel the boiler check again. It should feel cold within a few seconds.* Next, allow the water to rise in the glass gain and keep testing the feel of the check valve. When the glass gets about half full, the check should warm up at once. If the water continues to rise above half a glass, the check will get hot again. In this case it is possible that the fuel pressure to the nozzle is too

*This is a check on the separator float valve or the steam trap. When the water level is down, there should be no preheating of the feed water for the time being.

low, that is, too much water is being carried over into the separator with the steam. Try increasing the fuel pressure and blow the separator down again. Hold the hand on the check valve and wait for the water to come up in the glass. If the water stays at about half a glass and the temperature of the check is neither hot nor cold, the setting has been adjusted correctly.

(3) On some locomotives there is an opening with a tube about 2 inches in diameter in the exhaust stack. This is for observing the color of the exhaust gases. Look to see that the gases are not smoky. If they are black or whitish blue, try making a further change in the setting of the fuel metering key. If they will not clear, get the best results possible and report the condition at the end of the trip.

(4) If the generator seems to be operating properly but the train line steam pressure still is down, it may be that the train line demand is greater than the total capacity of the generators. This may be due to excessive cold weather; if not, it could be caused by a broken steam train line, leaking couplings, or open steam traps on cars.

(5) If the generator is not steaming properly, it can be shut down temporarily while the coil and separator are blown out.

93. It must be borne in mind that the generator will not steam properly if the separator is not blown down at proper intervals or if the soot blowers are not operated at proper intervals. Also, the flow of fuel oil may be restricted due to a dirty purolator or dirty oil filters. The handle on the purolator should be given a turn or two every hour.

OTHER TYPES OF GENERATORS

94. The Vapor Car Heating Company manufactures another type of steam generator for use as a stand-by heater for freight locomotives. This generator is known

as the type 4932-A-1. Its output is regulated manually, as required. It is used to keep the cooling water of the Diesel engine warm when the engine is shut down in cold weather. This generator operates on the same basic principles that have been described. The Company also manufactures a hot-water heater which is kerosene fired. This heater is used on switching locomotives for keeping the engine cooling water warm during layover periods.

95. The Vapor Car Heating Company publishes bulletins which describe the type 4932-A-1 generator and the No. 4015 hot-water heater. Students who are interested should ask their local officers for copies of one or both of these bulletins. If unable to obtain one locally, they can borrow one from the Bureau on request.

EXAMINATION QUESTIONS

NOTE: Questions 1 to 7 inclusive, can be answered by coloring the loose-leaf reproduction of Fig. 2 which is included with this text. The chart, when colored, should be sent to the Bureau with the answers to the remainder of the examination. If questions 1 to 7 are not answered by coloring the chart, then they should be answered in writing in the usual manner.

1. . . Trace the flow of cold water from the supply tank to the heat exchanger (full blue lines on chart).

2. . . Trace the flow of hot water from the heat exchanger to the furnace coils (blue dash lines on chart).

3. . . Trace the flow of steam from the coils to the separator, train line, and other steam connections (yellow lines on chart).

4. . . Trace the flow of hot water from the separator to the heat exchanger (blue dash lines on chart).

5. . . Trace the flow of water from the heat exchanger to the supply tank (full blue lines on chart).

6. . . Trace the flow of fuel oil from the fuel tank to the furnace (full red lines on chart).

7. Trace the flow of compressed air to the spray nozzle (black or green lines on chart).

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8. Explain fully how to start a generator that has been shut down for some time.

9. If it is desirable to have the generator furnish steam at 175 pounds pressure, how is this arranged?

10. If a car is to be set out, what, if any, changes must be made in the generator setting?

11. How is the generator shut down at the end of a run?

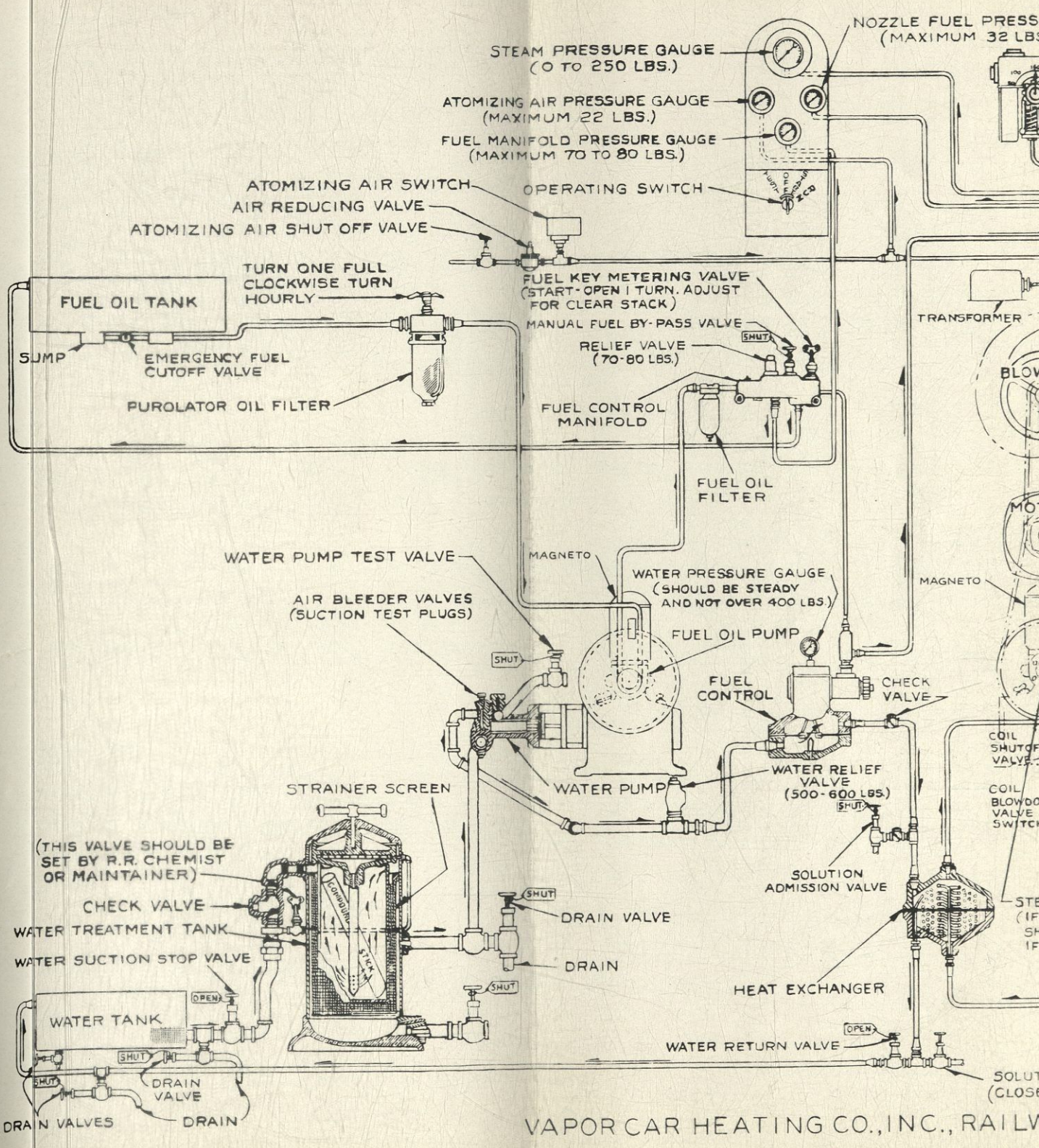
12. If the generator alarm rings and the out-fire light glows, explain what to do.

13. Tell how to blow out the coils and separator to remove loose sludge or scale.

14. Explain how and when to use the separator blowdown.

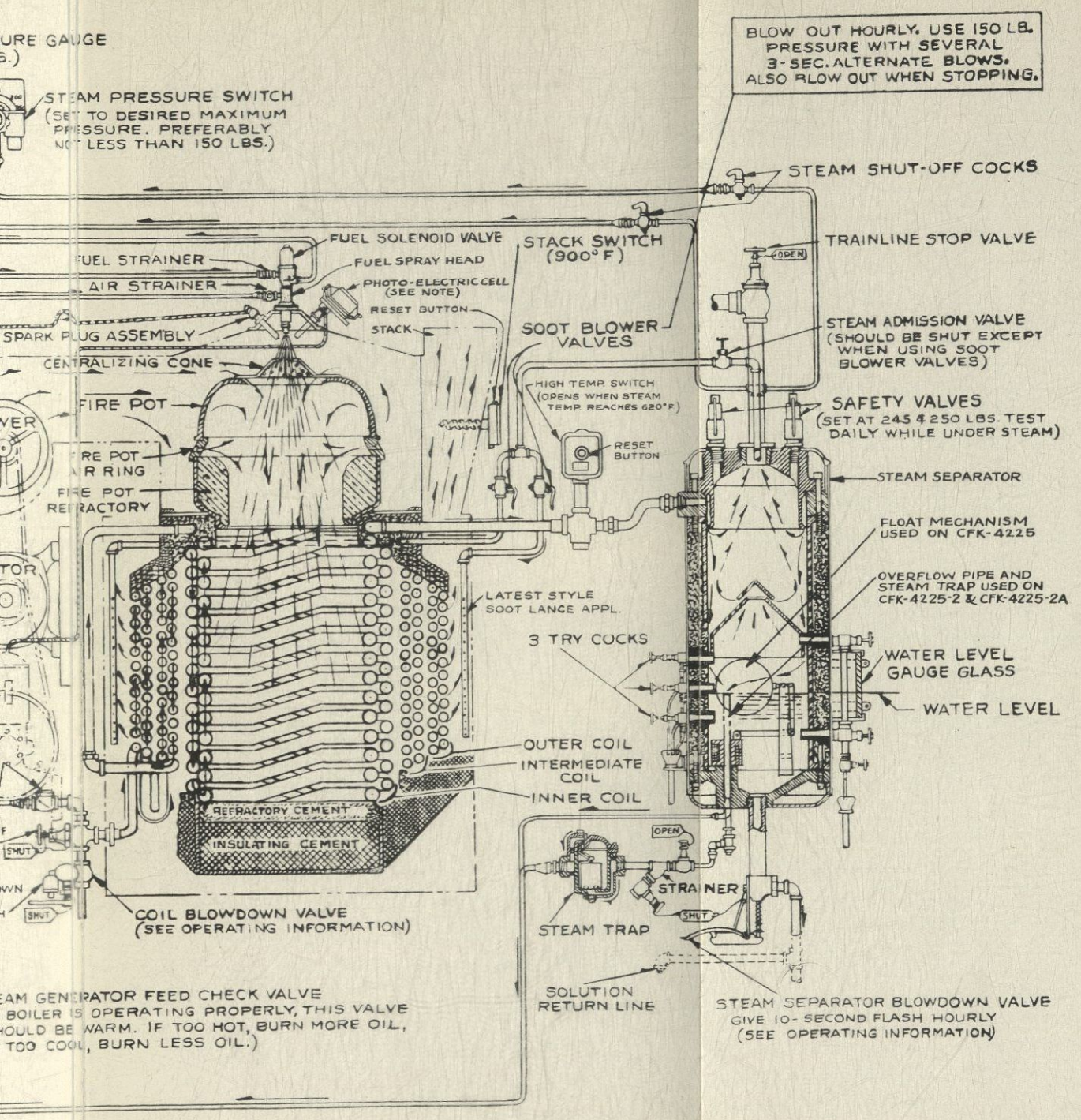
15. Explain how and when to use the soot blowers.

R.E.B.—5-45-15.



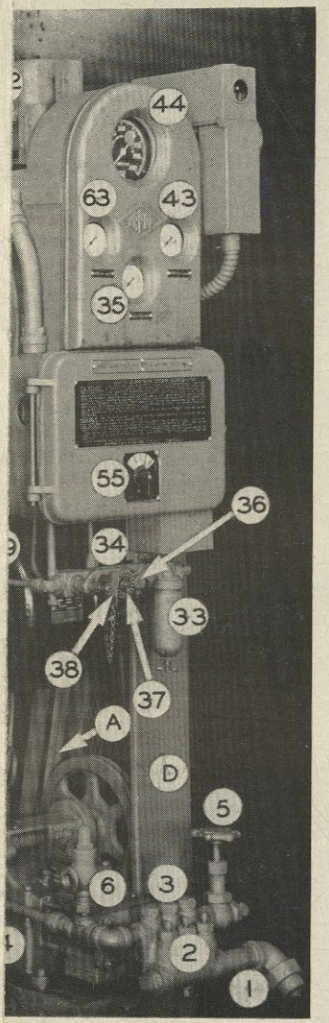
VAPOR CAR HEATING CO., INC., RAILW

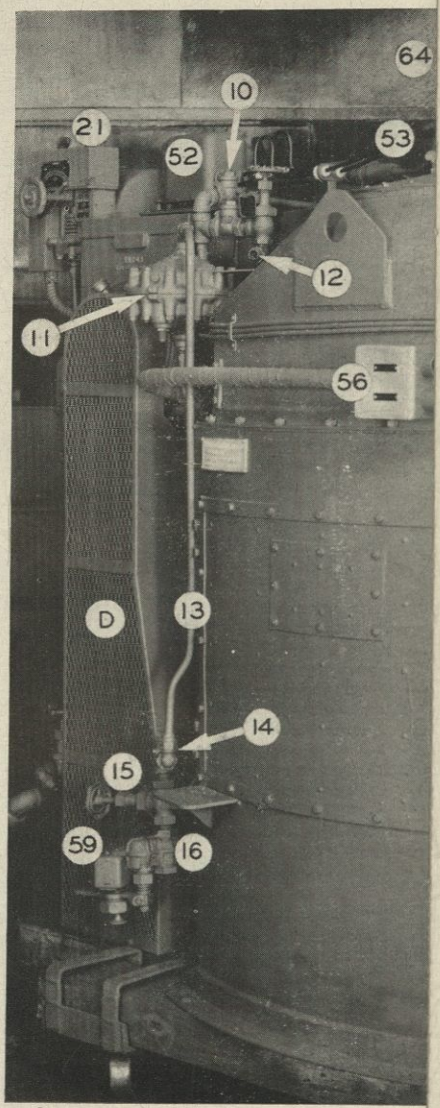
Fig. 2



SCHEMATIC DIAGRAM FOR CFK-4225, CFK-4225-2 AND CFK-4225-2A TYPE VAPOR-CLARKSON STEAM GENERATING UNITS.

WAY EXCHANGE., CHICAGO, ILL.





er pipes

ner

ion wires

g assembly

switch

box (top opening is for
n to stack temperature
itch)

perature switch

el gage glass light

59. *Coil blowdown switch*
60. Air shutoff valve
61. Air reducing valve
62. Atomizing air switch
63. Atomizing air pressure
64. *Air strainer*