Railroad Men's CATECHISM

By ANGUS SINCLAIR

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RAILROAD MEN'S CATECHISM

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BEING AN
INSTRUCTION BOOK FOR

Enginemen, Trainmen, Signalmen and Every Person Connected With the Movement of Trains

ANGUS SINCLAIR PUBLISHING CO.
NEW YORK

PREFACE

The questions used in this book are a series for the Examination of Engineers and Firemen employed by a leading railroad system. These questions were developed from a code prepared by the Traveling Engineers Association and extended by various writers on railroad engineering matters to suit changes in rolling stock and conditions of operating.

Twenty Questions and Answers for Engineers and Firemen have been added, questions and answers based upon the Standard Code of the American Railway Association, with which every person connected with train operating ought to be familiar.

As we consider that all intelligent railroad men are ambitious to acquire knowledge of the principles of mechanical science so far as it relates to their business, we have added a section of Mechanical Calculations.

This is one of the most *useful helps* ever offered to Railroad Men. It applies to men of every grade in railroad service.

RAILROAD MEN'S CATECHISM

SECTION I

First Year Examination

GENERAL QUESTIONS

1. Do you consider it essential to your success in business, to abstain from the use of intoxicating liquors? Do you consider it to your interest to work to the best of your ability for the interest of your employer, and be economical in the use of fuel and supplies?

A. This question will be answered according to the judgment of the man under examination.

2. What are the fireman's duties on arrival at engine house previous to going out on a locomotive?

A. See that the fire is in the condition to make up a proper fire for starting. See that the ash pan is clean. Ascertain that the engine has got on all the necessary tools and supplies, and that the engineer's oil cans are filled.

3. Is it your duty to compare time with your engineer, and should you insist on seeing all train orders?

A. I should consider it my duty to compare time with the engineer and insist on seeing the train orders, if that was the rule of the company I was working for.

4. Give the substance of the various rules pertaining to signals as found in the Book of Rules and Regulations of the operating department.

A. This question will be answered by describing the signals described in the book of rules. The meaning of swinging arms and lanterns in different ways must be explained, and also the meaning that the rules attach to the station signals used by the road.

[More particulars about train rules are given in the section relating to Standard Train Rules.]

5. In addition to any that you have not mentioned, what else do you consider a danger signal?

A. Any person near the track violently waving his arms or any sort of light would be regarded as a danger signal; also a fire burning on the track.

6. Explain the principle of the steam gauge.

A. There are several kinds of steam gauges, but all of them are operated on one of two principles. When internal pressure is applied to a bent flat tube, the tendency of the tube is to straighten out. That tendency is made use of in the Bourdon gauge, the necessary mechanism for operating the dial needle being connected with the tube. The other form of gauge is operated by a double diaphragm of corrugated plate. When pressure is admitted between the plates it forces them outward and the attachments operate the mechanism that moves the gauge needle.

7. What pressure is indicated by the steam gauge? What is meant by atmospheric pressure?

A. The pressure above the atmospheric pressure. The pressure of the atmosphere is that imposed by the body of air surrounding the earth. At sea level it is 14.7 pounds to the square inch.

8. What is the source of power in a steam locomotive?

A. Steam generated by heat.

9. What quantity of water ought to be evaporated in a locomotive boiler to the pound of coal?

A. From 7 to 10 pounds. It is seldom more than 5 pounds.

10. What is steam, and how is it generated?

A. The vapor of water. It is generated by the heat from the fuel burning in the fire box.

11. At what temperature does water boil?

A. At 212 degrees F.

12. What is the temperature of the water in the boiler when the pressure is 200 pounds?

A. At 200 pounds gauge pressure the temperature of the water is 387 degrees F.

13. What is combustion?

A. The chemical combination of fuel and oxygen.

14. What is the composition of bituminous coal?

A. A good quality of bituminous coal contains about 61 per cent fixed carbon, about 31 per cent of volatile matter, known as hydro-carbons, 7 per cent of ash and 1 per cent of sulphur.

15. What is carbon? From what is oxygen obtained?

A. Carbon is one of Nature's elements. Nearly all combustible material, such as wood and coal, consists principally of carbon. Oxygen for sustaining combustion is obtained from the air.

16. What per cent of oxygen is in the atmosphere?

A. The atmosphere contains 20.63 per cent of oxygen.

17. Is air necessary for combustion?

A. It is.

18. About how many cubic feet of air are necessary for the combustion of a pound of coal in a locomotive fire box?

A. It takes 2.66 pounds of oxygen to burn one pound of coal into carbon dioxide. It takes 4.35 pounds of air to supply one pound of oxygen, therefore it will take 11½ pounds of air to provide the oxygen necessary to burn each pound of coal. As some excess of air is necessary, 20 pounds of air should be admitted to the fire for each pound of coal to be burned. One pound of air fills about 13 cubic feet at ordinary temperatures, so we have 13 x 20 = 260, equal to 260 cubic feet of air needed for every pound of coal burned.

19. How many cubic feet of air, therefore, would be necessary for the burning of a "fire" of four scoopfuls, assuming each scoopful to weigh 10 pounds?

A. For four scoopfuls of coal, each weighing 10 pounds, the quantity of air required for combustion would be 40 x 260 = 10,400 cubic feet.

20. Why is it necessary to provide for combustion a supply of air through the fuel in the furnace?

A. Because it is only by forcing the air through the burning fuel that the proper mixture of the gases will be effected.

21. How can you prove that it is necessary to supply air to the fire box for combustion?

A. By shutting off the air supply.

22. What is the effect upon combustion if too little air is supplied through the fire? If too much air is supplied?

A. If too little air is supplied the fire loses activity and combustion produces carbon monoxide, a gas with only about one-third the heating properties of carbon dioxide, the gas formed when the supply of air is sufficient.

If too much air is supplied waste is caused by heating the surplus quantity of air, and the oversupply tends to depress the fire box gases below the igniting temperature.

23. What effect on combustion has the closing and opening of dampers?

A. A closing of the dampers cuts off the supply of air and prevents the fire from receiving its proper supply of air. Opening the dampers permits the air to pass through the grates. Under some circumstances it is better to keep one damper closed, unless the engine is working very hard.

24. How is draft created through the fire?

A. By the current of air induced by the exhaust through the flues and smokestack.

25. Describe a blower and its use and abuse.

A. A blower is a jet of steam passed up the smokestack to induce an artificial current of air. Its proper use is to prevent smoke when an engine is not working, to draw the fire gases away so that they do not pass into the cab and to stimulate the fire when necessary.

The abuse of the blower is drawing cold air through the tubes and by forcing the fire when it is not necessary, causing waste of steam through the safety valves.

26. What effect is produced by opening the fire door when the engine is being worked?

A. It cools the boiler and prevents the rapid generation of steam.

27. What bad effect?

A. It causes sudden contraction of the fire box sheets and flues, tending to cause leakage.

28. In what condition, therefore, should the fire be in order that the best results may be obtained from the combustion of the coal?

A. The fire ought to be maintained in the condition necessary to generate the steam required for the way the engine has to be worked. Even firing and even temperature go together.

29. What is the effect of putting too many scoops of coal on a bright fire? Is this a waste of fuel?

A. Throwing too much coal into a fire at one time depresses the temperature below the igniting point and causes the generation of smoke. The practice is wasteful of fuel.

30. What effect has the fire upon a scoopful of coal when it is placed in the fire box?

A. It distills the volatile gases first, then ignites the carbon of the coal.

31. In what condition should the fire be to consume these gases?

A. Bright and at a high temperature.

32. What is the temperature of the fire when in this condition?

A. About 3,000 degs. Fah.

33. How can the fire be maintained in this condition?

A. By regular firing. That is, by keeping up the supply of fuel as nearly as possible at the rate it is burned.

34. What is black smoke? Is it combustible?

A. It is unconsumed coal and can be prevented by good firing, if the coal is not too volatile. It is combustible when mixed with air and kept at a high temperature.

35. Have you made any effort to produce smokeless firing?

A. Certainly I have.

36. How can black smoke be avoided?

A. By careful firing. With some qualities of coal and a plain fire box smoke cannot be entirely prevented.

37. Can the firing be done more intelligently if the water level is observed closely? Why? Because regular boiler feeding and regular firing go together.

A. The fireman can work more intelligently when he knows that the boiler is being fed regularly.

38. What advantage is it to the fireman to know the grades of the road and the location of the stations?

A. This knowledge enables him to regulate the firing to suit the fluctuating work the engine will do.

39. How should the fire and water be managed in starting from a terminal or other station?

A. The fire ought to be made up sufficiently heavy to preclude the necessity for firing while passing through the yards. The boiler ought to be as full of water as can be carried without priming.

40. What is the purpose of a safety valve on a locomotive boiler? Why is more than one used?

A. To relieve the boiler from over pressure of steam. Two safety valves are used because one is

sometimes unequal to the task of preventing over pressure.

41. What usually is the cause for steam being wasted from the safety valve?

A. Injudicious firing, or want of co-operation between engineer and fireman.

42. What is the estimated waste of coal for each minute the safety valve is open?

A. From 15 to 20 lbs.

A systematic test was made of an engine with about 1,200 square feet of heating surface and 27 square feet of grate area to ascertain the volume of steam wasted through the safety valve. It was found to be 91 lbs. of water per minute. As each pound of coal burned will evaporate about 6 lbs. of water, the waste of coal in that case would be about 15 lbs. per minute.

43. What should be done to prevent waste of steam through the safety valves?

A. The firing should be so regulated when the engine is working that the steam will not rise to the blowing-off point; when steam has to be shut off unexpectedly blowing off may be prevented by closing the dampers, opening the fire box door a little and keeping the injector going. The surplus steam may also be blown back into the water tank.

44. What should be the condition of the fire on arriving at a station where a stop is to be made?

A. Bright and clear, so that little smoke will flow from the stack. There must be sufficient fire on the grates to build on when the engine is started.

45. How should you build up the fire when at stations in order to avoid black smoke?

A. By putting in small quantities of coal at a time at short intervals and permitting the charges to burn bright.

46. What should be the condition of the fire when passing over the summit of a long grade?

A. It should be burned down as low as the requirements of steam making will permit.

47. If the injector is to be used after passing over summit, how should the fire be maintained?

A. The fire ought to be maintained bright and the blower kept in use to create some circulation in the water of the boiler.

48. Is it advisable to take advantage of every opportunity to store in the boiler as much water as possible?

A. It is.

49. Why is it that if there is a thin fire with a hole in it, the steam pressure will fall at once?

A. Because cold air passes through the hole and has a chilling effect upon the boiler.

50. What would be the result of starting a heavy train with too thin a fire upon the grates?

A. Delay for want of steam.

51. How deep a fire should be carried?

A. It should be no deeper than necessary to make the required steam. The kind of fire box and the work to be done would influence the proper depth of fire.

52. Where should the coal, as a rule, be placed in the fire box?

A. It ought to be placed evenly over the entire surface of the grates.

53. Is rapid firing advisable?

A. No. Not the rapid firing that puts a heavy charge of fresh coal quickly into the fire box. The rapid action that puts a scoopful of coal where it belongs, having the door open as short a time as possible, is commendable.

54. When and for what purpose is the use of rake on the fire bed allowable?

A. When the surface of the fire is coking so that combustion is obstructed.

55. Within what limits may steam pressure be allowed to vary, and why?

A. When an engine is working the steam pressure ought to be kept as uniform as possible short of blowing off pressure. When approaching stations the steam pressure should be reduced sufficiently to prevent blowing off.

56. Is it advisable to raise steam rapidly?

A. Not if it can be avoided without causing delay. Rapid raising of steam, especially from cold water, puts destructive strains upon the boiler sheets.

57. Has improper firing any tendency to cause tubes to leak? How?

A. It has. Improper firing causes wide variations in the temperature of the fire box, and sudden reduction of temperature causes the tubes to contract and leak.

58. What would you consider abuse of a boiler?

A. Intermittent firing, causing fluctuating variations of fire box temperature, cooling by means of an open fire box door and intermittent boiler feeding. Feeding the boiler rapidly when steam is shut off abuses the boiler.

59. How would you take care of a boiler with leaky tubes or fire box?

A. Maintain the temperature as evenly as possible by uniform firing and boiler feeding. I should avoid feeding when steam was shut off.

60. What are the advantages of an arch in the locomotive fire box?

A. It tends to keep the temperature of the fire box uniform; it prevents cold air from passing directly into the tubes, and it lengthens the journey of the fire gases on their way to the tubes. The arch acts also to some extent as a spark arrester.

61. Why is it very important that coal should be broken so that it will not be larger than an ordinary sized apple, before being put into the fire box?

A. Because in that condition it provides the best surface for ignition and provides the proper openings for emission and mixture of the fuel gases.

62. When and why should you wet the coal in the tender?

A. As soon as the supply of coal has been put upon the tender. The wetting is done to keep down the dust. It also tends to keep the mass of fine coal together and prevents it from being drawn into the tubes by the suction of the exhaust.

63. Should coal be allowed to lie on the deck and fall out of the gangway?

A. Certainly not.

64. Do you understand that the coal used on the locomotive is property and represents money invested by the company?

A. I do.

65. What are the advantages of a large grate surface?

A. It permits of slower combustion than would be practicable with smaller grate surface and slow combustion under proper restrictions promotes economy of fuel.

66. Why are the grates made to shake, and when should they be shaken?

A. To break up the clinkers and ashes that close up the grate openings and restrict the supply of air. The grates should be shaken very lightly as soon as the fire shows that the air is too much restricted. With some kinds of coal the grates must be moved frequently to

prevent them from "sticking," a condition caused by fused clinker.

67. Why should grates not be shaken too frequently?

A. Because good fuel would be wasted and the ash pan prematurely filled, with danger of burning grates.

68. Is it a fireman's duty to avoid filling up the ash pan too full?

A. Certainly it is.

69. Is it permissible to dump ashes or fire over road crossings, switches or around stations?

A. It is not.

70. Is it objectionable to fill the tanks too full or spill water at stand pipes or water tanks?

A. It is a very objectionable and dangerous practice, and should be avoided.

71. What are the duties of a fireman on arriving at a terminal?

A. The answer to this question will vary according to the rules of the particular road.

72. Is the engineer responsible for the fireman's conduct while on duty and the manner in which the fireman's duties are performed?

A. He is.

SECTION II

Second Year Examination

GENERAL QUESTIONS

1. Has there been anything in the past year to interfere with your preparation for this examination?

A. The answer to this question will depend upon anything interfering or not.

2. Have there been any new signals introduced during the year or any changes on the old ones?

A. This question will be answered according to the knowledge about signals of the candidate.

3. Have you made any improvement in your method of firing, and have you obtained any better results economically and in smokeless firing during the year?

A. The answer to this question will also be based on the candidate's experience and progress.

4. Describe the general form of a locomotive boiler?

A. It is a cylindrical vessel of varying length and diameter, with a fire box in the rear and a smoke box in front. Flue tubes extend from the front of the fire box to the smoke box and carry through the boiler the hot gases generated in the fire box.

5. How does the wide fire box boiler with fire box projecting at each side beyond the wheels differ from the narrow fire box set between the wheels, and what advantage has the wide fire box over the narrow fire box?

A. The purpose of the wide fire box is to provide a larger grate area than what can be obtained with a fire box set between the wheels. It is also easier to fire properly than a very long narrow fire box.

6. What is a wagon top fire box?

A. A boiler with that part of the shell above the fire box raised above the level of the waist or cylindrical part of the boiler.

7. Describe a locomotive fire box.

A. The ordinary fire box is an oblong box secured to the back part of the boiler. It is so constructed that water spaces are provided between it and the outside shell at the sides and the back. The fire box is secured to the outside shell by stay bolts, and at the front end of the fire box is a flue sheet with the flues secured therein. At the bottom part of the fire box the grates are secured in a frame attached to the fire box and beneath these an ash pan. The crown sheet is sometimes supported by bars set on edge but more generally by stays of various kinds.

8. Why have two fire doors been placed in some of the wide fire boxes?

A. To make it easier to spread the coal over every part of the grates.

9. To what strains is the locomotive fire box subjected?

A. First to the strains due to high pressure of steam; second, to the strains that arise from varying temperature with the hot water on one side of the sheets and a hot flame or, perhaps, cold air, on the other side. Then the changes of temperature act to lengthen or shorten the sheets putting great strains upon the material. Varying temperature of feed water also puts strain upon the fire box.

10. How are the side and end sheets of the fire box supported?

A. By stay bolts.

11. What purpose is served by the small hole drilled in the outer end of stay bolts?

A. To give indication by leakage when a stay bolt breaks.

12. In what manner is a crown sheet supported?

A. Sometimes by crown bars, but generally by stay bolts.

13. What is a bad feature about crown bars?

A. They impede circulation of water and collect scale and mud.

14. What are the advantages of radial stayed crown sheets?

A. The radial stays offer little obstruction to the free circulation of the water. They also put less weight on the fire box than crown bars; and do away with the need of string stays to bind the fire box to the shell.

15. How are the inside and outside sheets secured at the bottom?

A. By the mud ring or foundation ring, as it is sometimes called.

16. Describe the ash pan.

A. It is a sheet iron pan that conforms to the outline of the mud ring and is secured thereto. There is a door at each end called dampers for restraining or cutting off the supply of air when necessary and to provide means for removing cinders and ashes that the ash pan collects.

17. Why are boilers provided with steam domes?

A. The dome provides a location for the throttle valve removed considerably above the water level in the boiler. This tends to prevent water from passing into the dry pipe along with the steam.

18. What must be the condition of a boiler in order to give the best results?

A. It must be kept as clean as possible and as free from scale and mud as circumstances will permit.

19. What is meant by circulation in a boiler?

A. The circulation is the moving of the water from one point to another inside the boiler. Circulation tends downwards at the cooler parts and upwards close to the heating surfaces. It is strongest about the fire box and arises from the heated water moving upwards and to the stirring given to the water by the steam rushing away from the heating surfaces. There is a theory that the water at the sides and end of the fire box flows downwards at the outside sheet and upwards on the hotter inside sheet.

20. What would be the result if a leg of the fire box became filled with mud?

A. The fire box side sheet would become overheated.

21. What would be the result if the fire box sheets became overheated?

A. The sheets would bulge between the stay bolts and would be likely to crack. If they were overheated by becoming dry rupture might ensue.

22. Why are boiler checks placed so far away from the fire box?

A. The checks are placed at the coolest part of the boiler so that the fire gases that have been cooled in passing forward may still be able to impart some heat to the incoming water.

23. What part of the locomotive boiler has the greatest pressure?

A. The steam pressure is uniform throughout, but there is a little pressure due to the weight of the water and that is greatest on the lowest point which is the mud ring.

24. What should be the length of a locomotive smoke box?

A. The ideas of designers vary greatly on this point. Extension smoke boxes vary from 40 to 60 inches. The most common length on the New York Central Lines is about 65 ins. for passenger and 60 ins. for freight engines.

18. What object is there in having the exhaust steam go through the stack?

A. For the purpose of creating draft.

19. How does this affect the fire?

A. The suction or draft created by the exhaust steam creates a partial vacuum in the smoke box which draws air through the grates, thereby stimulating the fire.

20. What should be done to prevent black smoke from trailing when the throttle is closed?

A. The dampers should be closed, the fire door partly opened and the blower started sufficiently to clear away the smoke.

21. What are the adjustable parts in the front end by which the fire is regulated?

A. With an extension front the diaphragm plate in front of the tubes is adjustable. With a diamond stack an adjustable lift pipe is generally set between the nozzles and the base of the stack. A hot pipe is sometimes also used with an extension front.

22. Explain what adjustment can be made and the effect of each adjustment on the fire?

A. When the diaphragm plate has the lower part too far away from the tube plate there is danger of spark throwing and the fire gases will pass too freely through the upper rows of tubes. With such a defect the fire is burned more actively on the back part of the grates than in front. If the plate is set with the lower part too near the tube plate draft will be obstructed and the fire will burn most actively in the front part of the grates.

There is no hard-and-fast rule for the adjustment of the lift or petticoat pipe. It is usually set with the bottom of the floor level with the top of the nozzle. If the draft cuts the front of the fire too much the petticoat pipe ought to be raised a little. If the back part of the fire is cut it ought to be lowered. Diaphragm and lift pipe ought to be set so that the fire gases will be drawn evenly through all the tubes.

23. What is out of place when the exhaust steam strikes the side of the stack?

A. Generally the lift pipe. That result will also come from the nozzle being out of plumb.

24. What effect has the stoppage of a number of flues?

A. It reduces the steam making capacity of the boiler Makes boiler steam poorly.

25. What is the effect of leaking steam pipe joints inside the smoke box?

A. It injuriously affects the steaming of the boiler.

26. What causes pull at the fire door?

A. Diaphragm plate or lift pipe being set too high.

27. Give briefly your opinion as to the best method of firing locomotives.

A. In the manner that will generate steam freely with the smallest quantity of coal. This is done generally by steady firing with the quantity to suit the way the engine is working.

28. If upon opening the fire door you discover what is commonly called "red" fire what might be the cause?

A. The free passage of air through the grates being obstructed.

30. Is it a waste of fuel to open the fire box door to prevent safety valves from blowing? How can the necessity for this be prevented?

A. First: It is a waste of fuel. Closing the dampers and starting the injector are the easiest remedies. Second: Escape of steam through the safety valves blowing may generally be prevented by careful firing and forethought when approaching stopping places. When blowing off steam cannot be prevented, some of the heat may be saved by blowing the steam into the tender.

OPERATION ON THE INJECTOR.

31. What is an injector?

A. An injector is an apparatus in which a jet of steam condensed by water imparts to the latter its velocity, with the result that the final energy of the combined steam and water is greater than that at which the water would issue from the boiler. This difference of energy in favor of the jet passing through the injector enables it to lift the boiler check and enter the boiler.

32. In a general way what are the two kinds of injectors?

A. In a general way, injectors are known as "Single Tube" injectors, when they have a single set of nozzles, and as "Double Tube" injectors when they have two sets of nozzles; one of the latter kind has the function of lifting the feed water and delivering it to the forcing set, which latter imparts to the water sufficient velocity to cause it to enter the boiler.

33. What is the difference between a lifting and a non-lifting injector?

A. A lifting injector is placed above the highest water level of the tank from which the feed water supply is taken, so that the injector has to lift the water up to its own level. A non-lifting injector is placed below the lowest level of the water of the tank from which the feed water is taken, and it flows to the injector by gravity.

34. What are the essential parts of an injector?

A. The essential parts of injectors are, in the first place, the nozzles, which perform the function of delivering or forcing the water into the boiler, and, in the second place, the operating mechanism, such as the lifting valve, steam valve, water valve, etc.

35. How should an injector be started?

A. In starting an injector, if it is a lifting one, the lifting valve should be opened first, and when the water appears at the overflow, the forcing valve of the injector should be opened gradually to its full extent. In starting a non-lifting injector the water should be admitted to the injector first, and when it appears at the overflow the steam valve should be opened gradually to its full extent.

36. Give some of the common causes for failures of injectors to work.

A. The most common causes for failure of injectors are the following: Leak in the suction pipe. Obstructed strainer or strainer of insufficient size. Liming up of the nozzles. Loose hose lining. Obstructions in the nozzles, such as pieces of coal, or other foreign matter washed in from the tank. Obstructions in the delivery pipe, such as a sticking boiler check which will not open properly. Leaky steam valve and boiler check, which will affect the starting of the injector by heating the suction pipe and the feed water.

37. What course should be pursued with check valve stuck open?

A. In case the check valve is not provided with a stop valve, it will be necessary to close the heater cock and water valve of the injector, to prevent water from the boiler from running out through the injector. In this case reliance for feeding the boiler must be had on the injector, the check of which must be in good condition. If the boiler check has a stop valve, this can be closed down to shut off the boiler pressure from the check, in which case the check can be taken out for cleaning or for the removal of the causes which made the valve stick open.

38. How may it be determined whether the check valve or steam valve is leaking?

A. To determine whether the check valve is leaking, the frost cock, with which all delivery pipes and most check valves are provided, should be opened. If water continues to issue from this frost cock, the indication is that the check valve is leaking. To determine whether the steam valve is leaking, the cap of the heater cock and the heater cock check should be removed. If the steam valve is leaking, steam will issue through the opening.

39. What may be done in this case?

A. In such cases the check valve and the injector must be reported for repair, and the leaky valves ground in.

40. What may be done if a combining tube is obstructed?

A. In case the combining tube is obstructed, it must be removed, the nozzles thoroughly cleaned, and all obstructions removed.

41. How may it be determined if the trouble is on account of a leak in the suction pipe?

A. When the suction pipe leaks, the injector works with a hoarse, rumbling sound, caused by the air drawn in through the leaks. A leak in the suction pipe may also be determined by closing the tank valve, and opening the steam valve of the injector slightly, with the heater cock closed. If there is a leak anywhere in the suction line, the steam under such circumstances will issue through the leak.

42. What should be done in case of obstructed hose or strainer?

A. In case of an obstructed hose or strainer, the connection between hose and strainer should be broken, and, with the heater cock closed, steam should be blown back through the strainer. The water allowed to flow through the open hose will usually wash out the obstruction. In most cases it will be sufficient to remove the waste cap of the strainer, and allow water from the tank to flow through to wash out the obstruction.

43. What should be done in case the feed water in the tank is too hot?

A. In case the feed water in tank is too hot, it will be necessary to obtain fresh water as soon as possible to reduce the temperature.

44. Will an injector work if all of the steam is not condensed by water?

A. An injector will not work properly if all of the steam is not condensed.

45. If it is necessary to take down the tank hose, how can the water be prevented from flowing out of a tank that has the siphon connection instead of the old style tank valve?

A. In case a tank is provided with a siphon connection in place of the usual style of tank valve, it is better to open the air vent at the top of the pipe, in order to prevent the water from flowing out when the tank hose is taken down. The sizes of the siphon pipes are usually large enough to admit air when the hose is disconnected, so that there is little danger of the water being siphoned out of the tank.

46. Explain how the water in the delivery pipe can be protected from freezing.

A. If the injector is not in use for a long period in cold weather, the frost cock in the delivery pipe should be opened to prevent freezing.

47. Explain how you would prevent the waste pipe freezing, either while the injector is working or shut off.

A. The waste pipe contains water only during the short period when the injector is started, and even then it flows through the pipe at a rapid rate, so that the danger of freezing is very remote. When the injector is at rest, the waste pipe is empty. A gradual freezing as a result of a badly leaking lifting or steam valve may be prevented by occasionally opening the lifting valve slightly, and allowing steam to blow through the waste pipe.

48. How can the suction pipe and injector hose be protected from freezing?

A. The suction pipe and hose may be protected from freezing by using the injector as a heater.

49. Explain how the heater is used on a lever Monitor injector.

A. In connection with the lever motion injector, it can be used as a heater by closing down the heater cock and opening the lever very slightly, and fastening it in that position by means of the thumbscrew on the side of the lever.

50. How is the heater used with a screw Monitor injector?

A. With a screw Monitor injector it can be used as a heater by closing down the heater cock and opening the steam valve spindle about half a turn.

51. Is the indication of water level by the gauge glass a safe indication if the water level in the glass is not moving up and down when the locomotive is in motion?

A. If the water level in the gauge glass of a locomotive is not moving up and down when the locomotive is in motion, the indication of the water level is not a safe one.

52. Is any more water used when an engine foams than when water is solid?

A. When an engine foams, the consumption of water is undoubtedly greater than when the boiler does not foam.

53. How should an injector be stopped?

A. In stopping an injector, the steam valve should be pressed firmly and gradually on its seat, avoiding (more particularly in the case of a lever mechanism) the closing of the valve with a sudden shock, which injures the valve and its seat, and has a tendency to loosen these seats, where they are inserted in the body of the valve.

SECTION III

Third Year Examination

GENERAL QUESTIONS

1. What are the duties of an engineman before attaching the locomotive to the train?

A. The duty of the engineman is to thoroughly inspect his engine for possible defects of machinery. He should know the condition of the fire box, grate bars, etc.; that gauge and water glass cocks are open and working freely, and that the crown sheet is covered with sufficient water to protect it from injury, and that the tender has been supplied with water. He should also know the condition of the engineer's brake valve and air pump, and take such other precautions as would prevent an engine failure.

2. What tools should there be on the locomotive?

A. The engine should be provided with such tools as are found necessary in everyday work. This includes also tools with which to make repairs in case of accident, Rake, coal pick and shovel are classed as tools.

3. What examination should be made after any work or repairs have been done on valves, brasses, etc.? Some companies specify that tools ought to be carried on the engine. Where that is done the answer to this question should be regulated accordingly.

A. A man should satisfy himself by personal inspection that the work has been properly done, that all movable parts have been returned to place and properly secured by bolts, set screws or otherwise.

4. How can it be known whether a boiler is carrying the proper steam pressure?

A. By the safety valves and steam gauge, which should correspond with the prescribed pressure as established by the company.

5. What attention should be given to boiler attachments, such as gauge cocks, water glasses, etc.?

A. It should be known that they are open and working freely at all times.

6. Is smokeless firing practicable?

A. It is practicable with certain kinds of coal. With other kinds of coal the best a fireman can do is to fire frequently keeping the fire as thin as practicable.

7. Trace the steam from the boiler through the cylinders to the atmosphere, and explain how it transmits power.

A. Steam enters from the main throttle located in the dome into the dry pipe, thence to the steam pipe and into the steam chest. From the chest it passes through the admission port into one end of the cylinder and forces the piston to the opposite end. When the piston has very nearly completed the stroke, the movement of the valve, which is in the opposite direction to the movement of the piston, establishes communication with the exhaust passage and permits the steam to pass through the exhaust passage into the stack and thence to the atmosphere.

8. How much power have the piston and crosshead on one side to turn the crank pin, when the center of the wrist pin, the crank pin, and the main driving axle on the same side are in a straight line?

A. None whatever.

9. How then is the engine kept going?

A. Since a locomotive consists of two complete engines whose main rods transmit their power to the same driving shaft upon which the main pins are at right angles to one another, it follows that the engine whose main pin is on either the top or bottom quarter exerts sufficient power to cause the wheel to rotate, carrying the pin on the opposite side past the dead center to a point where the steam becomes effective to move the engine on that side.

10. What is meant by "working steam expansively"?

A. By working steam expansively is meant the process by which steam is let into the cylinder and cut off before the piston has finished its full stroke, thereby allowing the expansive force of the steam to exert a certain amount of energy on the piston from the time that cut-off took place up to the point where release occurs.

11. How should the locomotive be started to avoid jerks and what train signals should be looked for immediately after starting?

A. The engine should be started with the reverse lever in full gear in the direction in which the locomotive is expected to move, and a gradual admission of steam.

Signals should be carefully looked for towards the rear end of the train to make sure that the entire train has been started.

12. After a locomotive has been started, how can it be run most economically?

A. By working steam expansively, that is, with the reverse lever cut back to a point where the engine will handle the train with a full throttle.

13. If you discovered that a fixed signal was missing or was imperfectly displayed, what should you do?

A. Stop. Ascertain the cause and report to the proper official from the first telegraph station as per standard or special rules covering this subject.

14. How rapidly should the water be supplied to the boiler?

A. Water should be delivered to the boiler steadily and in just sufficient quantity to replace the water which is being evaporated in doing work.

15. What is the difference between priming and foaming of a locomotive boiler?

A. Priming is produced by certain conditions of the water and has a tendency to raise the water in a solid mass, while foaming consists of an aggregation of bubbles which carry the sediment to the surface. In both cases water is carried with the steam to the cylinder. To the ordinary observer priming and foaming are the same thing.

16. What should you do in case of foaming in the boiler?

A. The throttle should be either partly or entirely closed for a few moments to ascertain the water level in the boiler. Where surface cocks are used, they should be used while the engine is at work, because they will then carry away the scum which has been driven to the surface. When recourse is had to the blow-off cock, it can best be done when the engine has been shut off, as the sediment then settles to the bottom.

17. What danger is there when the water foams badly?

A. There is danger of exposing the crown sheet to the intense heat through the water being too low, and liability of burning it.

ADJUSTING ROD BRASSES AND SETTING UP WEDGES.

18. What work about a locomotive should be done by the engineman?

A. He should set up the wedges and key up the rod brasses.

19. How should the work of setting up the wedges be done?

A. The engine should be placed with the crank pin of the right side on the upper, forward eighth, which brings the crank pin of the left side on the back, upper eighth. Block the wheels, and with the reverse lever in the forward motion, apply a small quantity of steam. As the action of the steam against the piston has a tendency to move it forward, the strain is thrown against the shoes, permitting a free movement of the wedges. The wedges should be set up with an ordinary wrench as far as possible

and then pulled down again about one-eighth of an inch to prevent the box from sticking either from overheating of the box or defective lubrication of the wedge.

20. How should rod brasses be keyed?

A. The key should be driven down just enough to bring together brass to brass. Any greater force would spring the crown of the brass against the pin and cause it to heat.

21. How should an engine be placed for the purpose of keying rod brasses?

A. That depends entirely on which rods are to be keyed. If the main rod is to be keyed, place the side of the engine upon which the work is to be done either on the upper, forward eighth or the lower, back eighth, as these positions present the greatest diameter of the pin to the rod brass and guarantee a free movement at all points without binding.

22. What is the necessity of keeping brasses keyed up properly?

A. To prevent unnecessary shocks and heating of rod brasses and pounding in driving boxes, which in time cause undue strain on the entire motion with disastrous consequences.

23. How should the side rods on mogul and consolidation locomotives be keyed?

A. Place the engine on the dead center either forward or back. First key the middle connection, next the ends of rods and observe that the rod moves freely on the pin. Now place the engine on the opposite dead center and notice if the rods move freely at this point also. This is particularly necessary with rod brasses having keys on both sides of pin and which are apt to be made either too long or too short, throwing the rods out of tram and causing undue strain on rods and driving boxes, and also danger of broken rods or pins.

24. What is meant by "engine out of tram"?

A. By an engine out of tram is meant one whose distance from center to center of axle or rod on one side does not coincide with the similar distance on the opposite side; or it may mean that the distance between two connected crank pins is not the same as the distance between the two axles to which the crank pins belong.

WHY SMOKE BOX IS KEPT AIR TIGHT.

25. Why is it important that there be no holes through smoke box sheets or front and none in the smoke box seams or joints?

A. There should be no possible chance for the admission of air to any part of the smoke box, because it tends to destroy the vacuum necessary to create a perfect draft on the fire and also fans fires in the smoke box that warp and destroy the sheets or front end.

VALVES AND PISTONS.

26. Describe a piston valve.

A. A piston valve is a cylindrical spool-shaped device having cast iron packing rings sprung into place on the valve, and operating in a cylinder of equal diameter. The valve cylinder is provided with suitable admission and discharge ports and permits the valve to perform the same functions as an ordinary slide valve.

27. What is a balance slide valve? How is it balanced and why? For what reason is the hole drilled through the top of the valve?

A. A balance slide valve is one where a certain percentage of the steam pressure exerted on the top of the ordinary slide valve has been prevented.

The balancing feature is obtained by a steam table extending beyond the extreme travel of the valve, and either bolted to the steam chest cover or cast in one piece with it. The Allen-Richardson valve has its valve grooved for the reception of four snugly fitting strips, which are supported

against the table by semi-elliptic springs, which make a steam-tight joint, and prevent any pressure reaching the enclosed part of the valve. The American balance valve obtains the same results but uses circular, tapering rings supported by coiled springs.

The small hole in the top of the valve is for the express purpose of allowing any pressure or water which may have accumulated on the top of the valve from whatever cause to escape to the exhaust port.

28. What is meant by inside and outside admission valves?

A. By inside admission valve is meant one where the steam enters the steam port of the cylinder from the inside edge of the valve and is exhausted from the outer edge of the valve; by outside admission is meant one where steam enters the steam port from the outer edge and is exhausted from the inner edge, similarly to our common slide valve, which is an outside admission valve.

29. What is the relative motion of main piston and valve for inside admission valve and for outside admission valve?

A. With inside admission the motion of the valve is in the opposite direction to the piston's motion at the beginning of the stroke. With outside admission the movement of the valve is in the same direction as the piston at the beginning of the stroke.

30. What is the difference in the valve motion for outside admission valves and inside admission valyes?

A. Both may have either direct or indirect motion, according to the position of the eccentrics on the shaft and the type of rocker arm used.

31. What is a direct motion valve gear? What is an indirect motion valve gear?

A. A direct motion valve gear is one that transmits the motion of the eccentric to the valve direct by means of a transmission bar or its equivalent connecting with the valve stem.

An indirect motion valve gear is one where the power is transmitted from the eccentric through the truck to the lower rocker arm, which gives motion to the upper arm that moves the valve rod connecting with the valve stem.

32. What is meant by lead?

A. Lead is the amount of opening a valve has when the piston is at the beginning of the stroke.

33. What is meant by steam side lap?

A. By steam side lap is meant the amount of the valve overlaps the steam ports, when the valve is on the middle of the seat.

34. What is meant by exhaust side lap and by exhaust side clearance?

A. Exhaust side lap is the amount the inner edge of the valve overlaps the steam ports when the valve is in the middle of the seat.

Exhaust side clearance is the amount the inside edge of the valve comes short of covering the ports when the valve is in the middle of the seat.

35. With an indirect valve motion, what would be the position of the eccentric relative to the crank pins? With direct motion valve gear? Why?

A. If the valves are the inside admission indirect, necessitating a rocker shaft, the eccentrics would lean toward the fire box when the main pin is on the forward dead center; while an outside admission indirect has the belly of the eccentrics leaning toward the main pin.

With an inside admission direct and a transmission bar, both eccentrics lean toward the pin; while with the outside admission direct the eccentrics have the same position as with the inside admission indirect. With the inside admission indirect the eccentric rods are crossed, when the crank pin is on the forward dead center; the eccentric rods with the outside admission direct are also crossed when the crank pin is on the forward dead center.

These positions of the eccentrics are necessary with the corresponding valve motion to secure correct movement of the valves.

36. What effect would be produced upon the lap and lead by changing the length of the eccentric rods?

A. Changing the length of the eccentric rods will either increase or decrease the travel or produce an uneven travel of the valve over the ports, causing either a too early or too late admission and release. It depends entirely on whether one or both rods have been shortened or lengthened. It affects the engine in that a too early admission on one end would give a too early release, and a too late admission a too late release on the other end. Changing the length of the eccentric rods does not affect the valve lead. Positive lead can only be obtained by advancing the eccentric toward the pin with the ordinary slide valve and indirect motion, while negative lead under similar conditions requires the eccentric to be turned from the pin.

37. Why are eccentric rods made adjustable?

A. To allow for adjustment of the valve travel so that even steam admission may be made at both steam ports.

CYLINDERS, PISTONS AND PACKING

38. Why is it necessary to keep the cylinders free from water?

A. To prevent rupture of cylinder and head which would necessarily occur should much water remain after the valve had closed all communication and the piston been forced to the end of its stroke.

39. Where is piston rod packing located? Cylinder packing?

A. The piston rod packing is located in the back cylinder head.

Cylinder packing is to be found in the grooved receptacles provided for that purpose in the circular surface of the piston.

40. How are the metallic packing rings on valve stems and piston rods usually held in place? And what provision is made for the uneven movement of the rods?

A. Metallic packing rings are held in place by stiffened spiral springs pressing against a ring and forcing the packing into a bell-shaped cone.

Suitable provision is made for the uneven movement of the rods in that the cone holding the metallic packing has a ground and steam-tight joint, which permits the cone to have a lateral motion against the face of the packing gland, and thereby prevents the escape of any steam.

CAUSE OF TANK SWEATING.

41. What is the cause of tank sweating? And what will prevent it?

A. Variations of atmospheric conditions. The temperature of the water in tank being of a lower degree than that of the surrounding atmosphere, condensation from the moisture in the air takes place on the exterior of the tank.

It can be prevented by bringing the water in the tank to the same temperature as the surrounding atmosphere.

FRICTION AND LUBRICATION.

42. What is friction?

A. Friction is the resistance between two bodies in contact, which resists the sliding of one upon the other.

43. Upon what does the amount of friction depend?

A. The amount of friction between two bodies in contact depends on pressure, temperature, speed, kind of material and quantity and quality of lubricant.

44. What is the effect of the introduction of oil or other lubricants between frictional parts?

A. It reduces friction in proportion to the quantity and quality of lubricant used.

45. Explain the principle on which grease cups operate. What is the objection in using water on a hot pin where grease is used, or a hot pin with babitted brasses?

A. The principle on which grease cups operate is that of compression and expansion. As grease reduces friction less rapidly than oil, a certain amount of heat is generated, and as grease expands more rapidly than metal, it is forced through the aperture in the cup down upon the pin.

As one of the ingredients of "rod grease" is lye, and as lye will freely dissolve in water, the application of water to a pin will remove the "grease" and destroy lubrication.

The intermittent use of water on hot pins provided with babbitted brasses where oil is used as a lubricant has a tendency to clog the feeder with babbitt metal, thereby preventing the flow of oil to the pin. It also produces unequal contraction of the pin, often with disastrous results. There can be no bad effect from the continuous use of water, if used before the brass becomes overheated and before the babbitt starts to melt.

BLOW-OFF COCK.

46. Explain the construction and operation of the blow-off cock?

A. A blow-off cock may be either a globe valve operated by a screw, a taper plug valve operated by a lever, a sliding disk valve operated by a lever, or a plunger valve upon whose upper end either steam or air may be forced to unseat it.

The object of any of these valves when open is to permit the escape of sediment and impurities from the boiler, and for that reason they are located at the bottom of the boiler.

BELL RINGER.

47. Describe a bell ringer; and how may it be adjusted?

A. The automatic bell ringer is a device whose mechanism consists of a valve having either a sliding or rotary movement and provided with a suitable admission and exhaust port, a piston operated in a cylinder, and a piston rod connected to the bell crank so as to impart a swinging movement. The motive power is air taken from the main reservoir.

Some types are provided with a threaded stem and a jam nut by which adjustment can be made, while others have a piston rod operating like a telescope and requiring no adjustment.

USE OF THE BLOWER.

48. How should the blower be used when an engine is on the cinder pit?

A. The blower should be used with just enough force while cleaning the fire to prevent the escape of gases from the fire door and possible injury to the fire cleaner.

When the engine is at rest it is sometimes necessary to use the blower to prevent the emission of smoke. In this case the fire door should be kept on the latch. The blower has sometimes to be used for stimulating the fire when the engine is not steaming freely. In such cases it can be employed to best advantage when descending grades or approaching stations with the steam shut off.

ENGINE DISABLED ON THE ROAD.

49. In case the locomotive in your care became disabled on the road what should you do?

A. First, protect the train front and rear by flags the prescribed distance. Make such temporary repairs as are necessary to get the train to the next siding, in order to prevent blocking the main line. When on the siding make all the repairs practicable with the tools at hand. If the breakdown is of such a nature as to prevent the possibility of making even temporary repairs, so as to clear the main lines, arrange to notify the nearest telegraph office of your location and ask for assistance.

50. Suppose a wash-out plug blew out, or a blow-off cock broke off or would not close, what should be done?

A. Draw the fire at once to prevent burning of fire box sheets. In addition to this, in cold, freezing weather, the pet cocks on all connections where there is any liability of water collecting should be opened to drain the pipes, and in the absence of cocks the couplings should be slacked off. The tender hose couplings should be disconnected and special care should be given to the air pump drain cocks to prevent the rupture of the steam cylinder of pump.

If a heavy fire was on the grates it might be necessary to dampen it with earth or water before dumping it.

51. What should be done, should the grates be burned out, or broken while on the road?

A. Block up the broken or burnt grates with fish-plates, brick, or anything conveniently at hand, and disconnect the good grate immediately ahead and back of the burnt section in order to prevent disturbing the other grates when shaking down fire.

TO PREVENT SPARK THROWING.

52. What precaution should be taken to prevent locomotives throwing fire?

A. In order to prevent engines from throwing fire, the netting in the smokestack or smoke box should be carefully looked after, and the cinder slide and hand-hole plates must be in their proper places and securely fastened. Equally important is the knowledge that the ash pan is clean, otherwise live coals, more dangerous than cinders, will roll out of the pan and start fires on bridges and along the company's property.

BURSTED OR LEAKY TUBES.

53. What should be done with a badly leaking, or bursted tube?

A. Where time and conditions permit, burst flues can be put in condition to bring in train. First, fill the boiler as full of water as it will hold, to compensate for loss. Then blow off steam through the whistle or remove release valve from chest, open the throttle, and blow off steam and deaden the fire so that the flue can be plugged. If the tube is burst, it must be plugged at both ends. If it is simply a case of leaky tube at tube sheet, the above method is not necessary. Simply plug the tube. Bran or any starchy substance admitted through the heater cock on injector after injector has been started will aid in stopping a bad leak.

54. Suppose that, immediately after closing the throttle, the water disappeared from the water gauge glass, what should be done?

A. Disappearance of water from water glass may be caused in various ways. The water may be bad and foamy, or the engine may have insufficient steam space, thus causing the water to prime, or the engineman may have taken too many chances on low water. As soon as the water disappears from the glass no time should be lost before banking or deadening the fire. Injectors should be kept at work until the water reappears in the glass before fire is rekindled.

THROTTLE VALVE DISCONNECTED.

55. What should be done in case a throttle stem becomes disconnected while the throttle valve is closed; and if it becomes disconnected while the throttle valve is open?

A. With a disconnected throttle closed—where the company requires the engineman to make repairs—steam must first be blown off and the dome cap raised to reach the disconnected rod. Not enough power can be had from the oil pipes to move the modern engine. If she is equipped with a drifting valve, she can be made to move herself without train.

If the throttle is disconnected and open, reduce pressure to a point where engine will not slip, and control the train by air brake.

What is often mistaken for a disconnected throttle is merely a stuck throttle, due to excessive lost motion of parts, and occurs when giving full throttle. Tapping the throttle rod often releases it from sticking.

ACCIDENTS TO VALVES OR VALVE MOTION.

56. In the event of a slide valve yoke or stem becoming broken inside of the steam chest, how can the breakage be located?

A. After satisfying myself that the eccentrics and visible parts of the valve motion were intact, consider the type of valve on the engine. With a broken valve stem or yoke, the valve is always forced to the forward end of chest. With an outside admission piston valve or a slide valve, place the lever in the forward gear and watch the steam leaving the cylinder cocks. Reverse the lever, and if the steam issues from both cocks on one side and from only the back one on the other, the latter has the disabled valve.

With the inside admission, steam would issue from the front and not from the back cylinder cock. Where relief valves are used, remove them first and watch movement of valve.

57. After locating a breakage of this kind, how should one proceed to put the engine in safe running order?

A. If the engine had relief valves on front end of chest, disconnect valve rod; and, after forcing valve to central position to cover ports, clamp stem from one end and block with a plug driven into relief valve of sufficient length to hold valve in place, leave up main rod and proceed. If relief valve were on back end, the chest cover would not have to be taken up, but back end of main rod would have to be disconnected and crosshead blocked ahead. The disconnected valve rod would hold the valve against forward end of chest.

58. If a slide valve is broken, what can be done to run the engine on one side?

A. If it is a balanced valve and broken so that the steam ports cannot be successfully covered, slip a heavy piece of sheet iron between valve and valve seat, and block valve front and back. The balance plate will then come down solid on valve and prevent leakage to cylinder.

With the ordinary slide valve and similar conditions, remove valve entirely and block with hard wood, having the grain of the wood crosswise of the seat. With the sheet iron over the seat and the chest filled with blocking so that the cover will close down on it firmly and make a steam-tight joint, proceed on one side without disturbing anything except the valve rod.

59. What should be done in case of link saddle pin breaking?

A. Put the lever in a notch forward where one would be safe in starting a train. Then raise the link on the disabled side to the same level as the good one, and block between top of link block and link. Have another block ready of sufficient length to raise the link enough, should it be necessary to back up the engine.

60. With one link blocked up, what must be guarded against?

A. Reversing the engine, unless the disabled side has been changed by raising or lowering to correspond with the good side.

61. How can it be known if the eccentric has slipped?

A. By a lame exhaust, or with a bad slip, one of the exhausts disappearing entirely, and by watching the crosshead to note when the exhaust takes place.

62. Having determined which eccentric has slipped, how should it be reset?

A. Having located the eccentric, if it is a go-ahead, move the engine so that crosshead will come very near to the end of its travel ahead. Then move the eccentric around pointing in the opposite direction to the back-up, leaning either toward or from the pin—which would depend entirely on the style of valve and whether direct or indirect motion. As soon as steam appears at front cylinder cock, tighten set screws.

For back-up eccentric, lever and crosshead will have to be placed in the opposite direction. The best way is to mark eccentrics before starting, by placing the lever in forward notch and having crosshead at front end of travel. Then make a mark on crosshead and guide, doing the same with eccentrics and straps. If from any cause an eccentric slips and engine is placed so that mark on crosshead corresponds with that on guide, the marks on three of the eccentrics will correspond with those on straps, while the fourth or slipped eccentric's mark will be some distance away from mark on its strap. By this method an eccentric can be set as true as any machinist can set it, and there is no guesswork.

63. What should be done in case of a broken eccentric strap or rod?

A. Take down the other strap and rod, cover ports and leave main rod intact.

64. How should the engine be disconnected if a lower rocker arm becomes broken? If a link block pin?

A. Unless the link interferes, all that is necessary is to remove broken part of the arm, cover ports by placing valve in central position and leaving main rod up; otherwise the eccentric traps and rods would have to come down. With a broken link block pin, there is more or less danger of interference between link and rocker arm. Take down eccentric straps and rods only, and cover port.

ACCIDENTS TO RUNNING GEAR.

65. What should be considered a bad tender or engine truck wheel?

A. One with sharp flange, or flat or shelled-out spots in tread of wheel, 2½ inches or more in length.

66. What should be done if an engine truck wheel or axle breaks?

A. It should be entirely removed or blocked up so as to have the wheel clear of the rail, and the truck frame should be securely fastened to the engine frame with chains.

67. What should be done if a tender truck wheel or axle should break?

A. Pursue the same course as with the engine truck wheel and fasten the truck frame with chains to the tender frame. Move slowly and cautiously to a point where repairs can be made.

68. How should an engine be blocked for broken engine truck spring or equalizer? For broken tender truck spring?

A. If pilot will not be too low, let truck frame ride on boxes; otherwise, block between top of boxes and truck frame.

Blocking for a broken tender spring will vary according to the type of truck used. Some have a coil spring over each axle box and are easily taken care of; some have semi-elliptic springs with the spring band against the tender frame and the ends of spring resting on arch bar over axle boxes, while others have elliptic or coil springs supporting the truck bolster and resting on the sand plank. With the first block over the individual box; with the second, between truck bolster and tender frame; and with the third, between truck bolster and sand plank.

69. If it is not necessary to take down the main rod on disabled side of the engine, how would one arrange to lubricate the cylinders?

A. By removing indicator plugs, if the engine is equipped with them, oiling through them and replacing plugs.

If the engine has no plugs, shift valve just enough to show a little steam at cylinder cocks and oil with the lubricator.

70. What should be done if a driving spring, spring hanger or equalizer should break?

A. Remove broken parts and block over box affected by break; as to blocking equalizers properly, one would have to be governed by the type of spring rigging used.

71. How can an engine be moved if the reverse lever or reach rod were caught at short cut-off by a broken spring or hanger?

A. By disconnecting the tumbling shaft arm and blocking over link block pin with blocking that would permit sufficient power to be used to start train.

BLOWS THROUGH VALVES OR PISTONS.

72. How can a blowing of steam past a valve, cylinder, packing or valve strip be distinguished and located?

A. When the valve has been placed to cover both steam ports and no steam escapes from cylinder cock but escapes through exhaust port to stack, it indicates that valve strips are down or broken and permit steam to escape through small hole in valve to exhaust port.

If valve covers ports and steam appears at both cylinder cocks, it indicates a cut valve or seat.

If piston is at beginning of stroke and valve uncovered and steam escapes from cylinder cocks at opposite end also from which it is admitted, it indicates leaky packing rings or cut cylinder.

A valve blow continues during the entire travel of valve, while a cylinder blow is strongest when piston is at beginning of stroke and gradually diminishes until cut-off takes place as piston nears end of stroke.

73. If a simple engine should blow badly and be unable to start the train when on the right-hand dead center, on which side would be the blow, generally?

A. On the left side, since that is the only power the engine has to move the other side off the dead center.

LEAKY THROTTLE, STEAM PIPES OR DRY PIPE.

74. If the throttle were closed and steam came out of the cylinder cocks what might be the cause?

A. Leaky throttle or dry pipe.

75. Is it possible to distinguish between a leaky throttle and a leaky dry pipe?

A. Yes, a leaky throttle will show dry steam only, while with a leaky dry pipe more or less water will pass out of the cylinder cocks with the steam when the engine is standing, and when the engine is working she appears to be working water all the time.

76. What effect has leaky steam pipes, and how should they be tested?

A. They interfere with the draft on the fire and prevent the engine from making steam.

Place the lever in the center, set the air brake, open throttle and watch the joints of steam pipes top and bottom. The proper test is the hydraulic test made in the shop.

77. How should the test for a leaky exhaust pipe joint or a leaky nozzle joint be made?

A. By placing the lever forward or back and moving the engine slowly with brakes set, and watching the joints. Cinders never accumulate around such leaks and are always driven away from them.

78. How should hot bearings be treated?

A. They should be cooled down gradually, so as to prevent undue strain on the metal. The cause should be ascertained, whether defective lubrication or poor workmanship, in order to guard against a recurrence of the difficulty.

ACCIDENTS TO VARIOUS PARTS.

79. What should be done if a steam chest cracks?

A. If the crack is not too serious, temporary relief can be obtained by driving wedges between chest bolts and chest.

80. What should be done if a steam chest breaks?

A. That depends on the type. With the chest commonly used, take up the chest cover, insert blocking in the steam passages to chest and bolt the cover down firmly upon them.

81. If a link lifter or arm were broken what should be done?

A. Block the same as for broken link saddle pin.

82. If the reverse lever or reach rod should break, what should be done?

A. Follow the same method as for broken link saddle pin.

83. What should be done if the piston, crosshead, connecting rod, or crank pin is bent or broken?

A. If the piston is broken or the piston rod bent, remove both, disconnect valve stem only, and cover ports.

With a broken crosshead or bent or broken main rod, the main rod would have to come down. Then, push piston ahead or back—this depends on the type of engine—and shift valve to force steam against piston in the direction in which it was desired to hold the piston, clamp valve, and block the crosshead as an additional precaution.

With a broken crank pin the rod would not have to come down, but could rest on the yoke or guide. First ascertain in the case of a piston valve whether it is an inside or outside admission before shifting, as the movement of the former is directly opposite to that of the latter.

84. What should be done if a safety valve spring breaks?

A. Remove the spring and block between valve and cap, allowing the other valve to do the work.

85. How can an engine be brought in with a broken front end or stack?

A. By boarding up and by protecting it with the canvas curtain on the cab. Placing a barrel on smoke arch in lieu of a stack will answer the purpose, but on a road with heavy traffic such expedients are not practicable.

86. What should be done when a frame is broken between the main driver and cylinder?

A. The safest plan is to be towed in dead. The other alternative is to disconnect the disabled side and bring the engine in light, because an attempt to bring in part of the train might damage the previously uninjured side.

87. What should be done when there is a loose or lost cylinder key?

A. If the key is loose and can be shimmed up, it is safe to go on. If key is lost and nothing available in its place, disconnect that side to prevent further damage.

88. What should be done if a frame is broken back of main driver?

A. Take down side rods on both sides back of main driver and proceed.

89. In case of broken side rods, what should be done?

A. Take down corresponding rod on opposite side also, and, if it is a consolidation, mogul or 10-wheel engine, and the intermediate rod is broken, all side rods would have to come down.

90. What can be done if the intermediate side rods were broken on a consolidation engine, having the eccentric on the axle ahead of main wheel?

A. There is nothing to be done but be towed in, unless only one side is broken, when it would be possible to bring the engine in under her own steam on one side, with the disabled side having its valve disconnected and ports covered, but this is not advisable, inasmuch as the engine might slip and break the other intermediate rod and do incalculable damage. All side rods ahead of the intermediate on both sides would have to come down.

91. Should one of the forward tires of a 10-wheel engine break, what must be done to bring the engine in?

A. Run the wheel upon a wedge so as to clear the rail under all conditions; remove the oil cellar and fit a block in its place; then place another block between bottom of box and pedestal binder. Also block under the equalizers nearest the disabled wheel to take the weight off the journal.

92. What is a good method of raising a wheel when jacks are not available?

A. To run them up on frogs or wedges.

93. How can it be known whether the wedges are set up too tight and the driving box sticks, and in what manner can they be pulled down?

A. If the wedges are set up too tight, the boxes will heat, the engine will ride hard and have a rough, jerky, up-and-down motion.

Drawing down the wedge bolt snug and running the wheel upon blocks or wedges and off again will generally bring down a wedge as the box drops down. A little oil or kerosene between wedge and pedestal will often be a help.

REPORTING WORK TO BE DONE.

94. In reporting work on any wheel or truck on engine or tender, how should they be designated?

A. It should be designated as engine truck, driver or tender truck wheel, giving the exact location and side.

Some roads have adopted a method which prevents mistake, by numbering the wheels, beginning at the forward engine truck wheel on right side, going around the tender and ending with engine truck wheel on left side, in consecutive numbers, as wheel No. 1, No. 2, No. 3, etc. On an 8-wheel engine the right forward engine truck wheel would be designated No. 1, while the left forward would be No. 16, according to this system.

95. What are some of the various causes for pounds?

A. Wedges not properly adjusted, loose pedestal braces, lost motion between guides and crossheads, badly fitting driving brasses, improper keying of rod brasses, engine and rods out of tram, loose piston on rod or loose follower bolts.

96. How can a pound in driving box wedges or rod brasses be located?

A. By placing the right main pin on the upper forward eighth, which brings the left main pin to the upper back eighth. Then by blocking the drivers, giving the cylinders

a little steam and reversing the engine under pressure, both sides can be tested at the same time.

97. When should crossheads or guides be reported to be lined?

A. When there is sufficient lost motion between crosshead and guides to cause a jumping motion when the pin is leaving either dead center and the crosshead is beginning the return stroke.

98. When should driving box wedges be reported to be lined?

A. When the wedge has been forced up as high as it can go and lost motion appears between wedge and box. It should then be reported lined down. Lining up is sometimes reported by enginemen, but this is incorrect.

99. When should rod brasses be reported to be filed?

A. When there is sufficient lost motion to cause pounding.

100. When should rod brasses be reported to be lined?

A. When the key is down to a point where it cannot be forced down further to prevent brass working in strap.

101. When should lost motion between engine and tender be taken up?

A. When there is ¼ in. or more lost motion between engine and tender, causing an undue strain on the draw-bar, by the forward and backward lurching of the engine while in motion, or the forward lurch in starting. It also causes severe strain on draft rods.

HOW THE INJECTOR WORKS.

102. Describe the principle on which an injector works.

A. The principle on which an injector works is a combination of forces, velocity and an induced current of water passing through suitably proportioned tubes, designated as steam nozzle, combining tube and delivery nozzle. Under a given pressure the velocity of escaping steam is much greater than that of water, which would be ejected were a hole opened in the boiler below the water line. The reduced orifice in the steam nozzle naturally increases the velocity of the escaping steam as it enters the combining tube where it entrains the feed water and condenses. As the escaping steam is being condensed it has lost none of its velocity except that due to friction of the pipes through which it passes, consequently it has a vastly greater penetrating force after condensation than the resisting force in the boiler. Leaving the combining tube, the condensed steam and feed water now pass through the delivery nozzle into the branch pipe, where the ram-like force imparted to the water by the velocity of the escaping steam unseats the boiler check and permits the free flow of water to the boiler.

103. What is generally the cause of failure of the second injector, and what should be done to obviate this failure?

A. Infrequent use causes the various parts to corrode and check to lime over and stick. Frequent use and a trial before starting on trip will guard against such failures.

104. What are the advantages of the combination boiler check?

A. It reduces the number of boiler check and injector failures.

105. If an injector stops working while on the road what should be done?

A. First ascertain the cause before applying the remedy. It may be due to a disconnected and closed tank valve, clogged strainers, loose coupling in feed pipe, which destroys the vacuum necessary to raise the water when starting a lifting injector, stuck check, etc.

106. How can a disconnected tank valve be opened without stopping?

A. By closing the heater valve and forcing the steam from injector back into tank to dislodge valve.

STEAM HEATING.

107. If the steam heat gauge showed the required pressure, and cars were not being heated properly, how should one proceed to locate the trouble?

A. First make sure that the connections on the cars were all coupled and their respective valves opened to the rear end of train. If no steam appeared at rear car, examine each angle cock or valve, and, if these were open, look for the trouble at the regulator reducing valve.

108. How does the steam heat reducing valve control the pressure?

A. By suitably adjusted springs and valves which restrict the steam passages in proportion to the amount of tension of the springs exerted upon the valves.

ABUSE OF AN ENGINE.

109. What constitutes abuse of an engine?

A. Improper care, working at a longer cut-off than necessary, pumping the water irregularly or in greater quantities than required.

110. How are accidents and breakdowns best prevented?

A. By frequent and careful inspection before starting and during each trip.

111. What are the duties to be performed by an engineman when giving up his engine at the terminal?

A. To thoroughly inspect the engine and report all defects in an intelligent manner.

112. In what manner should an engine be inspected after arrival at terminal?

A. All running gear, frames, cylinders, saddles, bolts, wheels, firebox, smoke arch and any other parts of the engine should be thoroughly examined and all defects correctly reported. No superficial examination is sufficient.

113. In reporting work on an engine, is it sufficient to do it in a general way, such as saying, "Injector won't

work"; "Lubricator won't work"; "Pump won't work"; "Engine blows," etc.?

A. No; he should be explicit and assign a cause for every failure, so as to assist the shop force in remedying the defect.

FIRE-BOX QUESTIONS.

114. What causes the drumming sound sometimes heard in the fire-box of a soft coal burning locomotive?

A. The combination of the combustion gases in a form that makes a series of minute explosions creating the drumming sound.

115. How can the disagreeable noise be stopped?

A. By closing a damper or putting the fire door on the latch.

116. What are the principal causes that prevent a locomotive boiler from steaming freely?

A. Badly adjusted draft appliances, leaky joints in steam pipes, tubes choked up, too much piston clearance, valves and piston packing blowing, and irregular boiler feeding or inferior firing, and poor fuel.

PERIODS OF EXHAUST

117. How often does an ordinary locomotive exhaust steam during a revolution of the driving wheels, and at what periods do the exhausts take place?

A. Four times. Beginning with the right hand piston moving from the forward center and the left crank set one-quarter behind the right hand crank. When the right hand crosshead has moved back to nearly the middle of the guides, the left hand exhausts on forward stroke; when the right hand crosshead reaches close to back of guides, the right hand cylinder exhausts on backward stroke; when the crosshead returning reaches near the middle of the guides, the left hand cylinder exhausts on backward stroke, and when the crosshead reaches close to the forward end of the

guides, the right hand cylinder exhausts on the forward stroke. That completes the cycle.

PHILOSOPHY OF COMMON THINGS.

1. What is matter?

A. Everything that occupies space: solids, liquids and gases; otherwise earth, water and air are classed as matter.

2. Describe the leading properties of a solid.

A. A substance that adheres strongly enough to oppose decided resistance to fracture, impression or penetration by other bodies.

3. What are the leading properties of a liquid?

A. The coherence of the particles are so slight that they can move about with little resistance and are easily permeated by more rigid substances.

4. What are the leading features of aeriform or gaseous matter?

A. It exists in such an attenuated condition that the particles repel each other, tending to separate and spread out indefinitely as in the case of unconfined steam.

5. What is a body?

A. It is a unit of matter either solid, liquid or gaseous.

6. Do solid, liquid and aeriform bodies always remain in the same condition?

A. No. All substances change under the forces of heat and cold. Heat will convert the most refractory solid into a gas, and cold and pressure will solidify the lightest gas.

7. What is a fluid?

A. Liquids and gases are classed as fluids.

8. What are the essential properties of bodies?

A. Impenetrability, Extension, Figure, Divisibility, Inertia, Porosity, Indestructibility, Compressibility, Expansibility, Mobility, Gravitation, Cohesion, Adhesion, Hardness, Tenacity, Elasticity, Brittleness, Malleability and Durability.

9. Define impenetrability.

A. That property which bodies have of occupying a certain space, so that where one body is another cannot be without displacing the first one.

10. What is extension?

A. The property of occupying a certain space—length, breadth and depth, which are called the dimensions of extension.

11. What is meant by figure?

A. The shape taken by any body.

12. Define divisibility?

A. The susceptibility of matter for dividing into minute parts. This peculiarity is most noticeable in the vast particles of coloring that proceeds from a grain of the substance and in the immense range of perfumes and odors.

13. What are the properties of inertia?

A. Inertia is the tendency of a body to remain at rest or in uniform motion unless interfered with by outside forces. Inertia keep the train at rest until the engine starts it, then the same tendency keeps it moving after steam is shut off, and it is brought to rest by the outside forces of friction, otherwise it would go on forever. The friction may come from brakes, the track, the atmosphere and from a variety of other sources.

14. What is meant by the term porosity?

A. Owing to the atomic arrangement of the particles of bodies there are small channels or interstices between the more solid parts which are called pores. All substances are porous, but in metals and some rocks the pores are so minute that they can be detected only by the most powerful microscopes.

15. What is that property of matter known as indestructibility?

A. It is the peculiarity which makes all bodies incapable of being destroyed. Wood or coal may be burned, water may be evaporated and sugar may be melted, but no atom of their elements has been destroyed. They merely assume new forms.

16. What is the compressibility of matter?

A. The property possessed by all matter of being squeezed into smaller size. It is the closing up of the pores in solid bodies and the pushing of the particles into closer contact in gases. The working of an air pump illustrates how easily air is compressed. The forcing of bolts into close-fitting holes illustrates the compression of metals. Cold compresses nearly all substances.

17. What is the expansibility of matter?

A. In a general way it may be regarded as the reverse of compressibility.

18. What is the meaning of the term mobility?

A. It is the property which renders the shape of a body capable of being readily changed. Water, for instance, is highly mobile because it can be easily moved about in its bed or vessel, although it is practically incompressible.

19. What is gravitation?

A. It is a force or tendency in every body to attract other bodies to itself. The attraction of the earth is the best example of gravitation, but all other bodies possess the same attribute in proportion to their mass.

SECTION IV

Questions and Answers on Compound Locomotives.

1. Wherein do compound locomotives differ from ordinary or simple engines?

A. Compound locomotives differ from the ordinary type in that a simple engine has but one set of cylinders of the same diameter and uses the steam but once, while a compound or double expansion engine has either two or four cylinders of varying diameters, and the steam, after passing through the first set and losing part of its energy, passes into the second set of cylinders, where a certain amount of its remaining energy is used.

2. Why is one cylinder on a compound locomotive called the high-pressure cylinder and the other one the low-pressure cylinder?

A. Because the high-pressure cylinder takes its steam directly from the boiler at nearly initial boiler pressure, while the low-pressure cylinder, under ordinary conditions, receives the steam from the high-pressure cylinder only and at a greatly reduced pressure.

3. What is the principal advantage claimed for compound locomotives?

A. Economy in the consumption of fuel and water. A compound engine in good order and properly operated does more work with a given volume of steam than a simple engine.

4. In the Schenectady two-cylinder compound what is the duty of the oil dash pot?

A. The duty of the oil dash pot in the Schenectady compound is to insure a steady movement of the valve without shock.

5. Is it necessary to know that the oil dash pot contains sufficient oil, and why?

A. The oil dash pot should be kept full of engine oil to prevent intercepting valve from slamming. Failure or breakage of intercepting valve can nearly always be traced to lack of oil in dash pot.

6. Explain how a Schenectady two-cylinder compound may be operated as a simple engine?

A. To operate the Schenectady compound (two-cylinder) as a simple engine, the handle of the three-way cock in the cab is moved by the engineer so as to admit either air or steam pressure into the pipe which connects with one end of the separate exhaust valve chamber, forcing the separate exhaust valve, which is otherwise held in normal position by a spring from right to left and in the direction of the intercepting valve. Then, as the throttle is opened, steam is admitted directly from the boiler into the passage which communicates with the intercepting valve, forcing the valve from left to right and permitting the steam to pass through it, and leaving it through suitable ports and passages, whence it passes through the reducing valve to the low-pressure steam chest. At the same time steam is admitted directly from the steam pipe to the high-pressure cylinder. Steam is exhausted directly from the high-pressure cylinder to the atmosphere through the receiver and separate exhaust passage, while steam from the low-pressure is exhausted directly to the atmosphere.

7. When should a Schenectady compound be operated as a simple engine?

A. Only at very slow speeds, when there is danger of stalling, and in starting very heavy trains.

8. Why not operate as simple when running faster?

A. Because it would mean not only a waste of steam and greater consumption of fuel, but also a greater and unnecessary wear and strain to the machinery.

9. Explain how the two-cylinder compound engine is changed from simple to compound.

A. To change a two-cylinder compound from simple to compound, the three-way cock would have to be returned to the normal position, which permits the pressure to be withdrawn from the piston head of the separate exhaust valve. As this pressure is exhausted to the atmosphere, the compressed spring is released and forces the separate exhaust valve to normal position, closing communication. The pressure in the receiver, due to the exhaust from the high-pressure cylinder, will rise and force the intercepting valve to the left, which opens the passage for the exhaust steam from the high-pressure cylinder through the receiver to the low-pressure steam chest. The movement of the intercepting valve to the left shuts off the live steam between the boiler and the low-pressure steam chest.

10. What moves the intercepting valve in a two-cylinder compound?

A. The intercepting valve is automatically operated by the steam pressure exerted upon it, due to the difference in areas of the end of the valve.

11. How should a compound locomotive be lubricated?

A. Two-thirds of the allowance for cylinder lubrication should be fed to the high-pressure cylinder while using steam. When drifting long distances this rule should be reversed, owing to the greater surface exposed in the low-pressure cylinder and the imperfect distribution of oil due to the absence of steam from the cylinders.

12. Why feed more oil to a high than to a low pressure cylinder?

A. Because part of the oil fed to the high-pressure cylinder is carried along with the steam to the low-pressure cylinder, and the high pressure of steam in the high-pressure cylinder causes more friction than exists in the low-pressure cylinder, and the greater the pressure the greater the friction, and consequently more oil is needed to counteract that friction. Because the higher temperature and pressure in the high-pressure cylinder produce more friction, therefore more oil is required for perfect lubrication, and as a certain amount of the oil fed to the high-pressure cylinder is carried along with the steam to the low-pressure cylinder, less need be fed directly to the low-pressure cylinder.

13. How much water should be carried in a boiler of a compound locomotive?

A. Just enough to guarantee absolute safety from overheating the fire box under all conditions of service.

14. Why should no more than the amount which you answer for the preceding question be carried in the boiler of a compound locomotive?

A. In order to assure the delivery of dry steam to the cylinders, as wet steam is particularly injurious to compound locomotives.

15. How should a compound locomotive be started with a long train?

A. Always in simple position.

16. When drifting, what should be the position of the separate exhaust valve, cylinder and port cocks?

A. In drifting, the three-way cock in cab should be in the same position as when working the engine simple, which causes the separate exhaust valve to open. The cylinder and port cock should also be open.

17. What will cause two exhausts of air to blow from the three-way cock when the engine is being changed to compound?

A. A weak separate exhaust valve spring or the exhaust valve itself sticking.

18. What does steam blowing at the three-way cock indicate?

A. A leaky separate exhaust valve seat and steam passing by the exhaust valve piston packing rings.

19. What can be done if the engine will not operate as compound when air pressure on the separate exhaust valve is released by the three-way cock?

A. This indicates that the separate exhaust valve is stuck and communication with the separate exhaust valve has not been closed. A small quantity of headlight oil admitted through the oil plug at the three-way cock and forced to the separate exhaust valve, repeating the operation shortly after with cylinder oil, will generally release the valve.

20. If the engine stands with the high-pressure side on the dead center and will not move when given steam, where is the trouble and what may be done to start the engine?

A. The trouble is due either to a stuck intercepting or reducing valve which prevents direct communication between the boiler and low-pressure cylinder. The position of the intercepting valve stem will indicate which valve is sticking. If the stem extends clear out, it would be the intercepting valve; and, unless some of the posts were broken a light tap on the end of the stem after the throttle is open will send it ahead. If the stem protrudes only a few inches, it will be the reducing valve that is sticking. Usually a few sharp blows on the intercepting valve back head with the throttle open will dislodge it, and direct communication between the boiler and the low-pressure cylinder will be again established.

21. Give reason for your reply to the preceding question.

A. Since the intercepting and reducing valves by their relative positions to the openings in their valve chambers control or prevent the free admission of steam from the boiler to the low-pressure cylinder direct, anything that prevents the free movement of either valve renders both of them inoperative. If the admission of steam into the passage connecting with the intercepting valve cannot move it from its normal position, direct communication between the boiler and low-pressure cylinder cannot be established, and the greatly reduced power conveyed from the high into the low-pressure cylinder is entirely inadequate to move the engine.

22. In the event of a breakdown, how should one disconnect?

A. Open the separate exhaust valve as when running simple; then block, cover ports, and disconnect the same as with a single expansion engine.

23. What may be done to shut off steam pressure from the steam chest and low-pressure cylinder?

A. The separate exhaust valve and intercepting valve should be placed in position to allow the engine to work as a single expansion engine.

24. Is it important that air be pumped up on a Schenectady two-cylinder compound locomotive before the engine is moved?

A. Yes, very important.

25. Why?

A. To insure a sufficient amount of air pressure to operate the separate exhaust valve so that the engine can be operated as a single expansion.

26. How are blows in a compound located?

A. That depends entirely on the type. To locate blows or leaks through valves or cylinder packing on two-cylinder compounds, tests are made precisely as with a single expansion engine. Engine should be worked simply—as a simple engine—while testing for such blows. To test blows in intercepting valve, place right-hand crank pin on top quarter and the reverse lever in the center of sector, close intercepting valve and open separate exhaust valve as when working simple. Steam will pass through the separate exhaust valve and appear at the exhaust nozzle, if the intercepting valve blows.

27. To what ports are the by-pass valves connected and why are they used?

A. To the steam ports, and they furnish communication between steam chest and steam ports in cylinder. They are used to relieve the cylinder from excessive back pressure when drifting.

28. Why are certain four-cylinder Schenectady compound locomotives in service called tandem compounds?

A. Because the high-pressure cylinder is ahead of and connected with the low-pressure cylinder, and both pistons are operated by the same piston rod.

29. Does the steam in a tandem compound locomotive exhaust from left to right cylinders in a similar manner to the cross compound?

A. No, the steam from the high pressure passes over to the low pressure on the same side.

30. Are the valves on a tandem compound locomotive designed to give outside or inside admission of steam?

A. The valves on a tandem are designed for both inside and outside admission.

31. What arrangement of steam ports have these engines, so that an outside and an inside admission valve may be operated by one valve?

A. On the high-pressure cylinder the valves are arranged for internal admission, and the steam ports in the high-pressure cylinder are crossed. On the low-pressure, the valves are arranged for external admission and the steam ports are those in use on the ordinary type.

32. Trace the course of the steam from the high-pressure valve to the atmosphere when working compound?

O. Since both valves operate on one stem, and as the high-pressure valve is internal and the low-pressure external admission, the ports in the high-pressure cylinder must necessarily be crossed, so that when live steam is admitted to one end of the high-pressure cylinder the exhaust from the opposite end of the high-pressure can pass over into the low-pressure cylinder to exert its energy in the same direction and in unison with the high-pressure.

Steam leaving the high-pressure valve and entering the back port in the high-pressure cylinder flows to the forward end of the cylinder, forcing the piston back. After spending its force it is exhausted to the high-pressure steam chest, passing through the center of the hollow high-pressure valve to the outer back edge of the low-pressure valve, enters the back end of the low-pressure cylinder, and after spending its force escapes through the exhaust port of the low-pressure valve directly to the atmosphere.

33. When and how may a tandem compound be operated as a simple engine?

A. Only in starting or when there is a possibility of stalling. It can only be operated as a simple engine when the starting valve is used.

34. What steam passages have communication with the starting valve?

A. The high-pressure steam ports and the passages surrounding the by-pass valve.

35. How does manipulation of the starting valves cause the engine to operate as simple?

A. The starting valve, which is operated by a lever in the cab, admits live steam directly to the low-pressure cylinder in the following manner: Steam is admitted to the high-pressure steam chest through the short steam pipe connecting saddle and chest, passing through suitable ports and around by-pass valves which register with the high-pressure steam ports. The by-pass valves are held against their seats by the pressure from below, which is in direct communication with the chest. The starting valve, having thus established communication with both high-pressure steam ports, steam passes through both hollow piston valves and is admitted to the low-pressure cylinder.

36. What other valves are in the starting valve casting?

A. The by-pass valve.

37. How many sight feeds to lubricators of a tandem compound, and what do they lubricate?

A. There are two lubricators each with a double sight feed and each sight feed lubricating only one of the four valves and pistons.

38. How should the oil used be distributed?

A. When the engine is working, the high-pressure should receive the greater and the low-pressure the lesser quantity, and when drifting these proportions should be reversed.

39. How should a Schenectady tandem compound be disconnected, in case of a breakdown on the road?

A. Just the same as a simple engine with reference to blocking crossheads, covering ports, etc.

Baldwin or Vauclain Compound.

On June 25, 1889, a patent was granted to Samuel M. Vauclain, of Philadelphia, for a four-cylinder type of engines. Cylinders were parallel and pistons were connected to one cross-head. One patent shows two piston valves, another shows but one, which is the style now used and known as either the "Vauclain" or "Baldwin" type.

This engine has four cylinders, two on each side, and pistons on each side are coupled to one cross-head. The ratio of volumes is as near 3 to 1 as convenient dimensions will allow. The low pressure cylinder is placed

either above or below high pressure, according to design of engine.

They are cast in one piece with the valve-chamber and saddle, the cylinders being in the same vertical plane, and as close together as they can be with adequate walls between them.

As the steam-chest must have the necessary steam passages cast in it and dressed accurately to the required sizes, the main passages in the cylinder casting leading thereto are cast wider than the finished ports. The steam-chest is bored out enough larger than the diameter of the valve to permit the use of a hard cast-iron bushing. This bushing is forced into the steam-chest under such pressure as to prevent the escape of steam from one steam passage to another except by the action of the valve.

As the supply for the high-pressure cylinder enters the steam-chest at both ends, the valve is in perfect balance, except the slight variation caused by the area of the valve-stem at the back end. This variation is an advantage in case the valve or its connection to the valve-rod should be broken, as it holds them together. Cases are reported where compound locomotives of this system have hauled passenger trains long distances with broken valve stems and broken valves, the parts being kept in their proper relation when running by the compression due to the variation mentioned. To avoid the possibility of breaking, it is the present practice to pass the valve-stem through the valve and secure it by a nut on the front end.

Cast-iron packing rings are fitted to the valve and constitute the edges of the valve. They are prevented from entering the steam-ports when the valve is in motion by the narrow bridge across the steam-ports of the bushing.

When the low-pressure cylinder is on top, the double front rail prevents the use of the ordinary rocker-shaft and box, and the valve motion is then what is called "direct acting," changing the location of the eccentrics on the axle in relation to the crank pin. When the low-pressure cylinder is underneath, the rocker-shaft is employed, and the eccentrics are placed in the usual position; the valve motion is termed "indirect acting." Great care should be taken by mechanics, when setting the valves on these locomotives, to observe this difference and not get the eccentrics improperly located on the axle. If the crank pin is placed on the forward center, the eccentric-rods will not be crossed when the rocker-arm or indirect motion is used, but will be crossed when no rocker-arm or direct motion is used. Serious complications have arisen from this being disregarded.

As is usual in all engines, air valves are placed in the main steam passage of the high-pressure cylinder. Additional air valves are placed in the steam passages of the low-pressure cylinders to supply them with sufficient air to prevent the formation of a vacuum, which would draw cinders into the steam-chest and cylinders.

Water relief valves are applied to the low-pressure cylinders, and attach to the front and back cylinder heads, to prevent the rupture of the cylinder in case the engineer should permit the cylinders to be charged with water, or to relieve excessive pressure of any kind.

In all other respects the locomotive is the same as the ordinary single-expansion locomotive.

Steam from boiler comes to passage marked "inlet." With valve as shown, steam is admitted at right to high pressure cylinder. At the same time the other end of cylinder is in connection with interior of valve so that exhaust comes through center of valve to right hand end of low pressure cylinder. The other end of low is in open to exhaust by outside cavity of valve. When valve is at the left, this is reversed and a little study of the drawing will make the action clear.

It is obvious that in starting these locomotives with full trains from a state of rest, it is necessary to admit steam to the low-pressure cylinder as well as to the high-pressure cylinder, which is accomplished by the use of a starting valve. This is merely a by-pass valve, which is opened to admit steam to pass from one end of the high-pressure cylinder to the other end and thence through exhaust to the low-pressure cylinder. This is shown at B in Fig. 3. The same cock acts as a cylinder cock for the high-pressure cylinder and is operated by the same lever that operates the ordinary cylinder cocks, thus making a simple and efficient device, and one that need not become disarranged. This valve should be kept shut as much as possible, as its indiscriminate use reduces the economy and makes the locomotive "logy."

Suggestions for Running a Vauclain Four-Cylinder Compound Locomotive.

It is not surprising, in view of their differences of opinion respecting single-expansion locomotives, that there has been much controversy among engineers and firemen in regard to the operation of compound locomotives of this system. The first thing the engineer must learn is to use the reverse lever for what it is intended; that is, he must not hesitate to move it forward when ascending a grade if the locomotive shows signs of slowing up. The reverse quadrant is always so made that it is impossible to cut off steam in the high-pressure cylinder at less than half stroke, which avoids the damage that might ensue from excessive compression. It is perfectly practicable to operate the engine at any position of the reverse lever between half stroke and full stroke without serious injury to the fire, since when this engine is operated at full stroke compound, by reason of the cylinder ratio employed, steam is expanded to about the same extent as when a simple engine is worked at 1-3 cut off.

When starting the locomotive from a state of rest, the engineer should always open the cylinder cocks to relieve the cylinders of condensation; and as the starting valve is attached to the cylinder cocks, this movement also admits steam to the low-pressure cylinder and enables the locomotive to start quickly and freely. In case the locomotive is attached to a passenger train and standing in a crowded station, or in some position where it is undesirable to open the cylinder cocks, the engineer should move the cylinder cock lever in position to permit live steam to pass by into the low-pressure cylinder, thus enabling the locomotive to start quickly and uniformly without any jerking motion. After a few revolutions have been made and the cylinders are free from water caused by condensation or priming, the engineer should move the cylinder cock lever into the central position, causing the engine to work compound entirely. This should be done before the reverse lever is disturbed from its full gear position. The reverse lever should never be "hooked up," thereby shortening the travel of the valve, until after the cylinder cock lever has been placed in the central position. It is often necessary to open the cylinder cocks when at full speed, to allow water to escape from the cylinders, especially when the engineer is what is commonly called a "high-water" man; in such cases no disadvantage is experienced and the reverse lever need not be disturbed.

As the economy of a compound locomotive depends largely on its greater range of expansion, the engineer should bear in mind that in order to get the best results he must use the reverse lever. After the starting-valve is closed and as the speed of the train increases, the reverse lever should be hooked back a few notches at a time until the full power of the locomotive is developed. If after moving the reverse lever to the last notch, which cuts off the steam at about half stroke in the high-pressure cylinder, it is found that the locomotive develops more

power than is required, the throttle must be partially closed and the flow of steam to the cylinder reduced. On slightly descending grades the steam may be throttled very close, allowing just enough in the cylinders to keep the air-valve closed. If the descent is such as to prevent the use of steam, close the throttle and move the reverse lever gradually to the forward notch and move the starting-valve lever to its full backward position. This allows the air to circulate either way through the starting-valve from one side of the piston to the other, relieves the vacuum, and prevents the oil from being blown out of the cylinder. On ascending grades, with heavy loads, as the speed decreases, the reverse lever should be moved forward sufficiently to keep up the required speed; as it is better to keep the speed than to lose it and then accelerate again. If, after the reverse lever is placed in the full forward notch, the speed still decreases and there is danger of stalling, the starting-valve may be used, admitting steam to the low-pressure cylinders. This should be done only in cases of emergency and the valve closed as soon as the difficulty is overcome.

The starting device should not be used for any purpose other than the "starting" of the train. After the train is in motion it should not be used. Cases have been observed where the engineers use it all the time and have the reverse lever "hooked up" in the top notch (half stroke), in consequence of which the locomotive will slow down to a low speed while burning an excessive amount of coal. Such running must result in general dissatisfaction.

The starting device is useful in emergencies; as, for instance, when stalling with a heavy train on a grade, if live steam is admitted to the low-pressure cylinder, sufficient additional power is obtained to start the train and take it over the grade. This should be resorted to only in emergencies, and allowance should be made for the extra repairs caused by frequent cases of this kind.

On account of the very mild exhaust, the fireman should carry the fire as light as possible. A little practice will enable him to judge how to get along with the least amount of fuel.

It is also noticeable that the water rate per horse-power varies very little on the compound locomotive when the reverse lever is moved towards full gear or longer cut-off; but in the single expansion engine it increases rapidly, causing engineers to remark that they cannot "drop her a notch" on account of "getting away with the water." This does not occur with the compound locomotive when the reverse lever is moved forward towards full gear, and no engineer should open the pass-by valve, admitting live steam to the low-pressure cylinder, until the last notch has been used on the quadrant and the engine is about to stall.

It is also desirable to move the reverse lever forward a notch before the locomotive slows down too much, as it is better to preserve the momentum of the train than to slow down and again have the trouble of accelerating. In this way both coal and water are wasted. If these instructions are observed, the locomotive will work satisfactorily.

Blows in Baldwin Compounds.

In the first place, it is essential to know whether there is a blow or not, and then to locate it. We do not mean a pound, but the leakage of steam past the various packing rings in the valve chambers and cylinders.

A peculiarity of certain blows in a Baldwin compound is that they may readily (and often are by the beginner in handling this type of engine) taken to be the result of some mishap to the valve motion, causing the engine to go lame. For this reason we say that it is essential

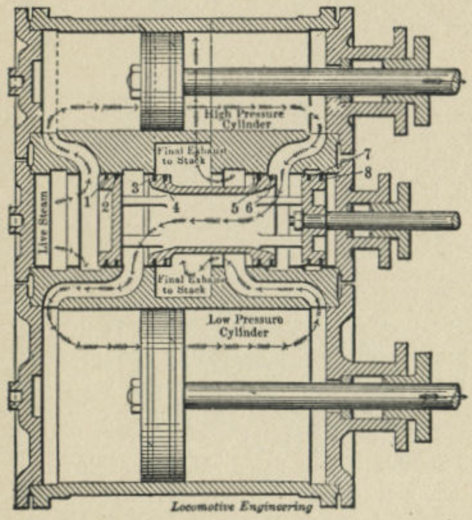
to know whether there is a blow or not, and a little careful inspection on the part of an engineer will soon determine this. When a lameness is heard in the exhaust the engineer should carefully note each exhaust when the engine is working slowly, and determine at what points the inequality or lameness occurs. If the engine has two equal exhausts and one very heavy and one very light, or goes on three legs as we say, the probability is that we have a slipped eccentric, a loose strap, a bent blade, or some mishap to the motion which would cause the lameness, any one of which will be detected by a careful inspection of the motion.

If the exhaust shows an alternate heavy and light one, we may safely conclude the trouble to be in the valve or cylinder packing, or in the starting valve. If in the latter it is caused by the rods and levers being of improper length, due to striking some obstruction along the track and bending them, causing the starting valve to stand other than central when the cylinder cock lever is in compound position, and allowing live steam to enter low pressure cylinder. If by putting lever in live steam (extreme back position) this inequality disappears, it will indicate the trouble to be in the starting valve connections.

If we do not find that the inequality in the exhaust disappears by this operation we may reasonably conclude that the trouble lies in the packing, though not positively so, as the movement of the lever may have closed the valve on the defective side and opened the one on the other, still giving an unequal exhaust, but in reverse order. This would, no doubt, be noticed by the observant engineer, who could further satisfy himself by getting down and examining the position of the starting valve lever, which should stand perpendicular to the rail when the cylinder cock lever is in central position. If found all right, we may safely conclude the trouble to be in the valve or cylinder packing. But which?

The alternate light and heavy exhaust before referred to may be due to one of two conditions when not caused by starting valve out of order, and the first thing to do is to determine which condition is present, though it is possible for both to be.

In the accompanying sketch the left cylinders and chamber are shown, as laid out by the builders in their



CYLINDER OF VAUCLAIN COMPOUND LOCOMOTIVE.

instruction book. For clearness in illustration the valve chamber is shown between the high and low pressure cylinders instead of behind one or the other, as in actual arrangement. The engine is nearing the quarter, and the valve, working full stroke, has traveled off the ports. Now, with the starting valve closed, open the throttle and admit steam to the high pressure cylinder, reverse the engine,

and we have live steam in both ends of the high pressure cylinder and in the back end of the low pressure. Now get down and raise the front cylinder cock, and if steam blows in any considerable quantity it will indicate low pressure packing or inside valve rings, 3 and 4 or 5 and 6, blowing. If by putting reverse lever in center notch, thus covering ports, the blow continues, it will indicate that *valve* rings are leaking, while if the blow ceases it is the cylinder packing. Of course, if the blow continues with the ports covered, both the valve rings and cylinder packing might be leaking, but this is an unlikely condition, and we have never seen such a case. This test is similar to the test for cylinder packing blowing in a simple engine.

Now to test the high pressure packing. With the engine in the position shown, admit steam to the front end of the high pressure cylinder, keeping the starting valve in central (compound) position. Now slack off the union nuts in the live steam pipe at each end of the high pressure cylinder, and if steam appears at each opening thus made it will show that high pressure packing or valve rings 1 and 2 or 7 and 8 are leaking. If the blow stops by putting the reverse lever on the center it will indicate high pressure cylinder packing blowing; if it continues then the valve rings are probably leaking, though, as in the case of the low pressure, it may be both, but is not at all likely. If the blow continues from but one end, it is the valve rings on that end. This latter might also be said of the low pressure test. If we raise both cylinder cocks in the trial and steam comes from but one end with the valve central, of course in this case it is understood to be the inside rings 3 and 4 or 5 and 6.

There are several other combinations of valve ring blows which might be possible, but the above are the most frequent, so we will not mention the others for fear of confusion.

In the foregoing we have taken the trouble to have been located on the left side. When a blow occurs in actual practice it is difficult for the beginner, and even an experienced runner may make a mistake in locating the blow on the proper side of the engine. A little careful observation will, however, enable one to do this accurately.

When the irregularity in the exhaust is first noticed let the engineer decide whether his engine is made strong or weak by the defect. If stronger, the trouble is on the side from which the heavy exhaust comes; if weaker, it is from the side of the weak exhaust.

When cylinders are provided with indicator plugs it will be more convenient to remove them than loosening the union nuts in the live steam pipes in testing high pressure packing.

The presence of broken pieces of packing in the cylinder cocks, causing them to stick up, is pretty sure indication of defective valve packing on that side, as the many ports in the valve chamber bushing, together with the eight packing rings on the valve, present many more chances for breakage than are present in the cylinders. In the majority of cases the trouble will be found in the valve packing, and in making examinations when there is a case of doubt the valve should be examined first, as it is less trouble to pull, and the defect is more apt to be found there.

The live steam pipe, midway in which the starting valve is located, is tapped into the steam way leading from the valve chamber to the high pressure cylinder at either end, and when we pull the lever clear back we allow some of the live steam from the receiving end of the high pressure cylinder to flow around to the other end and take the course of the exhaust steam to the low pressure cylinder, and the amount of power gained thereby increases as the speed decreases, due to the longer time given for the small inch pipe to carry the live steam to the large cylinder. When the starting valve lever is central this valve

is closed, and only exhaust steam from the high pressure cylinder goes to the low. In the extreme forward position the valve is opened to the atmosphere, as well as opening communication between the ends of the high pressure cylinder, thus acting as a drain or cylinder cock to the high pressure cylinder, and the cylinder cocks are also opened in the low pressure cylinder.

Repairs to Baldwin Four-Cylinder Compound.

On account of the great similarity to single-expansion locomotives, mechanics familiar with the latter have no difficulty in understanding these compound locomotives.

The cross-heads, when badly worn, may, in a short time, be retinned by any coppersmith; in fact, an ordinary laborer can be taught this in a few days. The cross-head is heated warm enough to melt solder, and is then cleaned and wiped with solder, using dilute muriatic acid, such as tinsmiths use in soldering. Block tin is then poured against the surfaces so prepared, to which it adheres. A piece of iron placed alongside the cross-head can be used to regulate the thickness.

The cross-head is then put on a planer to true it up, care being used not to let the tool "dig in" and tear off the tin.

The pistons are treated the same as in ordinary single-expansion engines. The packing-rings in the low-pressure cylinder require renewal more frequently than those in high-pressure cylinders. It is also more difficult in compound cylinders to detect faulty packing-rings, and they are sometimes noticed only by the locomotive failing in steam and in not making time on the road.

The piston-valves should last a long time if properly lubricated, but when the bushing and valve are worn enough to require attention, the bushing should be bored out and new rings put in the valve; very often it is not necessary to bore the bushing; merely to put new packing-rings in the valve.

After the bushings have been bored several times, larger valves may be fitted to them so as to have as little play as possible. A very convenient type of boring bar for boring out the bushings has been designed, by which the work can be done without taking down the back head of the steam-chest. It is possible with this tool to bore out the bushings in less time than required to face a valve seat on a single-expansion locomotive.

If both high-pressure piston rods or heads break, remove pistons, drive wooden plugs into piston rod holes from inside and put up front cylinder heads, and proceed light.

If one high pressure-front cylinder head is broken, disconnect valve stem from valve rod on that side, place valve central, to cover ports and clamp valve, same as with simple engine; disconnect main rod and block cross head, same as simple engine.

With one or both low-pressure pistons broken, proceed as to plug piston-rod holes as with high pressure; replace front cylinder head. Place starting valve lever in compound position and proceed light.

If both low-pressure cylinders are broken, run as simple engine, with starting valve in compound position.

There have been several cases of low-pressure piston breaking off and not giving evidence enough to call the engineer's attention to it. There are two indications, of this however; the engine becomes deficient in power and the exhaust would be as though the valves were not set properly.

When extracting old bushings, it is best to split them with a narrow cape chisel—they are only fit for scrap when removed, and can be much more quickly removed this way than to attempt to draw them out with draw screws.

Enough attention should be given the starting valves to

insure their moving in harmony with each other. Engineers sometimes strain the cylinder cock shaft, which causes one starting valve to open and the other to remain shut; this causes the exhaust to beat unevenly, and the engineer is apt to complain that the valves are out of square. Before altering the valve motion on these engines, make sure that the starting valves open and close simultaneously, and examine low-pressure pistons and piston valve for broken packing-rings. In one case an engineer ran his locomotive two days without any piston-head on one of the low-pressure pistons, and even then could not tell what was the matter, only that the locomotive sounded "lame" and did not make good time with the train. Men were put to work to locate the trouble, and found it, to the great surprise of the engineer.

Richmond Compound.

The Richmond compound (Mellin System) has the intercepting valve on the low-pressure side, and is moved automatically by receiver pressure.

Starting in simple position, the engineer admits air or steam into small cylinder at the left opening to emergency exhaust valve for the high-pressure cylinder. Steam from that cylinder comes over through receiver and also through intercepting valve at the left to emergency exhaust. At the same time live steam to low-pressure cylinder goes from passage so marked through reducing valve R to low-pressure chest.

Changing to compound, the emergency exhaust is closed by spring, and receiver pressure acting on the large area of intercepting valve forces it open, closes live steam passage through reducing valve, and receiver steam goes to low-pressure cylinder. In starting an ordinary train, the emergency exhaust is not open, but the live steam opens reducing valve, closes intercepting valve passage to receiver and starts engine simple. When the exhaust from high pressure cylinders fills receiver with pressure sufficient to open intercepting valve, the engine goes into compound as before.

STARTING.

With ordinary trains the engine will start smoothly with the emergency exhaust valve in the compound position—that is, with the handle of the operating valve in the bridge pipe pointing ahead; but with heavy trains that start should be made with the valve in the simple position, or with the handle pointing to the rear; it should be left there, however, as short a time as possible, usually six or seven car-lengths being sufficient distance, as when running in this position the exhaust has a very severe action on the fire, besides increasing the steam consumption.

The cylinder cocks should always be opened when starting, as condensation is very rapid for the first few revolutions, especially in the high-pressure cylinder. Water resulting from this condensation is carried over to the low-pressure cylinder, and increases the danger of blowing out a cylinder head, should slipping occur.

USE OF EMERGENCY VALVE WHILE RUNNING.

Only use the simple feature (the emergency) with the reverse lever in the corner, and cut it out before pulling the lever back. It should only be used to avoid stalling, and at speed not over six to eight miles per hour.

If on a long grade it should be necessary to work the engine simple, it should be changed into compound at intervals whenever there is an opportunity without the risk of stalling.

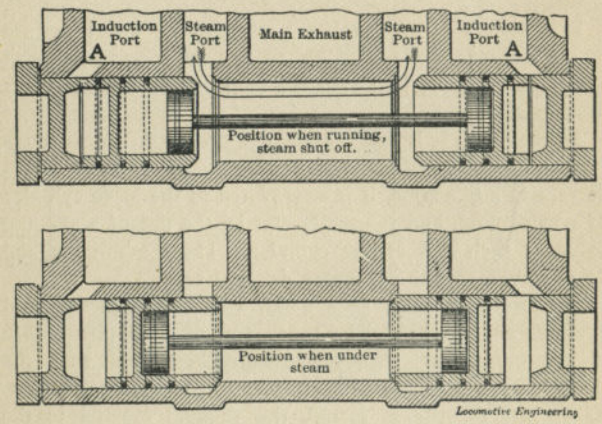
LUBRICATION.

The high pressure cylinder is lubricated in the same way as the cylinders on a simple engine. The low pressure lubricator pipe is branched off at the smoke box with $^1/_{16}$" choke leading to the low pressure steam-chest; the other

branch leads direct to the live steam passage in the intercepting valve.

With this arrangement the low pressure slide valve is lubricated while running, and the intercepting valve while standing still. Very little lubrication is needed for the latter.

On the emergency-exhaust operative valve in the bridge pipe will be noticed a small oil-cup. Fill this cup with



RICHMOND OVER-PASS VALVE.

cylinder oil once every two days for the purpose of lubricating the emergency-exhaust valve. Do NOT FLOOD THIS VALVE WITH OIL.. The steam merely forces this valve off its seat, and is exhausted through the same pipe that admitted it, naturally entraining most of the oil.

EXHAUST RELIEF VALVE.

The exhaust relief valve, located under the emergency valve, is also automatic in its action. It opens when the throttle is shut, and allows air to pass from and to the cylinder this way when drifting, thus preventing sparks being drawn into the cylinder, and modifies the action on the fire caused by the discharge of air from the cylinder through the exhaust pipe. If the engine is drifting with the reverse lever too far from the corner, sparks may collect in this valve, and it should, therefore, have an occasional examination and cleaning out.

OVERPASS VALVES.

The Richmond engine has a peculiar or novel feature in the overpass valve. With an engine running without steam or "drifting," as railroad men call it, the cylinders become air pumps. The air forced out draughts the fire at a time when it is not needed, and on mountainous roads cuts quite a figure in coal consumption. While this is present in any engine, it is aggravated in the large cylinder of a compound, and is usually met by the use of a vacuum valve at each end of the cylinder. These admit air and do not overcome the needless draught on fire.

The overpass valve does away with this objection and operates as follows: The outer end of both pistons are in communication with the steam chest, and with the throttle open are held to their seat by the steam pressure. When the throttle is closed, the vacuum created in the steam chest causes the valves to open and allow a free passage of air from one end of the cylinder to the other.

The double piston placed in between the valves serves as dashpot to modify the shocks in opening. These valves should be cleaned at intervals, especially when the engine is new, otherwise the sand and grit will cause them to stick.

BREAK DOWNS.

In case of break down on either side, take down parts same as for simple engine, block slide valve on broken side in centre, open the emergency exhaust and proceed.

Underneath the cylinders, and screwed into the steam and exhaust passages, are six small drip valves. These valves should be examined frequently and cleaned out, especially on new engines, as grit and dirt from new cylinders have a tendency to cause them to stick and leak.

If a Richmond compound sticks on centre or has an unequal double exhaust when working compound, it is an indication that the intercepting valve may be stuck. It must be pushed clear back, when you can proceed, and it will probably work all right.

If engine should refuse to go into compound, the separate exhaust valve or emergency exhaust is probably stuck open or broken. See if this valve stem is in or out. It is valve stem with spring which sticks out through cover at back of cylinder saddle. If it is in and will not come out fully, tap lightly. If it does not seat, disconnect small steam pipe, remove cover and free the valve. Replace cover and proceed. If valve is broken you must run engine simple unless this part can be blocked solid, in which case you must run compound all the way home.

SECTION V

Air Brake Questions and Answers—First Series.

1. What is an air brake?

A. It is a brake operated by compressed air, and requires special mechanism for the application of the power.

2. How is the air compressed for use in the brake system?

A. By means of an air pump, or compressor, located at some convenient place on the side of the locomotive boiler.

3. What are the essential parts of the air brake as applied to a locomotive?

A. They are an air pump or compressor, an air pump governor, a main reservoir, an engineer's brake and equalizing discharge valve; a duplex air pressure gauge, a plain triple valve, an auxiliary reservoir, a brake cylinder, with a piston in it, and the necessary piping, stop cocks and angle cocks.

4. How many kinds of triple valves are there in use?

A. Two; the plain and the quick-action triples.

5. What is the main reservoir used for, and where is it located?

A. Primarily for the storage of a large quantity of air, to be used in releasing the brakes and quickly recharging the auxiliaries; and secondarily, to catch the moisture, dirt and oil which are pumped in along with the air. It may be located in any convenient place about the engine or tender, but it is usually placed under the boiler, just back of the cylinder saddles, or under the running board.

6. What is the usual standard train pipe pressure?

A. With the plain quick-action brake 70 lbs., and with the high-speed quick-action brake 110 lbs.

7. What pressure is usually carried in the main reservoirs?

A. With the plain brake, 90 lbs.; with the high-speed brake, from 120 to 130 lbs.

8. Why is it important that all air brake apparatus should be kept tight and free from leaks?

A. In order that the air brake mechanism may operate properly and that there may be no waste of air, with its attendant evils, or any unnecessary work required of the pump.

9. Where does the air come from that operates the sand blower, bell ringer, air whistle signal, water scoop or other devices?

A. From the main reservoir.

10. How should an air pump be started?

A. Very slowly, with all drain cocks wide open. After the water has drained away, close all drain cocks, and when a pressure of 35 or 40 lbs. has accumulated in the main reservior, open the pump throttle sufficiently to run the pump at a speed that will maintain the required pressure and perform the brake work satisfactorily. The steam end of the pump should be lubricated freely during the starting, just after the drain cocks are closed.

Air Brake Questions—Second Series.

1. Why is the present brake called the automatic brake?

A. Because it is automatic in its action; that is, its normal condition is when it is held off, due to the maintenance of train line pressure, and anything which happens to reduce train pipe pressure will cause the brake to apply of its own accord, or automatically.

2. Where is the compressed air stored?

A. In the main reservoir on the engine; in the train line which extends throughout the train, under the cars and connects the brake valve with the triple valves, and in the auxiliary reservoir under each car.

3. What are the functions of the auxiliary reservoir, train pipe, triple valve and brake cylinder?

A. The auxiliary reservoir holds a storage of compressed air for supplying the brake cylinder with pressure with which the brake piston is pushed out, engaging the system of levers which brings the brake shoes up against the wheels and supply braking power. The train pipe stores a quantity of compressed air which holds the triple valve in release position normally, but when the train pipe pressure is reduced, the triple valve will shift and apply the brake. The triple valve performs a three-fold function. When in release position, it permits a charge of pressure to pass from the train pipe into the auxiliary reservoir. In application position, it permits pressure to pass from the auxiliary reservoir into the brake cylinder. In release position, it permits pressure to discharge from the brake cylinder to the atmosphere. Thus air passes through the triple valve three times. The brake cylinder receives pressure from the auxiliary reservoir in service application, and from both train pipe and auxiliary reservoir in emergency application, which pushes out the piston and applies the brake.

4. Where does the pump deliver the air?

A. To the main reservoir on the engine.

5. Where does the main reservoir pressure begin and end?

A. It begins with the discharge valves of the air pump and ends at the rotary valve of the engineer's brake valve.

6. What is excess pressure?

A. That amount of pressure contained in the main reservoir higher than that in the train line, available for releasing brakes.

8. How should a brake be cut out?

A. By turning the stop cock in the branch, or cross-over pipe.

9. How should the handle of cut-out cock stand when closed?

A. Parallel with the pipe.

10. How should handle of the angle cock stand when closed?

A. At a right angle with the pipe.

11. What does line, or mark, at end of plug cock indicate, regardless of position of handle?

A. This line, or mark, indicates the direction of the passage way through the plug cock, and by it may be known whether the cock is open, regardless of the handle itself.

12. How should a brake be "bled" off?

A. The release valve should be sharply opened for an instant, then quickly closed. This operation may be repeated until the triple valve begins to discharge the air, which can be heard at the retaining valve or exhaust port of the triple, then no further opening of this valve should be made.

13. When should the brake valve be used in the emergency position?

A. Only in extreme emergency cases to prevent accident, such as loss of life or property, then the handle should be placed in the emergency position and left there until the train stops or the danger of accident is over.

14. What does the red hand on the air gauge register?

A. Main reservoir pressure.

15. What does the black hand register?

A. The pressure above the equalizing piston and in chamber D. This pressure may be properly classed with train line pressure.

Air Brake Questions and Answers—Third Series.

AIR PUMP.

1. Explain how an air pump should be started and run on the road.

A. It should be started slowly to permit the condensation to be drained off. The lubricator should be started carefully, and the pump worked slowly until about 40 lbs. have been accumulated in the main reservoir to cushion the steam and air piston of the pump. Then the throttle should be opened wider, giving a speed of about one hundred and thirty or one hundred and forty single strokes per minute. The amount of work being done really governs the speed of the pump.

2. How should the steam end of the pump be oiled?

A. By the sight-feed lubricator, with a good quality of valve oil, and at the rate of about one drop per minute. This amount will vary with the condition of the pump and the work being done.

3. How should air end of a pump be oiled, and what lubricant should be used?

A. High-grade valve oil, containing good lubricating qualities and no sediment should be used. A good swab on the piston rod will help out a great deal. Oil should be used in the air cylinder of the pump sparingly but continuously, and it should be introduced on the down stroke, when pump is running slowly, through the little cup provided for that purpose, and not through the air suction valves. An automatic oil cup, such as has recently come into practice, is preferable to hand oiling.

4. When first admitting steam to the 9½-inch pump, in what direction does the main valve move?

A. If the main piston is at the bottom of the cylinder, as it usually is after steam has been shut off and gravity controls it, the main valve will move to the position to the right.

5. With the main valve to the right, which end of the cylinder will receive steam?

A. The bottom, or lower, end.

6. When the main piston completes its up stroke, explain how its motion is reversed so as to make the downward stroke?

A. When the main piston reaches and is nearly at the top of its stroke, the reversing plate catches the shoulder on the reversing valve rod, moving the reversing rod and valve to their upper positions, where steam is admitted behind the large head of the main valve, forcing this main valve over to the left, carrying with it the slide valve which admits steam to the top end of the cylinder and exhausts it from the bottom end, thereby reversing the stroke of the pump.

7. Explain the operation of the air end of the 9½-inch air pump on an up-stroke and on a down-stroke.

A. The air piston is directly connected with the steam piston, and any movement of the steam piston will consequently be transmitted directly to the air piston. When the steam piston moves up, the air piston will, of course, go with it, thus leaving an empty space or a vacuum in the lower end of the air cylinder, underneath the air piston. Atmospheric air rushes through the air inlet, raising the lower receiving valve, and filling the bottom end of the cylinder with atmospheric pressure. At the same time the air above the air piston will be compressed. The pressure thus formed holds the upper receiving valve to its seat, and when a little greater than the air in the main reservoir, the upper discharge valve will lift and allow the compressed air to flow into the main reservoir. When the piston reaches the top of the stroke its motion is reversed, and on the down stroke the vacuum in the upper end of the air cylinder is supplied by atmospheric pressure passing through the upper receiving valve. The main reservoir pressure is held by the upper discharge valve, and the air being compressed in the bottom of the cylinder holds the bottom receiving valve to its seat, and when compressed sufficiently, forces the lower discharge valve open and passes to the main reservoir.

8. Give some of the causes of the pump running hot.

A. First, air cylinder packing rings leaking. Second, discharge valves stuck closed or the discharge passages so obstructed that the pump will be pumping against high air pressure continually. Third, poor lubrication. Fourth, high speed. Fifth, discharge or receiving air valves leaking. Sixth, air piston rod packing leaking.

9. If the pump runs hot while on the road, how would you proceed to cool it?

A. First, reduce the speed of the pump, and look for leaks in the train line. Second, make sure that the packing around the piston rod is not too tight and in bad condition. Third, see that the main reservoir is properly drained. If the pump still runs hot it should be reported at the end of the trip.

10. If the pump stops, can you tell if the trouble is in the pump or in the governor?

A. Yes. It may be tested by opening the drain cock in the steam passage at the pump, and noting whether there is a free flow of steam; if so, there is a free passage through the governor and the trouble is not there.

11. State the common causes for the pump stopping.

A. There are several reasons. First. it may be stopped by the governor being out of order; second, the valves may be dry and need lubrication; third, nuts may be loose or broken on the piston rod or one of the pistons pulled off. Fourth, the reversing valve rod may be broken or bent, or the reversing plate may be loose, or the shoulder on the reversing valve rod or the reversing plate may be so badly worn as not to

catch and perform their proper functions. Fifth, nuts holding the main valve piston may be loose or broken off. Sixth, excessive blow past the packing rings of the main valve.

12. Should a pump make a much quicker down stroke than up, what effect does it indicate?

A. An upper discharge air valve leaking, a lower receiving air valve stuck to its seat, or broken.

13. Should it make a much quicker up stroke, what defect does it indicate?

A. The lower discharge valve leaking badly, or the upper receiving valve is probably broken, or stuck to its seat.

14. Should an engineman observe the workings of a pump on the road, and report repairs needed, and do you consider yourself competent?

A. Yes.

GOVERNOR.

15. What is the function of the air pump governor?

A. To properly regulate the pressure in the main reservoir.

16. Explain how the governor operates.

A. The governor is an automatic arrangement for admitting and closing off steam to the air pump, and is actuated by air pressure. The steam valve, which shuts off and opens up the steam passage way to the pump, is controlled by an air piston and spring. When air pressure is admitted above the piston, it forces the piston down, closing off the steam to the pump. When the air pressure is exhausted from above the piston, the spring forces the piston up and allows steam pressure to pass to the pump. The admission and exhaust of the air to this piston is controlled by a diaphragm and spring. The air from the main reservoir enters the body of the governor underneath the diaphragm, which is held by a spring of given tension, depending on the pressure desired in the main reservoir. While the main reservoir pressure is less than the pressure the governor is set for, this diaphragm is held down by the spring, and the air can pass no farther than a small pin valve attached to it, but when the main reservoir pressure overcomes the tension of the spring, it raises the diaphragm, unseats the pin valve and allows the air to flow to the top of the air piston, shutting off the pump. During the time the air is acting on this piston some of it escapes through a large leakage port, which is always open. When the main reservoir pressure drops below the pressure the spring is adjusted to, the spring forces the diaphragm down, seating the pin valve and allowing the air on top of the piston to escape to the atmosphere, through the small vent port.

18. Why is it necessary that the relief port in the improved governor be kept open?

A. If this port is not kept open, the air pressure, which holds the piston down, cannot escape when the diaphragm valve closes, and consequently the governor will not operate the pump properly.

19. Where would you look for the cause, if the governor allowed a very high main reservoir pressure to accumulate, especially in winter weather?

A. The main reservoir pressure may not reach the governor, due to the stoppage in the pipe, or in the union at the governor. This may also be due to the space on top of the diaphragm being filled with dirt. If the air is getting to the diaphragm valve, and is so indicated by the blow at the leakage port, the trouble must then be due to the drip pipe being stopped up or frozen, thereby preventing the air and steam, which leak in under the air piston, from escaping.

20. If the pin valve in the governor leaks, what effect will it have on the pump?

A. It will allow a certain amount of air pressure to

flow in on top of the air piston. If the leak is greater than the escape from the little leakage port, the under pressure will accumulate, and cause the governor to slow down or completely stop the pump.

21. How can you tell if the pin valve leaks?

A. It will blow continually at the leakage port while the pump is running.

MAIN RESERVOIR.

22. What harm is there in allowing water to accumulate in the main reservoir?

A. It reduces main reservoir capacity or space which should be employed in storing air pressure for releasing and recharging the brakes. The moisture also is carried in the air, goes back into the train pipe, and gets into the triples, where it freezes in cold weather.

23. How often should the main reservoir be drained?

A. After each trip.

24. Where does the main reservoir pressure begin and end?

A. It begins at the top side of the discharge valves in the pump and ends on the top side of the rotary valve of the engineer's brake valve.

25. What is the main reservoir used for?

A. It is a storehouse, or storage tank, for air pressure, to charge and recharge the air brakes.

26. What pressure is usually carried in the main reservoir?

A. Ninety pounds with the 70-lb. brake, and about 130 lbs. with the high-speed or 110-lb brake.

ENGINEER'S VALVE.

27. What kinds of engineer's brake and equalizing discharge valves are used?

A. Three forms; the D-8 with the excess pressure valve, the D-5 with the poppet valve form of feed valve, and the E-6, F-6 or G-6 with the slide valve feed valve attachment. These three forms are all of the equalizing discharge type, and have respectively excess pressure valve, the poppet valve feed valve, and the slide valve feed valve. The initial and figure designations given the forms of valves are those used in the different catalogues of the manufacturer.

28. How is the amount of excess pressure regulated when the G-6 brake valve is used?

A. The slide valve feed valve attachment is adjusted by the regulating spring to control the train line pressure when the brake valve handle is in running position. The air pump governor is adjusted to control the amount of pressure to be carried in the main reservoir. The difference between these two pressures is what is commonly known as "excess pressure," and is used for releasing and recharging the brakes.

29. How is the excess pressure regulated with the D-8 brake valve?

A. With the excess pressure valve spring. This valve will give the amount of excess pressure desired by placing behind the valve a spring of sufficient tension or resistance to cause the difference between the main reservoir pressure and the train pipe pressure. For instance, if 20 pounds excess pressure is desired, the spring is so prepared that when the brake valve handle is in running position the main reservoir pressure passing to the train pipe will meet a resistance of 20 pounds, thus giving 20 pounds more in the main reservoir than in the train line.

30. How should the feed valve of a G-6 brake valve be cleaned?

A. The stop cock in the train pipe under the brake valve should be closed, and all train line pressure drawn off the brake valve with the handle in service position, thus eliminating all chance of the parts being roughly moved

or injured when the valve attachment is taken apart. Then remove the large cap nut, and take out the piston spring and slide valve. Clean these parts carefully, taking care that no lint or dirt remains on the parts. Oil the slide valve and its seat very sparingly with a good quality of oil, then replace the parts carefully. Next remove the diaphragm valve, clean it carefully, taking especial care not to bruise or scratch its ground surface. The same care should be exercised in cleaning the diaphragm valve seat, observing that none of the small ports are stopped or clogged with dirt or foreign matter. No oil is necessary on the diaphragm valve and its seat. As a rule, it is unnecessary to remove the regulating spring and diaphragm, but when it is necessary, it should be done by the repair man, and not when the engine is in service on the road, if it can be avoided. In fact, all work possible should be done on the brake valve by the air brake machinist, either in the roundhouse or machine shop.

31. Name the different positions of the brake valve.

A. Full release, running, lap, service application, and emergency application.

32. In what position of the brake valve is there direct communication between the main reservoir and train pipe?

A. The first, or full release, position.

33. Is there no other position of the brake valve in which the air may pass from the main reservoir to the train line?

A. Yes; running position. However, in running position the air passes indirectly, or through the passages and ports of the feed valve attachment, in order to get from the main reservoir to the train line.

34. When making a service application, do you draw air direct from the train pipe?

A. No. In service application the engineer draws air directly from the small equalizing reservoir and from the chamber on top of the equalizing piston. This reduction causes a differential in pressures acting on the piston, and the train line pressure under the equalizing piston being greater causes the piston to rise and discharge train line pressure at the angle fitting of the brake valve until such time as the latter pressure becomes lower than that remaining on top of the piston, when the piston will descend, closing off the discharge of train line pressure.

35. With the G-6 brake valve in running position, if the black hand of the gauge goes up and equalizes with the red hand, what is the defect?

A. As the black hand indicates train line pressure, and the red hand main reservoir pressure, the train line pressure is evidently being increased, due to the leakage of main reservoir pressure coming into it. This leakage of main reservoir pressure into the train line pressure may be due either to a leaky rotary valve or leaky body gasket. Also, there may be a leakage in the feed valve attachment past the supply valve, or in the attachment gasket, or the regulating spring may be improperly adjusted.

36. How can it be ascertained which one of these defects is causing the trouble?

A. Discharge all air from the brake valve. Place the brake valve handle on lap and start the pump. If there is a leakage of main reservoir pressure into the train line, which will be indicated by the rising of the black hand, the trouble is either in the rotary valve and its seat, or in a defective body gasket. However, if the black hand does not rise while handle is on lap position, but if both hands go up together in running position, above the figure the feed valve adjusting spring is set for, the trouble is probably either in a faulty supply valve in the feed valve attachment, or in the small gasket between the feed valve attachment and the brake valve body.

37. What is the effect of leakage from the equalizing reservoir, or the connections to the small chamber above the equalizing piston?

A. When a service application is made, the leakage from the equalizing reservoir in the chamber above the piston will cause more air to escape than is desired by the engineer, the equalizing piston will remain raised off its seat longer than intended, and more pressure will be drawn from the train line than desired, thus making a heavier application than is wanted. In other words, a continuous, or, at least prolonged, application will be made, and the engineer will be unable to reliably regulate the flow of pressure from the train pipe in service application. In release and in running positions, this leakage will merely mean a waste of air pressure. On lap, train line pressure will continue to escape at the angle fitting, either slowly or rapidly, according to the size of the leak.

38. Should the equalizing piston fail to seat, how can it be known if it is due to dirt on the seat of the valve or leak of the equalizing reservoir pressure?

A. This question was partly answered in the preceding. If there is dirt between the valve and its seat, there will be a constant blow of train line pressure through the angle fitting at all times, but if the piston fails to seat, due to leakage from the equalizing reservoir in the chamber above the piston, there will be no leakage of pressure at the angle fitting with the brake valve handle in full release, or running position.

GENERAL.

39. If there is a continuous blow at the train pipe exhaust port, or angle fitting, what should be done to stop it?

A. If the blow is due to dirt between the valve and its seat, make several service applications and releases. If this does not stop the blow, the valve may be taken apart and cleaned, provided it is known that the trouble is caused by dirt between the valve and its seat. If the piston will not seat on account of leakage from the equalizing reservoir in the chamber above the equalizing piston, or the connections, each connection should be gone over carefully with soap suds to detect and locate the leak, and it should then be taken up. A torch blaze is not sufficient. If it is impossible to stop the leaks, on account of breakage of the parts, etc., a blind gasket may be placed in the connection between the chamber D and equalizing reservoir, plugging this opening, and a plug should be placed in the angle fitting of the train pipe discharge, and braking be done very cautiously and carefully with the valve handle in emergency position. This latter, however, is an expedient that is very seldom necessary.

40. What is the effect of leaving the handle of the brake valve in full release position too long, before returning it to the running position, after releasing brakes?

A. The train line and auxiliary reservoirs will be charged higher than the feed valve is adjusted for, thus permitting the equalization of pressures between the auxiliary reservoirs, train line and main reservoir. Should the handle be then drawn to running position, main reservoir pressure will be unable to pass through the feed valve attachment to the train line until such time as the latter pressure becomes reduced below the point at which the feed valve is adjusted. Should there be leakage in the train line, brakes will apply and drag until the brake valve is thrown to full release position, thus releasing the brakes. The brake valve handle should not be left in full release position after releasing brakes.

41. If, from any reason, the brakes should drag, how can they be released from the engine?

A. If it is found that the train line is overcharged before leaving a terminal, a fairly heavy application of the brake may be made in service position, and the brake valve handle placed in running position. Several repetitions of this process may be necessary. However, if the overcharge occurs while the train is running, and brakes will not release in running position, the valve handle may be placed

in full release position and left there until the next stop is made, and then care should be taken to not overcharge again in full release position, but to return to running position in due season, thus preventing this trouble. Sometimes a series of light applications and releases may be made while running to reduce an overcharged train pipe; however, this is not practical on fast, modern trains.

42. If the brakes apply suddenly, what should the engineer do?

A. Place the brake valve in lap position and ascertain the cause. It will probably be due to a burst or parted hose, to the opening of a conductor's valve or the rear angle cock. However, regardless of the cause, the brake valve handle should be placed on lap, to save the main reservoir pressure for releasing the brakes after the train pipe opening has been closed.

43. If the pipe connecting the chamber above the equalizing piston with the equalizing reservoir should be broken off, what should be done?

A. Plug up the connection to chamber D, also the angle fitting on the under side of the brake valve, and brake cautiously and carefully in the emergency application position.

44. What should be done if the pipe leading to the black hand or the air gauge should break? If the pipe to the red hand should break?

A. If the black hand pipe should break, plug the connection at the brake valve, using careful judgment in gauging by sound the amount of pressure drawn from the equalizing chamber in service application. If the red hand pipe should break, plug the connection at the brake valve, taking care that the pump governor is operating and observing that sufficient main reservoir pressure is being accumulated with which to release brakes after each application.

45. How is the train pipe pressure regulated to 70

pounds, while the handle of the G-6 brake is in running position?

A. By the adjusting nut and spring in the feed valve attachment.

46. What is the reason for having the equalizing reservoir on the brake valve?

A. The equalizing reservoir is used to give an enlarged capacity for the required volume of air pressure on top of the equalizing piston, to permit the equalizing piston to draw pressure gradually from the train pipe in service application. If this enlarged capacity were placed in the brake valve, the valves would be entirely too large and bulky for location in the cab; however, this capacity is obtained by employing a reservoir of suitable capacity, and locating it in a remote and convenient place, and piping it to the brake valve. If the reservoir was not used, and the chamber D capacity was restricted to its present size alone, it would be impossible to reduce pressure sufficiently slow to permit the piston to rise gradually as it now does; but instead, the pressure would be exhausted quickly, the piston would rise suddenly and make a heavier application of the brake than was desired.

47. What effect would a leak from the equalizing reservoir have?

A. It would be troublesome to the engineer inasmuch as he would not be able to control the discharge of train line pressure, as the leakage of pressure above the piston would cause the piston to discharge more train line pressure than he intended and desired; hence, he would be unable to properly control brake applications on his train.

48. How can a leak past the packing ring in the equalizing piston be located?

A. Ascertain that the rotary valve and body gasket are tight, place the brake valve handle on lap position

and open the angle cock at the end of the tender, thus discharging train line pressure below the equalizing piston. If the black hand now falls, indicating a reduction of pressure in chamber D above the piston, that pressure is evidently passing by the piston into the train pipe and out at the angle cock. Another way is to observe whether the black hand rises when the brake valve has been returned to lap after making a service application. With a long train, a leaky packing ring would permit train line pressure to leak past it into chamber D, which would be indicated by a rise of the black hand on the gauge, during a service application.

49. What danger would there be from a leakage of main reservoir pressure into the train pipe, when the brakes were set and brake valve was on lap position?

A. Such a leakage would increase the train line pressure and cause the triple valves to go to release position, thus releasing the brakes.

50. What danger is there in a leak from the main reservoir to the train pipe when the brakes are released and handle in running position?

A. The train would be overcharged, and no excess pressure could be carried, if the leakage were of such consequence and there was a considerable lapse of time between brake applications. This unduly increased train line pressure would have a tendency to produce wheel sliding.

51. What repairs may be made on the road to overcome such leakage?

A. It does not pay to make road repairs generally, as frequently more harm is done thereby than good. The four bolts holding together the top and bottom portion of the valve may be carefully tightened, taking care not to break the bolts, and thereby creating a worse condition than existed before. It would be better to exercise unusual care and caution in handling the trouble while on the road, and report it upon arrival at the terminal.

TRIPLE VALVE.

52. How many kinds of triple valves are there in general use?

A. Two, the plain type and the quick action type.

53. What is the function of the triple valve piston, the slide valve and the graduating valve?

A. The function of the triple valve piston is, by variation of pressures on its two sides, to move the slide valve on its seat to the application, graduating, and release positions, and to open and close the feed groove in the piston bush. The function of the slide valve is, by movement due to the triple valve piston, to make connection between the auxiliary reservoir and brake cylinder, applying the brake, and to make connections between the brake cylinder and the atmosphere, releasing the brake. The function of the graduating valve is, from movement given by the triple piston, to admit pressure gradually from the auxiliary reservoir to the brake cylinder, in response to reductions made in the train pipe pressure.

54. Explain how the quick action triple operates when making an emergency application of the brakes.

A. A sudden reduction of pressure in the train pipe will cause the triple piston and its parts to be moved to quick action application position, which first throws into operation the emergency feature of the triple, admitting train line pressure to the brake cylinder, after which auxiliary reservoir pressure is permitted to pass to the brake cylinder, where a higher pressure is obtained than in a full service application of the brake.

55. Name the parts of the quick action triple valve that are not in the plain triple valve.

A. The emergency piston, the rubber-seated emergency valve, and the non-return check valve and its spring.

56. Where does the air come from which sets the brakes in emergency with the plain triple valve?

A. From the auxiliary reservoir only.

57. Where does the air come from which sets the brakes when an emergency application is made with the quick action triple?

A. The first portion of air going to the brake cylinder is contributed by the train pipe, after which the auxiliary reservoir sends in its portion of air to the brake cylinder.

58. What causes a blow at the triple valve exhaust, and how may it be located?

A. This blow may be from three sources, the train pipe, the auxiliary reservoir, or the brake cylinder. If the blow is from train line pressure, it may be detected by closing the stop cock in the cross-over pipe, and the brake will promptly apply. If the blow is caused by auxiliary reservoir pressure, there will be a steady leak of pressure at the exhaust port when the brake is released and the brake will not apply when the cut-out cock is closed in the cross-over pipe. If brake cylinder pressure causes the blow, it will only happen when the brake is applied and will cease when the brake is released and the brake cylinder empty of pressure.

59. About how much time is required to charge the auxiliary reservoir to 70 pounds in the train pipe?

A. It should be no less than 45 seconds and no more than 70 seconds.

TRAIN AIR SIGNAL.

60. Explain in a general way the operation of the whistle signal reducing valve.

A. The valve consists of an adjusting or regulating spring which limits the amount of pressure which will pass through the valve, a piston and a supply valve. If the spring is adjusted for 40 pounds, the standard pressure, the piston will descend and permit the supply valve to close when 40 pounds has been reached, thus shutting off further supply to the signal line. If the signal line reduces below 40 pounds, or what the valve is adjusted for, the adjusting spring and piston will permit the supply valve to open and admit main reservoir pressure, until the predetermined amount has been accumulated, when the supply valve will then be closed.

61. Explain how the signals are transmitted from the car to the engine.

A. On the engine is a valve containing a rubber diaphragm, on the under side of which is suspended a stem which, when raised, will permit pressure to pass from the signal valve outward through the air whistle. When the pressure on the top side of this diaphragm is equal or greater than that on the under side, the stem will remain seated, closing the port to the whistle; however, if a reduction be made in the chamber above the diaphragm, or in the signal line connected to this chamber above the diaphragm, the greater pressure on the under side will cause the diaphragm and stem to rise, permitting pressure to pass to the whistle producing the blast.

62. If the signal whistle blows when brakes are released, where would you look for the trouble?

A. In the pressure reducing valve. Dirt or other foreign substance has settled between the supply valve and its seat, thus permitting main reservoir pressure to accumulate in the signal pipe. When brakes are released, main reservoir pressure falling below the signal line pressure, will permit the signal line pressure to pass backward into the main reservoir, making a

reduction in the signal pipe and on the top of the diaphragm on the signal valve, thus producing the blast the same as if a reduction were made at the car discharge valve.

63. If the proper discharge of air is made at the car discharge valve, and the whistle on the engine only responds with a weak blast, where would you look for the trouble?

A. The car discharge valve may be partially choked, or the diaphragm stem in the signal valve may be loose, responding poorly to a signal line reduction. Also, the adjustment of the whistle bowl on the stem should be examined. Sometimes wind blowing across the whistle bowl when running may weaken the blast.

HIGH SPEED BRAKE.

64. How much pressure is carried in the train pipe when using the high speed brake?

A. One hundred and ten pounds is generally adopted as the standard train line pressure in high speed brake service.

65. What changes are necessary in the usual quick action car equipment to convert it into a "high speed brake"?

A. An additional attachment to the brake cylinder by pipe connections of the high speed automatic reducing valve.

66. What parts are necessary to change the engine and tender equipment to the "high speed brake"?

A. A high speed automatic reducing valve for the tender brake cylinder, another for the driver brake and truck brake cylinders, one reversing cock and the 90 pound and 110 pound feed valve attachments, a Siamese fitting and second pump governor top.

67. At what pressure will the auxiliary reservoir

and brake cylinders equalize with an emergency application using the high speed brake?

A. With a 7-inch piston travel the equalized pressures will be about 86 pounds.

68. Explain in a general way the operation of the high speed reducing valve.

A. The valve consists of a piston and stem whose downward movement is regulated by the adjusting spring. A small slide valve with a triangular escape port is attached to the upper side of the piston. If the adjusting spring is set at 60 pounds, and an emergency application of the brake be made, the piston will descend when 60 pounds has been accumulated in the brake cylinder, and the apex or smallest part of the triangular port will permit brake cylinder pressure to pass through it and escape to the atmosphere; as the brake cylinder pressure reduces, the piston will gradually move up a larger part of the triangular port, thus increasing the opening for the escape of brake cylinder pressure to the atmosphere. When the brake cylinder pressure has blown down to 60 pounds, the port will be closed, shutting off further escape of brake cylinder pressure to the atmosphere. In service application, the larger portion of the triangular port will permit brake cylinder pressure to escape to the atmosphere when 60 pounds has been accumulated in the brake cylinder, thus blowing down the pressure quickly and preventing more than 60 pounds being accumulated in the brake cylinder in service application.

69. If a train with a high speed brake should pick up a car not equipped for high speed brake service, what should the engine man do?

A. Usually a small safety valve is supplied by yard inspectors for cars not equipped with the high speed reducing valve. Sometimes, however, the car in unusual cases is permitted to go without either a reducing valve and without a safety valve, care being taken by the engineer in service applications of the brake not to slide the wheels.

70. When a car that is equipped with an ordinary brake is coupled to a train using the high speed pressure, what must be done with this car to run it with the high pressure?

A. This is answered in the preceding question.

71. How does the pressure developed in the brake cylinder, with the high speed brake, with a given reduction, compare with pressure developed with the same reduction made with the ordinary quick action brake?

A. If reductions less than that which will cause a full application of the low pressure brake is made, the resultant brake cylinder pressures will be the same with the low pressure brake as with the high pressure brake; however, if the reduction made should do more than produce an equalization of the low pressure brake, the cylinder of the high pressure brake would have the highest pressure, and would give a greater breaking force.

72. How many full applications with the high speed brake can be made before recharging is necessary, and have left as much pressure as is used with the ordinary quick action brake?

A. The high speed brake will usually, with proper piston travel, permit of two full service applications and releases and still have sufficient pressure reserved to make an emergency application as great as the 70 pound brake would give when fully charged.

73. How should the engine truck or driver brake be cut out?

A. A suitable arrangement of cutout cocks should be supplied which will permit of the auxiliary reservoir being cut out when the brake cylinder is cut out, thus preventing the brake left cut in having too large an auxiliary reservoir capacity, which would tend to slide the wheels when brakes were applied.

74. How should both the driver and engine truck brakes be cut out?

A. By the stopcocks arranged for that purpose.

STRAIGHT AIR BRAKE.

75. On what is the straight air brake designed to operate, and what extra parts are required on engine and tender?

A. The straight air brake is designed to operate on the engine and tender alone, and not on the cars of the train. To operate the combined automatic and straight air brake, extra parts as follows should be supplied: Reducing valve for the straight air system, set at 45 pounds; an engineer's straight air brake valve; a double seated check valve for the driver brake cylinders; a double seated check valve for the tender brake cylinder; a safety valve, set at 53 pounds, one for the driver brake cylinders and one for the tender brake cylinder; and a straight air brake hose connection between the engine and tender.

76. What should be done to release the brakes when they do not release with the handle of the straight air brake valve in release position?

A. The automatic brake valve handle should be placed in full release position, then returned to running position.

77. What pressure should be developed in the brake cylinder by this brake?

A. About 45 pounds, as indicated by the adjustment of the reducing valve in the pipe between the main reservoir and straight air brake valve.

78. Where are leaks in the train pipe most likely to occur?

A. First, at the hose couplings; second, at the unions in the train pipe; third, through porous hose; and fourth, at the exhaust port of the triple valve.

79. What is the leakage groove of the brake cylinder for?

A. To permit pressure going to the brake cylinder at the improper time to escape to the atmosphere, past the brake cylinder piston, instead of accumulating there and pushing out the brake system and applying the brake.

80. As a rule, how great a reduction of train pipe pressure is necessary to insure the brake piston moving out beyond the leakage groove?

A. On a train of a few cars, about 5 to 7 pounds is sufficient; but on a long train 10 or 12 pounds will be required. This depends also upon the condition of the triple valves and the condition of the equalizing piston in the brake valve.

81. Should the brakes be tested before leaving the terminal?

A. Yes, first by the yard testing plant to determine the proper piston travel and condition of the brakes, and second, by the engineer after coupling up to be sure that all angle cocks are open and that the brakes are operative.

82. What is the proper brake cylinder piston travel on freight cars?

A. From 5 to 7 inches is the accepted standard travel.

83. How is the slack taken up on a tender?

A. With a brake of the equalized type, a dead lever is supplied for taking up the slack. On other types, the slack may be taken up at points where holes are provided for connecting rods in the brake rigging.

Some riggings are supplied with turn buckles for this purpose, but the practice is not considered the best for tenders.

84. If a brake is stuck and cannot be released from the engine, how would you proceed to release it?

A. Open the "bleeder" cock quickly and close it quickly, thus making a sudden reduction in the auxiliary reservoir pressure which will allow the greater train pipe pressure to shift the triple from application position to release position.

85. What is the proper piston travel for passenger cars?

A. About six inches standing travel.

86. If, when testing brakes, it is found that one will not apply, what might be the cause?

A. The brake might be cut out by the cock in the cross-over pipe, the auxiliary reservoir might not be charged, or the triple valve piston and slide valve might be so corroded that they will not move in response to an ordinary train pipe reduction.

87. Can a brake be operated if the retaining valve is broken off?

A. Yes, the retaining valve is operated only to hold pressure in the brake cylinder to prevent a full release of the brake, and has nothing to do with the application of the brake.

88. With a 70 pounds train pipe and auxiliary reservoir pressure, how much of a reduction will be required to apply the brakes fully?

A. About 20 pounds, providing the adjustment of piston travel is as it should be.

89. Has the piston travel anything to do with the pressure obtained in the brake cylinder?

A. Yes, the longer the piston travel the greater will be the capacity of the cylinder for consuming the auxiliary reservoir pressure sent to the cylinder, and consequently the lower will be the brake cylinder pressure. The shorter the piston travel, the less will be the volume in the cylinder into which the auxiliary reservoir pressure must go, and the higher will be the brake cylinder pressure.

90. With all things uniform, what is the highest pressure that can be obtained in full service application?

A. About 50 pounds, with the piston travel adjusted at about 7 inches travel. Emergency application? A. About 60 pounds with a 7-inch piston travel.

91. Is a greater initial reduction required with a 50-car train than with a 10-car train?

A. Yes, if a service application be made, for the train line pressure may leak past a poor fitting ring in the equalizing piston of the brake valve and on to the top side, thus causing the piston to descend and close off the escape of train line pressure before the full reduction has been made. If the train be short, the leakage upward past the piston ring into chamber D will be less than it will be with a longer pipe, which has a greater volume and a better chance for leakage.

MISCELLANEOUS (AIR BRAKE).

92. Explain how a terminal test of the brakes should be made.

A. All train pipe couplings should be made and angle cocks opened except the one on the rear of the train, which should be closed. All hand brakes should be off. The first test made should be for leaks at the hose couplings and other points in the train line and auxiliary reservoir connections. A service application of about 10 pounds should be made, and examination be made to learn whether all brakes have applied. Care should be taken that all brakes are cut in. The piston travel should be adjusted on all cars to about

6 or 7 inches. When brakes are released, care should be taken to know if all brakes are off and that the brake rigging does not foul at any point on the truck or car framings. The retaining valves should be known to be in operative condition and all handles turned down when not in operation.

93. What is meant by a running test, and how is this test made?

A. A running test consists of a light application of the brakes by the engineer when the train is pulling out, and before it has gotten up to speed, to be sure that all angle cocks are open and that the brakes are operative.

94. At what points on the road should the running test be made?

A. At terminals and at all points where the angle cocks have been manipulated to take in or set out cars, etc. It is also the rule on some roads to make a running test at points where it shall be absolutely necessary for the brakes to perform their functions, such as on drawbridges, etc.

95. When should the brakes be released when making a stop with a passenger train of less than ten cars?

A. Shortly before coming to a dead standstill, to allow the brakes to right themselves, and thus preventing a shock to the passengers. *b.* Of ten or more cars? A. Brakes should be held on until the train comes to a standstill, as releasing to avoid a shock with a long train will frequently break it in two. A two-application stop should be made, and the brakes be held on with a light second application until the train comes to a standstill.

96. When should the brakes be released in making a stop with a freight train?

A. The brakes should be held on until the train comes to a stop, as with a long passenger train of ten or more cars.

97. Why is it dangerous to repeatedly apply and release the brakes on a long train without giving the auxiliary reservoirs time to recharge?

A. The auxiliary reservoir pressure will become depleted by repeated applications, and the holding power of the brakes be thereby reduced and be insufficient to control the train.

98. When two engines are coupled together in double heading, which engine should have full control of the brakes, and what should the other engine do?

A. The first engine should do the braking, and the second engineer should close the stop cock under his brake valve, and place the brake valve on lap, thus throwing out of service all of his air brake equipment except the foundation brakes on his engine, which are operated by the leading engine.

99. In case a hose should burst while on the road, what should the engine men do to assist the train men in locating it?

A. Place the brake valve handle in full release position, thus causing the escape of air at the bursted hose to manifest itself to the brakemen as quickly as possible, easing the steam throttle off to reduce speed of the air pump.

100. How would you apply and release the brakes on a freight train, when only a part of the train is equipped with air brakes?

A. A reasonable reduction in the train pipe pressure should be made to apply the brakes on the air cars, and when the slack of the train has been bunched, which is indicated by the pushing forward sensation when the slack is taken up, then the brakes may be applied with greater force if desired. In releasing, the straight air brake on the engine and tender should be held on while the train brakes are being released and the slack allowed to run out. This will prevent the slack running out in a manner which will snap the train in two.

101. What precaution should be taken in starting a long freight train with all cars equipped with air brakes, and in operation?

A. The slack should be taken easily until the entire train is stretched, thus preventing a break-in-two, which might occur if the slack were taken suddenly.

102. In releasing brakes on a long freight train, what should the engine men do to be sure that the brakes have released?

A. Leave the brake valve handle in full release position about as many seconds as there are cars in the train, before bringing the brake valve handle to release position.

103. How is the slack taken up on the American outside equalized driver brake?

A. By a slack adjuster feature on the connecting rod to the bell crank lever.

104. Are the train pipe and auxiliary reservoir pressures equal at all times?

A. No. *b.* What time are they equal? A. Before the brake is applied, when the triple valve has lapped itself during the application of the brake, and after a release of brakes when the auxiliary reservoir has become fully recharged.

105. How many applications of the brake are necessary to make a stop with a passenger train, and why?

A. The two-application stop is considered the best in modern passenger train service. The first application should be heavy and sufficient to slow down the train to about eight or ten miles an hour, when the brakes should be released before reaching the point at which the stop is desired, and a second and lighter application should be made to finish up the stop, and should be held on until the train is brought to a standstill. If brakes are released on a long passenger train before coming to a full stop, the

slack of the train will run out, and the train be snapped in two.

106. How would you make a stop on a grade with a passenger train?

A. By the two-application method, holding on the brake for a second application.

107. Explain the operation of the pressure retaining valve.

A. When the handle of the retaining valve is turned down it is inoperative. When the handle is turned up in a horizontal position, the free exit for air from the brake cylinder to the atmosphere is cut off and the pressure must pass upward against the weighted valve which has a resistance of 20 pounds. All over this amount will raise the valve and blow off, but all below that amount will be held in the brake cylinder.

108. What benefits are derived from the use of the retaining valve?

A. On mountain grades the pressure retained in the brake cylinder, by turning up the handle of the valve, will hold the train in check while the auxiliary reservoirs are being recharged for subsequent application of the brake.

109. Name the defects which cause the retaining valve to be inoperative.

A. First, defective packing leather in the brake cylinder. Second, defective union in the retaining valve pipe. Third, retaining valve or pipe broken off.

110. Explain how a stop at a water tank or coal chute should be made with a long freight train.

A. The engine should be equipped with a straight air brake for this purpose. The train brakes should be used until the speed of the train has been brought down to three or four miles an hour, then released and the straight air brake applied to cover the last few feet of the distance to the desired stop. If the engine is not equipped with the straight air brake it would be better with a long train of all air-braked cars, to stop, holding on the brakes, and to cut off the engine while taking coal and water, as considerable time and damage will be saved by this method.

111. Do you think it poor policy to reverse the engine while the driver brakes are applied?

A. Yes; tests have proven this.

112. Should the train pipe be blown out before leaving the engine house?

A. Yes; as cinders or sparks are likely to be gathered in the coupling head or hose.

113. Are the brakes any more liable to stick after an emergency application than after a service?

A. Yes; as dirt in the train line might work between the emergency valve and its seat, permitting train pipe pressure to pass to the brake cylinder.

114. If, in making a service application, you notice some wheels slide, do you think it good policy to drop sand to start them turning again?

A. No; a wheel once stopped cannot be started to turning again by sand dropped on the rail, and that process will only cut the wheel worse and make the flat spot longer.

115. Explain the principle of the duplex governor applied to freight engines.

A. The high pressure head of the duplex governor is connected direct to the main reservoir pressure and is usually set for 110 pounds. The low pressure head is connected to port *f* in the brake valve, and is set at 90 pounds. When the brake valve handle is in full release position or running position, the low pressure head is operative, but when placed on lap, there being no main reservoir in port *f*, the high pressure head must govern, thus permitting the pump to compress air during the time the brake valve handle is on lap while making a brake application.

116. Are the results from shocks on passenger trains likely to be expensive and give the road a bad reputation?

A. Yes.

117. Do you understand the importance of watching the air gauge closely?

A. Yes.

118. When descending a grade, how much should the speed be reduced before releasing the brake to recharge?

A. The speed of the train should be brought down to about 10 or 12 miles per hour before recharging. Frequent recharge is preferable to long runs between periods of recharging.

119. What is meant by application of the brakes?

A. The operation by which train line pressure is reduced to permit of triple valve movement, which will send pressure to the brake cylinder.

120. Do you understand that the braking power is considerably more on passenger than on freight cars, and on this account greater care must be exercised in handling them?

A. Yes.

MASTER CAR BUILDERS' ASSOCIATION

SECTION VI

Air Brake and Train Air Signal Instructions

A.—GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employes of this railroad whose duties bring them in contact with the maintenance or operation of the air brake and train air signal. They must be obeyed in all respects, as employes will be held responsible for the observance of same as strictly as for the performance of any other duty.

Every employe whose duties are connected in any way with the operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

A book of information will be issued, in convenient form, giving a complete explanation of such parts of the air brake and train air signal equipment as is deemed necessary for the care and operation of same. Any employe of this railroad whose duties require a knowledge of the operation and maintenance of the air brake and air signal will be furnished with a copy of same upon application at place designated by special notice, and every employe will be held responsible for a full knowledge of his duties in the operation or maintenance of the air brake or signal equipment.

B.—INSTRUCTIONS TO ENGINEMEN.

Enginemen when taking charge of locomotives must see that the air brake apparatus on engine and tender is in good working order, and that the air pump and lubricator work properly; that the devices used for regulating main reservoir and train pipe pressure are adjusted at the authorized amount; that brake valve works properly in all its positions; and that, when brakes are fully applied, with cam type of driver brake the piston does not travel less than 2 inches nor more than 3½ inches, and with other forms from 4 inches to 6 inches, and that the tender brake piston does not travel less than 6 inches nor more than 9 inches. They must know that the air signal responds by opening hose cock on its train pipe.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

MAKING UP TRAINS, TESTING BRAKES AT TERMINAL POINTS AND BEFORE STARTING DOWN SUCH GRADES AS MAY BE DESIGNATED BY SPECIAL INSTRUCTIONS.—The train pipe under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been charged with air pressure, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and leave them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and must not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector, or trainmen, of the number of brakes in service and their condition. In testing passenger brakes, the American Railway Association code of train air signals for applying or releasing must be used, one of which signals must be given from the discharge valve on rear car.

Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a passenger train back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the locomotive.

4. SERVICE APPLICATION.—In applying the brakes to steady the train on descending grades, or for reducing speed for any purpose, an initial train pipe reduction of not less than five pounds must be made. Releasing brakes at low speeds must be performed with great care, dependent upon local conditions.

With freight trains, first allow the slack to run up against the locomotive. Great care must then be taken to apply the brakes with five to nine pounds reduction, according to length of train pipe, and not make a second reduction until the effect of the first reduction is felt on entire train, in order to prevent shocks which otherwise might be serious. When a freight train must be brought to a full stop, the train brakes must be held applied until stop is made.

In making a service stop with a passenger train ALWAYS RELEASE THE BRAKES A SHORT DISTANCE BEFORE COMING TO A DEAD STOP, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start the release will take place quickly.

5. EMERGENCY APPLICATIONS.—The emergency application of the brakes must not be used, except in actual

emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a full stop.

ENGINEMAN'S STRAIGHT AIR BRAKE VALVE ON LOCOMOTIVES.

a—Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

b—Always carry an excess pressure of ten pounds, or more, in the main reservoir, as this is neessary to insure a uniformly satisfactory operation.

c—When using the automatic brake, keep the straight air brake valve in release position; and when using straight air, keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking.

d—The straight air reducing valve should be kept adjusted at forty-five pounds, and the driver and tender brake safety valves at fifty-three pounds.

When a full application of straight air causes either or both safety valves to operate, it indicates that same are out of order, or too high adjustment of the reducing valve, or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

6. BRAKES APPLIED FROM AN UNKNOWN CAUSE.—If it is found that the train is dragging as though the brakes were applied, without rapid falling of the train line pointer, the engineman must make an effort to release the brakes, which may be done as follows: First, if train pipe pressure is less than the authorized amount and the required excess pressure is carried in the main reservoir, move the handle of the brake valve to the full release position for a few seconds and then return it to the running position; secondly, should the train pipe be fully charged with pressure, apply the brakes with a five or ten pounds reduction, according to the length of the train

pipe, and release the brakes in the usual manner. In case the brakes cannot be released, the train must be stopped and the trainmen notified to examine the brakes.

If, however, the brakes go on suddenly with a fall of the train line pointer, it is evidence that (a) a conductor's valve has been opened, (b) a hose has burst or other serious leak has occurred, or (c) the train has parted. In such an event, the locomotive throttle should be closed and the brake valve handle immediately placed on lap or emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the brake apparatus has been examined and the signal to release given.

7. BRAKING BY HAND.—NEVER USE THE AIR BRAKE when it is known that the trainmen are operating the brakes of the air brake cars by hand, except in cases of emergency, as there is danger of injury to the trainmen by so doing.

8. CUTTING OUT BRAKES.—THE DRIVER AND TENDER BRAKES MUST ALWAYS BE USED AUTOMATICALLY AT EVERY APPLICATION OF THE TRAIN BRAKE, unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple valve down to a position midway between a horizontal and a vertical position, first releasing the brake and leaving the bleed cock open. With the special types of triple valve, close the cut-out cock in the branch pipe.

9. DOUBLE HEADERS.—When two or more locomotives are coupled in the same train, the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train pipe, just below the brake valve. Engineman of each locomotive, except the head one, must close this cock and carry the

handle of brake valve in running position. He will start his air pump and let it run, as though he were going to use the brake, for the purpose of maintaining air pressure on his locomotive and enabling him to assume charge of the train brakes should occasion require it.

10. AN EXTRA AIR-BRAKE HOSE, COMPLETE, must always be carried on the locomotive, for repairs in case of burst hose. Upon locomotives having the air signal, a signal hose, complete, must also be carried for the same purpose.

C.—INSTRUCTIONS TO TRAINMEN.

11. MAKING UP TRAINS AND TESTING AIR BRAKES.—When the locomotive has been coupled to the train, or when two sections have been coupled together, the brake and signal couplings must be united, the cocks in the train pipes—both brake and signal—must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up properly in the dummy coupling, when cars are so equipped.

After the train has been charged with air, the engineman must then be requested to apply the brakes. When he has done so, the brakes of each car must be examined to see if they are properly applied. When it is ascertained that each brake is applied, the engineman must be signaled to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) The brakes of each car must then be examined to see that each is released, and the engineman informed as to the number of brakes in service and their condition.

If any defect is discovered it must be remedied and the brakes tested again—the operation being repeated until it is ascertained that everything is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. At points where there are no inspectors, trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition, without special orders from the proper officers. The air brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air brake in service than provided for by special instructions. When hand brakes are also used they must be applied upon those cars next behind the air-braked cars, except in cases of emergency.

12. DETACHING LOCOMOTIVE OR CARS.—First close the cocks in the train pipes at the point of separation, and then part the couplings, invariably by hand.

13. COUPLINGS FROZEN.—If the couplings are found to be frozen together or covered with an acumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

14. BRAKES STICKING.—If brakes are found sticking, the signal "brakes sticking" must be given as hereafter prescribed by the American Railway Association, or by special rules, in which case, if the brakes cannot be released from the locomotive, or if the brakes are applied to detached cars, the release may be effected by opening the bleed cock in the auxiliary reservoir until the air begins to release through the triple valve, when the reservoir cock must immediately be closed.

15. TRAIN BREAKING INTO TWO OR MORE PARTS.—First close the cock in the train pipe at the rear of the first

section and signal the engineman to release the brakes. Having coupled to the second section, observe the rule for making up trains—first being sure that the cock in the train pipe at the rear of second section has been closed, if the train has broken into more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with reference to the third section, and so on. When the train has been once more entirely united, the brakes must be inspected on each car to see that all are released before proceeding.

16. CUTTING OUT THE BRAKE ON A CAR.—If, through any defect of the brake apparatus it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-action brake is used, or by turning the handle of the cock in the triple valve to a position midway between a horizontal and a vertical, where the plain automatic brake is used, first releasing the brake. With the special types of triple valves, close the cut-out cock in the branch pipe. When the brake has been thus cut out, the cock in the auxiliary reservoir must be opened and left open upon passenger cars, or held open until all the air has escaped from the reservoir upon freight cars. THE BRAKE MUST NEVER BE CUT OUT UPON ANY CAR UNLESS THE APPARATUS IS DEFECTIVE, and when it is necessary to cut out a brake the conductor must notify the engineman and also send in a report stating the reason for so doing.

17. CONDUCTOR'S VALVE.—Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve placed in each car so equipped. THE VALVE MUST BE HELD OPEN UNTIL THE TRAIN COMES TO A FULL STOP, AND THEN MUST BE CLOSED AGAIN.

This method of stopping the train must not be used except in case of emergency.

18. BURST HOSE.—In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, provided the train be in a safe place. If it is not, the train pipe cock immediately in front of the burst hose must be closed, and the engineman signaled to release. All the brakes to the rear of the burst hose must then be released by hand, and the train must then proceed to a safe place, where the burst hose must be replaced and the brakes again connected and tested, so as to ascertain that the rear brakes are responsive, by test, to the brake valve on engine. One extra air brake hose complete should be carried by all crews and one extra signal hose complete carried by passenger crews for repairs.

19. BRAKES NOT IN USE.—When the air brakes are not in use, either upon the road or in switching, the hose must be kept coupled between the cars or hung up properly to the dummy couplings, when cars are so equipped.

20. PRESSURE-RETAINING VALVE.—When this valve is to be used, the trainmen must, at the top of the grade, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure-retaining valves horizontally upon all or a part of the cars, as may be directed. At the foot of the grade the handles must all be turned downward again. Special instructions will be issued as to the grades upon which these valves are to be used.

21. TRAIN AIR SIGNAL.—In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found to be defective, it may be cut out of use upon that car by closing the cock in the branch pipe leading to the valve. The conductor must always be immediately notified when the signal has

been cut out upon any car, and he must report the same for repairs.

In using the signal pull directly down upon the cord during one full second for each intended blast of the signal whistle, and allow three seconds to elapse between the pulls.

22. REPORTING DEFECTS TO INSPECTORS.—Any defect in either the air brake or air signal apparatus discovered must be reported to the nearest inspector, and if the defect be a serious one in passenger service, it must be remedied before the car is again placed in service.

D.—INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. GENERAL.—It is the duty of the engine-house foremen to see that the air brake and signal equipment is properly inspected upon each locomotive after each run. It must be ascertained that all pipe joints, connections and all other parts of the apparatus are air tight, duplex gauges tested every thirty days, and that the apparatus is in good working order.

24. AIR PUMP.—The air pump must be tested under pressure, and if found to be working imperfectly in any respect it must be put into thoroughly serviceable condition.

25. PUMP GOVERNOR.—The pump governor should cut off the steam supply to the pump when authorized pressure has been obtained.

26. BRAKE VALVE.—This valve must be kept clean and known to be in working order in all its positions before the locomotive leaves the engine-house.

27. ADJUSTMENT OF BRAKES.—The driver brakes must be so adjusted that the piston travel on the cam type will be not less than 2 inches nor more than 3½ inches, and in other forms not less than 4 inches nor more than 6 inches. When the cam brake is used care must be taken to adjust both cams alike, so that the point of contact

of the cams shall be in line with the piston rod. The tender brake must be adjusted by means of the dead truck levers, so that the piston travels not less than six inches when the air brake is applied and the hand brake is released. This adjustment must be made whenever the piston travel is found to exceed nine inches.

28. BRAKE CYLINDERS AND TRIPLE VALVES.—These must be examined, cleaned and lubricated at least once every six months. A record must be kept of the dates of last cleaning and lubrication of these parts for each locomotive.

29. DRAINING.—The main reservoir, and also the drain cup in the train pipe under the tender, must be drained of any accumulation after each trip. The auxiliary reservoirs and triple valves must also be drained frequently, and daily in cold weather, and the train pipe under the engine and tender blown out.

30. AIR SIGNAL.—The train air signal apparatus must be examined and tested by suitable appliances from both the head of the engine and the rear of the tender, to know that the whistle responds properly. A pressure gauge must be applied to the air signal pipe once each month, and oftener if found to be necessary, to ascertain that the reducing valve maintains the authorized pressure per square inch in the train signal pipe.

E.—INSTRUCTIONS TO INSPECTORS.

31. GENERAL.—It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high speed reducing valve, the conductor's valves, the air signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car and free from leaks. For this purpose they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with

the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which cannot be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of freight cars, with the air brakes in good condition, which may be used in operating the train as an air-brake train.

32. MAKING UP TRAINS AND TESTING BRAKES.—In making up trains the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the couplings properly hung up to the dummy couplings if so equipped. After the train is fully charged the engineman must be requested to apply the brakes. When the brakes have been applied they must be examined upon each car to see that they are applied with proper piston travel. This having been ascertained, the inspector must signal the engineman to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

This examination must be repeated if any change is made in the make-up of the train before starting.

HIGH SPEED REDUCING VALVES ON LOCOMOTIVES AND

TENDERS must be tested at least once every month, and adjusted to authorized pressure, if necessary, and cleaned and lubricated at least once in three months, and oftener if tests show that same is necessary.

33. CLEANING CYLINDERS AND TRIPLE VALVES.—The brake cylinders and triple valves must be kept clean and free from gum. They must be cleaned and lubricated as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinder or reservoir, in the space left opposite the words:

Cylinder, cleaned and lubricated....................

Triple, cleaned and lubricated......................

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the bleed cock in the reservoir.

34. GRADUATING SPRINGS.—The graduating springs in the Westinghouse quick-action freight triple valves are .049 inch in diameter, nickeled-steel wire, 16 coils, 2¾ inches free height, 29-64 inch inside diameter, and in passenger .08 inch diameter, nickeled-steel wire, 13¼ coils, 2⅝ inches free height, 29-64 inch inside diameter. The graduating springs used in the Westinghouse plain triple valve in locomotive service are made of phosphor-bronze wire, .083 inch in diameter, 12 coils, 2½ inches free height, 25-64 inch inside diameter.

35. ADJUSTMENT OF BRAKES.—The slack of the brake shoes must be taken up by means of the dead truck levers.

In taking up such slack it must be first ascertained that the hand brakes are off, and the slack is all taken out of the upper connections, so that the truck levers do not go back within one inch of the truck timber or other stop when the piston of the brake cylinder is fully back at the release position. When under a full application the brake piston travel is found to exceed nine inches upon passenger or freight cars, the brake shoe slack must be taken up and the adjustment so made that the piston shall travel not less than six inches. In taking up the brake shoe slack it must never be taken up by hand brakes. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

36. BRAKING POWER.—Where the cylinder lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

37. REPAIR PARTS.—Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

38. HANGING UP HOSE.—Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy couplings, when cars are so equipped.

39. RESPONSIBILITY OF INSPECTOR.—Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR BRAKE AND TRAIN AIR SIGNAL.

GENERAL.

(All parties who have to do with the use, adjustment, care or repairs of air brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.)

1. Question. What is an air brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake cylinder on each car, and it pushes out a piston in that cylinder, which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes this spring reacts and pushes the piston in again.

5. Q. Where is the compressed air kept ready for use in the automatic air brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train pipe.

6. Q. Where does the compressed air come from directly that enters into the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car in service application, and from the auxiliary reservoir and train pipe in emergency application.

7. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train pipe and triple valve when the brakes are released.

8. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe below that in the auxiliary reservoir, and is released by raising the train pipe pressure above that remaining in the auxiliary reservoir.

9. Q. Why does the compessed air not enter directly into the brake cylinder from the train pipe?

A. Because the triple valve used with the automatic brake prevents the air from entering directly from the train pipe to the brake cylinder when the pressure in the train pipe is maintained or increased.

10. Q. What other uses has the triple valve?

A. It causes the brake cylinder to be opened to the atmosphere under each car, to release the brakes when the pressure in the train pipe is made greater than that in the auxiliary reservoir, and it opens communications from the train pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced it closes the openings from the train pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

11. Q. How many forms of triple valves are there in use, and what are they called?

A. Two; the plain triple and the quick-action triple.

12. Q. How can you tell the plain triple from the quick-action triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-action triple has no such cock in it, but there is a plug cock in the cross-over pipe leading from the train pipe to the triple, when the quick-action triple is used.

13. Q. What are these cocks for in both cases?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

14. Q. How does the cock handle stand in the plain triple when the pipe is open for automatic action?

A. It stands in a horizontal position.

15. Q. In what position does the same handle stand when the brakes are cut out by closing the cock?

A. It stands at an inclined position midway between horizontal and vertical.

16. Q. How does the handle in the plug cock in the cross-over pipe, used with the quick-action triple, stand for automatic action?

A. It stands with the handle crosswise with the pipe, and groove in plug lengthwise when cock is open.

17. Q. How does the handle and groove stand when the cock is closed and brake cut out of action?

A. It stands with the handle lengthwise of cross-over pipe, and the groove crosswise when closed.

18. Q. How is the train pipe coupled up between the cars?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

19. Q. How is the train pipe closed at the rear end of train?

A. By closing the cock in the train pipe at the rear end of last car.

20. Q. How many such train pipe cocks are there to a car, on the air brake train pipe and on the air signal train pipe, and why?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

21. Q. How many kinds of train pipe cocks are there in use at the ends of the cars?

A. Two.

22. Q. Describe each and give the position of the handle and groove for open and closed in each case.

A. The older form of train pipe cock is a straight plug cock in the train pipe, not far from the hose connection; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed; it is now found principally on the air signal pipe. The other form of train pipe cock now used on the air brake pipe is an angle cock placed at the end of the train pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed. The groove is also a guide to tell whether open or closed.

23. Q. What uses have these train pipe cocks besides to close the pipe at the end of the train?

A. They are used to close the train pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

24. Q. Why is it necessary to close the train pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train pipe, which would apply the brakes.

25. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air brake must first be released on the train from the locomotive, then the adjacent train pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

26. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car they cannot be released without bleeding the auxiliary reservoir.

27. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice on the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

28. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling if provided for in such manner that the flat pad on the dummy will close the opening in the coupling.

29. Q. What pressure should be carried in the train pipe and auxiliary reservoir?

A. The authorized pressure, as per special instructions.

30. Q. Why should the authorized pressure be maintained?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and if it be exceeded, there will be danger of sliding the wheels.

31. Q. How much pressure can be obtained in the brake cylinder by the service application of the brakes with seventy pounds in the auxiliary reservoir?

A. About fifty pounds to the square inch, with an 8-inch piston travel.

32. Q. Why can only fifty pounds pressure be obtained under these circumstances?

A. Because the air at seventy pounds pressure in the auxiliary reservoir expands into an additional space when the auxiliary reservoir is opened to the brake cylinder. and when the pressure has become equalized it is thus reduced to fifty pounds.

33. Q. How much must the train pipe pressure be reduced in order to get fifty pounds pressure in the brake cylinder in ordinary service?

A. Twenty pounds.

34. Q. Can the brakes be applied so as to get only a portion of this fifty pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train pipe pressure less than twenty pounds.

35. Q. If the train pipe pressure be reduced ten pounds what will be the pressure in the brake cylinder?

A. About twenty-five pounds.

36. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple valve.

37. Q. Is it important to keep all the air brake apparatus tight and free from leaks?

A. Yes.

38. Q. Why is this important?

A. In order to get full service from the air brakes and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

39. Q. Is it important to know that the train pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

40. Q. Why is this very important?

A. Because if any cock in the train pipe were closed all the brakes back of the cock which is closed would be prevented from working.

41. Q. How can you ascertain that the train pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

42. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air brakes?

A. Yes.

43. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

44. Q. At what other times should the brakes be tested?

A. After each change in the make-up of the train and before starting the train down certain designated grades.

45. Q. From where does the air signal apparatus receive its pressure?

A. From the main air reservoir through the reducing valve.

46. Q. How much air pressure should be carried in the air signal train pipe?

A. The authorized pressure.

47. Q. Is it important that this train pipe and its connections be also kept tight?

A. Yes.

48. Q. After taking up the slack of the brake shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than six inches, nor more than nine inches.

49. Q. What would happen if the piston traveled less than six inches when brakes are fully applied?

A. A partial application of the brakes might not force the piston beyond the leakage groove in the brake cylinder provided for the escape of small amounts of air.

50. Q. Why should the piston travel not be permitted to exceed nine inches on passenger cars, tenders, or freight cars?

A. Because if it travels farther than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

51. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than two inches nor more than three and one-half inches for the cam type of brake, and from four to six inches for other forms.

52. Q. If the brakes stick upon any car so that the engineman cannot release them at any time, how should they be released?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple valve, and then closing it again.

53. Q. What is the pressure retaining valve, and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades, and holds the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

54. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

55. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

56. Q. Why should the piston rod on the air pump be kept thoroughly packed?

A. To prevent the waste of air and steam.

57. Q. How should the steam cylinder of the air pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

58. Q. How should the air cylinder of the air pump be oiled; what kind of oil?

A. It should be supplied with valve oil as often as necessary through a cup provided for that purpose. Also, a well saturated swab should be kept on the piston rod. Lard oil, and other animal or vegetable oils, should not be used, as their use causes the brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

59. Q. What regulates the train pipe pressure?

A. The train pipe governor, or feed valve, provided for that purpose.

60. Q. Why should the authorized pressure be carried in train pipe?

A. Because this pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train pipe pressure is liable to cause the wheels to slide.

61. Q. What does the feed valve attachment on the brake valve accomplish?

A. When properly adjusted it restricts the train pipe pressure to the authorized amount, with the brake valve handle carried in running position.

62. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

63. Q. If the main valve in the brake valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may release. The main valve should be thoroughly cleaned, and if worn it should be faced to a seat.

64. Q. If the piston in the brake valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard and will have to be released.

65. Q. How and why should the train pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows out the oil, water, scale, etc., which may accumulate in the pipe, and which would be blown back into the train pipe and triple valves if not removed before coupling to the train.

66. Q. When the locomotive is coupled to the train, why is it necessary to have excess pressure in the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineman's valve is placed in the release position.

67. Q. Why should the driver brakes be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

68. Q. In making a service application of the brakes, how much reduction of the train pipe pressure from seventy pounds does it require to get the brakes full on?

A. About twenty-five pounds reduction.

69. Q. What should the first reduction be in such an application?

A. Not less than five pounds, so as to insure moving the pistons in the brake cylinders past the leakage grooves.

70. Q. What is the result of making a greater reduction of pressure than twenty-five pounds?

A. A waste of air in the train pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

71. Q. How many applications of the brakes are necessary in making a stop?

A. One or two applications.

72. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake cylinders is thrown away, and if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

73. Q. In releasing and recharging the train, how long should the handle of the brake valve be left in the release position?

A. Until the train pipe pressure has risen nearly to authorized pressure.

74. Q. In making service stops with passenger trains, why should you release the brakes just before coming to a full stop?

A. So as to prevent stopping with a lurch; it also requires less time for the full release of the brakes after stopping.

75. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop?

A. Because long freight trains are apt to be parted by

releasing the brakes before rear brakes are fully released.

76. Q. In making service stops, why must the handle of the brake valve not be moved past the position for service applications?

A. So as to prevent unnecessary jerks to the train and the emergency action of the triple valve when not necessary.

77. Q. If you find the train dragging from the failure of the brakes to release, how can you release them?

A. By placing the handle of the brake valve in full release position for a few seconds and returning it to the running position, if the train pipe pressure is not up to the authorized amount; but if maximum pressure is in train pipe, the brakes should be applied with from five to ten pounds reduction, according to the length of train pipe, and released in the usual manner.

78. Q. When the brakes go on suddenly when not operated by the brake valve, and the gauge pointer falls back, what is the cause, and what should you do?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the engine throttle should be closed and the handle of the brake valve should immediately be placed on lap position to prevent escape of air from main reservoir.

79. Q. Are the brakes liable to stick after an emergency application, and why?

A. The brakes are harder to release after an emergency application because they are on with full force and it requires higher pressure than usual in the train pipe to release them again. In this case it is necessary always to have in reserve the excess pressure of the main reservoir to aid in releasing the brakes. With the quick-action triple valve this is especially necessary, because air from the train pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a correspondingly high pressure in the train pipe afterward to cause the brakes to be released.

80. Q. In using the brakes to steady the train while descending grades, why should the air pump throttle be kept well open?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train pipe and auxiliary reservoir when the brakes have been released again.

81. Q. In descending a grade, how can you best keep the train under control?

A. First, by commencing the application of the brakes early, so as to prevent too high a speed being reached; secondly, by making an initial reduction that will lightly apply all brakes in the train and by slowing the train down just before it is necessary to charge the auxiliary reservoir, so as to give time enough to refill same before much speed is again attained.

82. Q. If the train is being drawn by two or more locomotives, upon which locomotive should the brakes be controlled, and what must the engineman of the other locomotive do?

A. The brakes must be controlled by the leading locomotive, and the enginemen of the following locomotives must close the cock in the train pipe just below the brake valves. The latter must always keep the pump running and in order, and main reservoir charged with pressure, with the brake valve in the running position, so that he may quickly operate the brakes if called upon to do so.

83. Q. If the air signal whistle gives only a weak blast, what is the probable cause?

A. Either the reducing valve is out of order, so that the pressure is considerably less than forty pounds, or the whistle itself is filled with dirt or not properly adjusted, or the port under the end of signal valve is partly closed by gum or dirt.

84. Q. If the reducing valve for the air signal is allowed to become clogged up with dirt, what will the result probably be?

A. The signal pipe might get the full main reservoir pressure, and the whistle will blow when the brakes are released.

85. Q. If you discover any defect in the air brake or signal apparatus while on the road, what must be done?

A. If it is something that can not be readily remedied at once, it must be reported to the Engine-house Foreman as soon as the run is completed.

86. Q. What is the result if water be allowed to collect in the main reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding air, and the brakes are more liable to stick. In cold weather, also, the water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

87. Q. How often must the air brake and signal apparatus on locomotives be examined?

A. After each trip.

88. Q. Under what pressure must it be examined?

A. Under full pressure.

89. Q. Should the train pipe pressure exceed the maximum, where would you look for the cause of the trouble?

A. In the devices controlling train pipe pressure.

90. Q. How often must the main reservoir and the drain cup under the tender be drained?

A. After each trip.

91. Q. How often must the triple valves and the cylinders of the driver and tender brakes be cleaned and lubricated?

A. They must be thoroughly cleaned and lubricated once every six months. If the driver brake cylinders are so located that they become hot from the boiler, they may require lubrication more frequently.

92. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the locomotive goes out.

93. Q. How is the brake shoe slack of the cam driver brake taken up, and what precautions are necessary?

A. By means of the cam screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact with the cams will be in a line with the piston rod.

94. Q. How is the brake shoe slack of driver brakes on a locomotive with more than two pairs of driving wheels taken up?

A. By means of a turnbuckle or screw in the connecting rods.

95. Q. How is the slack of the tender brake shoes taken up?

A. By means of the dead truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead lever.

96. Q. How far should the driver brake piston travel in applying the brakes?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other forms.

97. Q. What travel of piston should the tender brakes be adjusted for?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches and with others eight inches.

SPECIAL FOR TRAINMEN.

98. Q. How should you proceed to test the air brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be required to apply the brakes; when he has done so the brakes must be examined upon each car to see that the air is applied and that the piston travel is not less than six nor more than nine inches. The engineman must then be required to release the brakes; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so. (In testing passenger brakes, the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.)

99. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car in the train.

100. Q. When might you cut out a brake upon a passenger car?

A. Never, unless it gets out of order while on the run, in which case it must be reported to the inspector at the end of the run, or upon the first opportunity which may give sufficient time to repair it.

101. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

102. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train pipe cock immediately ahead of the burst hose must be closed and the engineman signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

103. Q. If the train breaks in two, what must be done?

A. The cock in the train pipe at the rear end of the first section must be closed and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

104. Q. Explain how the pressure-retaining valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure-retaining valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure-retaining valve in the horizontal position.

105. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-action brake, or in the triple valve of the plain automatic brake, and then opening the release cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

106. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the

triple valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train pipe should always be open from the locomotive to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again, and so that the brakes may be applied with the conductor's valve upon any car.

107. Q. Should the train pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened, and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

108. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of a pipe leading from the train-brake pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

109. Q. What is the air signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord for one second and releasing immediately, allowing three full seconds to elapse between pulls.

110. Q. If the discharge valve on the air-signal system

is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch pipe leading from the train-signal pipe to the discharge valve; to do so the handle of this cock should be placed lengthwise with the pipe.

111. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car such adjuster must be fully released before the slack is taken up elsewhere.

SPECIAL FOR INSPECTORS.

112. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of services?

A. I do.

113. Q. Why is it important that no leaks should exist in the air brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

114. Q. What must be done with the air brake or air-signal couplings when not united to other couplings, on cars equipped with dummy couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling so as to prevent dust and dirt from entering the hose.

115. Q. If the air issues from the exhaust port of the quick-action triple valve when the brakes are off what is the cause?

A. It is probably due to dirt on the rubber seated emergency valve.

116. Q. How often must the cylinder and triple valves be examined, cleaned and lubricated?

A. As often as once every six months on passenger cars and once in twelve months on freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinders.

117. Q. What is the difference between the quick-action passenger and freight triple valve?

A. The passenger triple valves have larger ports and slide valves.

118. Q. How may a passenger triple valve be distinguished?

A. By having one exhaust outlet, or suitable lettering designating the class of service.

119. Q. How may a freight triple valve be distinguished?

A. By its two exhaust outlets, one being plugged.

120. Q. When should the graduating spring of the triple valve be replaced with a new one?

A. When it is worn or rusted out, or not of standard size.

121. Q. To what travel of piston must the brakes be adjusted?

A. Not less than six inches, and this adjustment must be made whenever the piston travel is found to exceed nine inches.

122. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

123. Q. What are the different holes in the outer end

of the cylinder levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of the different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power, otherwise the brake will be inefficient, or the wheels may be slid under the cars.

124. Q. How many sizes of high speed brake-reducing valves are there in use, and how will it be known to which size of cylinders they should be connected?

A. There are three sizes, namely, one for 8-inch, one for 10-inch and 12-inch, and a third for 14-inch and 16-inch cylinders, and they can be distinguished by the raised figures cast on their bodies.

125. Q. To what pressure must the high speed brake-reducing valve be adjusted on passenger equipment cars?

A. The authorized pressure.

SIGHT FEED LUBRICATORS.

FIRST SERIES OF QUESTIONS.

1. Describe the manner in which a sight feed lubricator operates.

A. Sight feed lubricators operate on the hydrostatic principle. In other words, the lubricator depends on the action of natural laws which have to be complied with or failure is the result. The positive steam pressure in the lubricator and pipes being the same as the back pressure, these soon neutralize each other and this leaves the positive pressure of the column of water extending through the pipe leading from the condenser, the condenser itself, and the part of the pipe above it; against this is opposed the back pressure of the column of water in the sight feed

glass. As the latter is much less than the positive pressure, the drops of oil are forced through the nozzle.

2. How should a lubricator be shut off before filling?

A. The feed valves should be shut off first, the water valves next and the steam valves last.

3. Will any bad results ensue from filling a lubricator full with cold oil?

A. Yes; if the lubricator is not provided with an expansion chamber. Oil expands about one-fifth in volume while being heated, from about 70 degrees to the temperature of steam at 200 lbs. pressure, which is 387.7 degrees F.

4. Which is the better practice, to close the feed valves or water valve while waiting on sidings, etc.?

A. The better practice is to close the water valve instead of the regulating valve while waiting on side tracks, or while waiting for orders. By so doing the hydrostatic pressure is cut off from the body of the lubricator and the pressure within the body of the lubricator equalizes with that in the feed glass chamber. Then, by opening the water valve, the feeds will start off at the same number of drops per minute as originally, as the adjustment has not been interfered with. It is not generally understood that if it becomes necessary to do any switching or if the engineer wishes for any reason to feed less oil, he can slow down the number of drops per minute by simply throttling the water valve. This will give the same effect as adjusting the feeds to a slower rate. The only objection that can be made to closing the water valve in these cases is that the air pump does not receive oil while the water valve is thus closed.

5. In what order should valves on lubricator be opened?

A. First, the steam valve. Next, the water valve. Last, the regulating stems. Under no circumstances should the water valve be opened first.

6. Does the draft from the open cab window affect the working of the lubricators? Why?

A. It did with the old tubular glass type of lubricator. The draft blowing on the lower feed arm congealed the oil to such an extent that it affected the rate of feed, but with the newer type of lubricator, such as the Detroit No. 21, the feed chamber is within the body, and the feeds are not affected by any drafts or change of temperature.

7. What else might cause irregularity of the feed?

A. There are three conditions. First, if the engineer should throttle the steam to the lubricator down to that point where it becomes wire-drawn, the combined steam chest pressures would overcome the lubricator pressure and the feed would slow down. Second, if sediment should gather in the water passage to such an extent that the openings would be closed up, this condition would be similar to throttling the water valve and would reduce the number of drops per minute. Third, when the opening through the small choke in the automatic steam chest plug becomes enlarged beyond 7/64 in. the rate of feed will vary. The same will happen when the opening through the chokes at the lubricator end of the oil pipe in some type of lubricators becomes enlarged.

8. If the feeds should stop while running, what is the best plan to follow?

A. Shut feed valve, blow out glass thoroughly, permit it to fill with water and start feed. If this does not give the desired result, at first opportunity disconnect tallow pipe from steam-chest valve and blow out the tallow pipe. Put the reverse lever on center and give engine steam. This will clean out the chest valves and oil plug.

9. If the sight feeds get stopped up, how should they be cleaned?

A. This question has reference to lubricators while in service filled or partly filled with oil. Cleaning can be accomplished by either of the following methods: First,

open the feed regulating valve wide to the feed in question and open the sight feed drain stem. The result will be a lessened pressure in the sight feed chamber, which will force the clogging matter out of the cone. If the obstruction is too great to be forced out in this way try closing the other regulating feed stems and also the water valve. Open the drain valve to the body of the lubricator. This will allow the pressure to escape through the body of the lubricator and at the same time the steam pressure will blow down through the feed cone and will dislodge the obstruction and force it into the body of the lubricator.

10. How should the choke plugs be cleaned?

A. Take them out and examine them. Run a small wire through the opening. They should be renewed when the opening is 7/64 in. in diameter.

11. Can you explain the use of the equalizing pipe?

A. The main object of the equalizing tubes is to overcome the back pressure from the steam chest. At the same time it furnishes condensation to the sight feed chambers. By the use of these tubes the same pressure exists on top of the water in the sight feed chamber as on the surface of the water in the condenser and this steadies the feed.

12. What will be the effect if an equalizing pipe were broken off or became very loose?

A. This has no application to the No. 21 Detroit lubricator bullseye type, as the equalizing tubes are drilled through the metal. In the old style of lubricators, the water of condensation would escape in case the equalizing tubes were broken or became very loose.

13. How can it be known whether the equalizing tubes are stopped up?

A. When it occurs in certain types of lubricators the feeds become unbalanced. It cannot happen to Detroit No. 21 lubricators.

14. Can you explain why, when engine is being worked slowly, with full throttle, the valves become dry and the

lever jumps when the lubricator is apparently feeding properly?

A. There are several reasons, especially with lubricators having the chokes at the lubricator end of the tallow pipe. There may be traps in the tallow pipes in which the oil will accumulate to a greater or less extent, instead of going to the cylinders. The tallow pipes should always have a gradual descent from the lubricator to the steam chest. Another cause is that too small a steam pipe is used to connect the boiler with the lubricator, or steam may be taken from a fountain which has not a large enough connection with the boiler to supply all the demands made on it. Then, again, the lubricator may be properly installed and the engineer may cause this trouble by throttling the steam to the lubricator.

15. What would you do under these circumstances?

A. Supply the correct conditions.

16. How many drops in a pint of valve oil fed through a lubricator?

A. It is impossible to state any absolutely definite number of drops in a pint of valve oil. There are so many conditions which affect the number, such as the density of the oil, the temperature of the oil, the rate of feed, viscosity of oil, size of nozzle, etc. Tests have been made which indicate that there are in the neighborhood of 6,000 drops in a pint of oil; others give 6,600 drops, and this may be taken as a fair basis for answering the following questions.

17. Assuming that five drops per minute are fed to each of two valves and a drop per minute to the pump, how many hours would be required to feed a pint of valve oil?

A. There would be eleven drops per minute leaving the lubricator under these conditions, and assuming that there are 6,600 drops in a pint of oil, the pint of oil would last for 600 minutes, or 10 hours.

18. Assuming that the engine is run 20 miles an hour, how many miles per pint would be run?

A. If a pint of oil lasts 10 hours and an engine runs 20 miles per hour steadily it will be able to run 200 miles on the pint of oil.

19. How many drops per minute should ordinarily be used?

A. This depends on the style of engine and the character of the service being performed and may differ on different roads.

ELECTRIC HEADLIGHT QUESTIONS AND ANSWERS.

1. In preparing the electric headlight for service, what would be the first duties of the engineer?

A. See that bearings have oil, that lamp has sufficient carbon and that commutator is clean.

2. How would you start dynamo to electric headlight?

A. Slowly.

3. How would you operate throttle to dynamo?

A. Wide open.

4. Would there be any danger in opening the throttle quickly?

A. No danger, but not best to do so.

5. How much oil is it necessary to have in cellar to bearings?

A. Enough for ring No. 22 to touch.

6. What kind of oil should be used in these bearings?

A. Valve oil outside and engine oil inside bearing.

7. What should the commutator be cleaned with?

A. Waste, damp first, then dry.

8. How often should commutator be cleaned?

A. Every trip.

9. How should the brushes bear against the commutator?

A. With a good bearing, with only enough pressure to keep them from sparking.

10. With the old style brush holder is there more danger of sparking at commutator than with the improved brush holders?

A. Yes.

11. Should the mica be kept below the commutator bars?

A. Yes.

12. How far should the mica be maintained below the surface of the commutator bars?

A. About 1/64 in.

13. Should sand paper ever be used on commutator?

A. Yes, when commutator is rough or out of round.

14. How should commutator be cleaned after using sand paper on same?

A. Between the copper strips to remove any foreign substance that may have lodged there.

15. What precaution should be taken when applying the carbon?

A. See that it falls freely through clutch No. 44 and carbon holder is on guide.

16. Is it necessary that copper brush attached to carbon clamp bear lightly against guide to upper carbon holder?

A. Yes.

17. What should always be noted after a new carbon has been applied?

A. See question No. 15.

18. If the carbon does not raise up when pushing down on this lever, what is the reason?

A. Carbon is not in clutch No. 44.

19. If the carbon is in clutch and does not fall down freely, what should be done?

A. Change carbon or trim round until it does.

20. How long should a carbon burn?

A. Eight to nine hours.

21. If the carbon continues to burn up in much shorter time, what may be the trouble?

A. Speed too high, or too much draft in case.

22. Is there another reason why carbon will burn more rapidly than it should?

A. No.

23. What are the duties of the tension spring on the lamp?

A. To pull carbons together.

24. What is the correct adjustment of the tension spring?

A. As loose as possible and not break the arc when locomotive is standing.

25. If you should have this tension spring adjusted too tight, what would be the result?

A. Current would become heavy and the light dull.

26. Could you adjust this spring with too light a tension?

A. Yes.

27. Why is it necessary that the point of electrode should be cleaned and free from scale before starting out on a trip?

A. To allow carbon and copper electrode to touch each other, as scale is a non-conductor.

28. If this scale was not cleaned off would the light burn?

A. No.

29. What determines the amount of electrical pressure of voltage of this device?

A. Speed.

30. What is voltage?

A. Pressure.

31. If the voltage or electrical pressure becomes too great, what damage might be done to the copper electrode?

A. It would "fuse."

32. What are the indications shown when the copper electrode is fusing?

A. Green light.

33. What should be done by the engineer when a green shaft of light is seen?

A. Throttle steam at once and report at end of trip.

34. When the light goes out, what is the first thing the engineer should do?

A. Turn off steam.

35. What great damage could be done the armature and field coils if the steam was not shut off, to the turbine, and it should be allowed to run for some considerable time when the light was not burning?

A. Might overheat them and burn off insulation.

36. When there is a short circuit, how may it be made known to the engineer?

A. By turbine running very slow, laboring hard and only a red light at carbons.

37. Where are short circuits most likely to occur?

A. In incandescent wires.

38. How may an engineer know by the operation of this device when the light fails, due to the circuit being broken?

A. Turbine will be running fast with light exhaust and can get no current.

39. What is one of the most essential things in regard to this light?

A. Cleanliness.

TRAIN RULES.

The following train rules taken from the Standard Code refer to the various signals, audible and visible, used on railways. These are authorized by the American Railway Association:

SIGNAL RULES.

RULE 7.—Employes whose duties may require them to give signals, must provide themselves with the proper appliances, keep them in good order and ready for immediate use.

RULE 8.—Flags of the prescribed color must be used by day, and lamps of the prescribed color by night.

RULE 9.—Night signals are to be displayed from sunset to sunrise. When weather or other conditions obscure day signals, night signals must be used in addition.

RULE 10.—VISIBLE SIGNALS.

Color Signals.

Color.	Indication.
(a) Red.	Stop.
(b) ———	Proceed, and for other uses prescribed by the rules.
(c) ———	Proceed with caution, and for other uses prescribed by the rules.
(d) Green and white.	Flag stop. (See Rule 28.)
(e) Blue.	(See Rule 26.*)

*RULE 26.—A blue flag by day and a blue light by night, displayed at one or both ends of an engine, car or train, indicates that workmen are under or about it; when thus protected it must not be coupled to or moved. Workmen will display the blue signals, and the same workmen are alone authorized to remove them. Other cars must not be placed on the same track so as to intercept the view of the blue signals without first notifying the workmen.

RULE 11.—A fusee on or near the track burning red must not be passed until burned out. When burning green it is a caution signal.

RULE 12.—HAND, FLAG AND LAMP SIGNALS.

Manner of Using.	Indication.
(a) Swung across the track.	Stop. (See page 167.)
(b) Raised and lowered vertically.	Proceed. (See page 167.)
(c) Swung vertically in a circle at half arm's length across the track when the train is standing.	Back. (See page 168.)
(d) Swung vertically in a circle at arm's length across the track when the train is running.	Train has parted. (See page 168.)
(e) Swung horizontally above the head when the train is standing.	Apply air brakes. (See page 169.)
(f) Held at arm's length above the head when the train is standing.	Release air brakes. (See page 169.)

RULE 13.—Any object waved violently by any one on or near the track is a signal to stop.

RULE 14.—AUDIBLE SIGNALS.

Engine Whistle Signals.

NOTE.—The signals prescribed are illustrated by o for short sounds; —— for longer sounds. The sound of the

whistle should be distinct, with intensity and duration proportionate to the distance signal is to be conveyed.

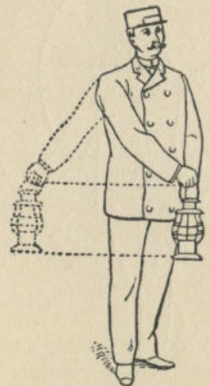
Sound.	Indication.
(a) o	Stop. Apply brakes.
(b) —— ——	Release brakes.
(c) —— ooo	Flagman go back and protect rear of train.
(d) —— —— —— ——	Flagman return from west or south.
(e) —— —— —— —— ——	Flagman return from east or north.
(f) —— —— ——	When running, train parted; to be repeated until answered by the signal prescribed by Rule 12 (d). Answer to 12 (d).
(g) oo	Answer to any signal not otherwise provided for.
(h) ooo	When train is standing, back. Answer to 12 (c) and 16 (c). When train is running, answer to 16 (d).
(j) oooo	Call for signals.
(k) —— oo	To call the attention of yard engines, extra trains or trains of the same or inferior class or inferior right to signals displayed for a following section.
(l) —— —— oo	Approaching public crossings at grade.
(m) ————	Approaching stations, junctions and railroad crossings at grade.

A succession of short sounds of the whistle is an alarm for persons or cattle on the track.

RULE 15.—The explosion of one torpedo is a signal to stop; the explosion of two not more than 200 feet apart is a signal to reduce speed and look out for a stop signal.

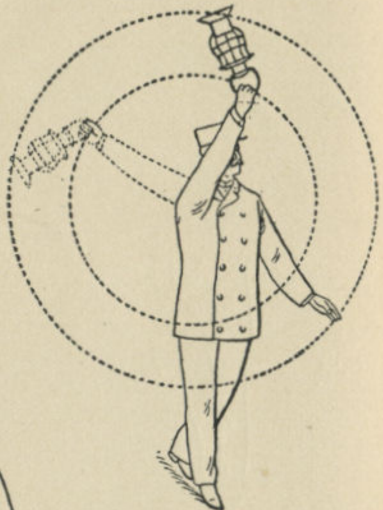
RULE 16.—COMMUNICATING SIGNALS.

Sound.	Indication.
(a) Two.	When train is standing, start.
(b) Two.	When train is running, stop at once.
(c) Three.	When train is standing, back the train.
(d) Three.	When train is running, stop at next station.
(e) Four.	When train is standing, apply or release air brakes.
(f) Four.	When train is running, reduce speed.
(g) Five.	When train is standing, call in flagman.
(h) Five.	When the train is running, increase speed.



STOP—Swung across the track. See Rule 12 (a).

PROCEED—Raised and lowered vertically. See Rule 12 (b).

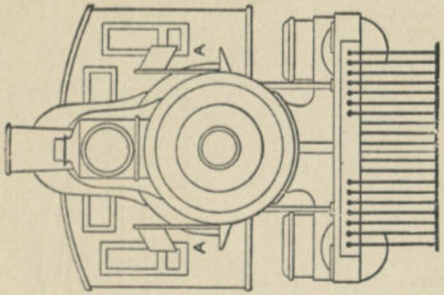


TRAIN HAS PARTED—Swung vertically in a circle at arm's length across the track. See Rules 12 (d) and 14 (f).

BACK—Swung vertically in a circle at half arm's length across the track. See Rules 12 (c) and 14 (h).

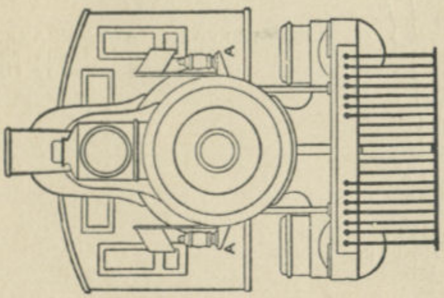
RELEASE AIR BRAKES—Held at arm's length above the head. See Rue 12 (f).

APPLY AIR BRAKES—Swung horizontally above the head. See Rule 12 (e).



ENGINE RUNNING FORWARD BY DAY AS AN EXTRA TRAIN.

White flags at A A.
See Rule 21.

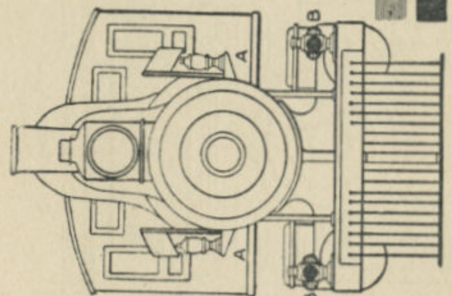


ENGINE RUNNING FORWARD BY NIGHT AS AN EXTRA TRAIN.

White lights and white flags at A A
See Rule 21.

GREEN.

RED.

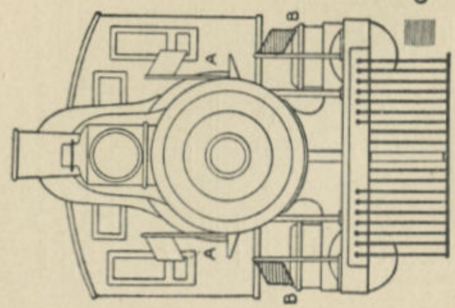


ENGINE RUNNING BACKWARD BY NIGHT AS AN EXTRA TRAIN, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.

White lights and white flags at A A. See Rule 21.

Lights at B B, as markers, showing green at side and in direction engine is moving and red in opposite direction. See Rules 19 and *D*-19.

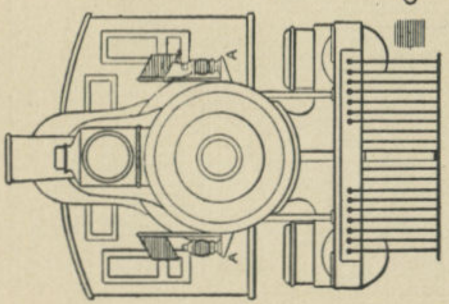
GREEN.



ENGINE RUNNING BACKWARD BY DAY AS AN EXTRA TRAIN, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.

White flags at A A. See Rule 21.

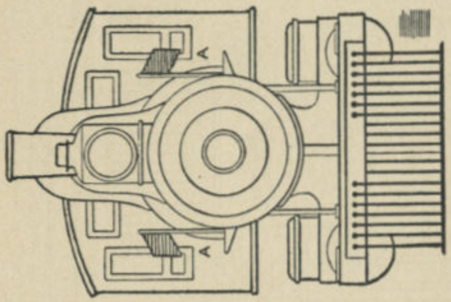
Green flags at B B, as markers. See Rules 19 and *D*-19.



GREEN.

ENGINE RUNNING FORWARD AT NIGHT DISPLAYING SIGNALS FOR A FOLLOWING SECTION.

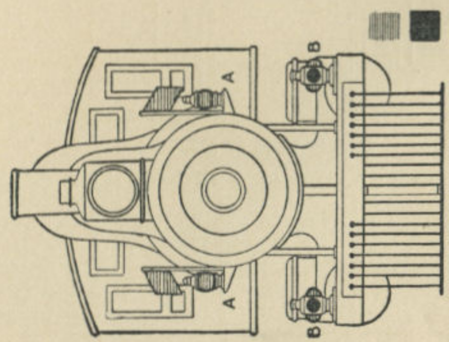
Green lights and green flags at A A.
See Rule 20.



GREEN.

ENGINE RUNNING FORWARD BY DAY DISPLAYING SIGNALS FOR A FOLLOWING SECTION.

Green flags at A A.
See Rule 20.



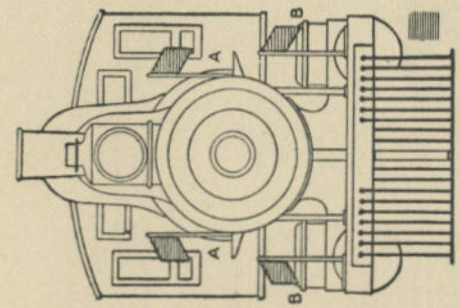
GREEN.

RED.

ENGINE RUNNING BACKWARD BY NIGHT, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS, AND DISPLAYING SIGNALS FOR A FOLLOWING SECTION.

Green lights and green flags at A A. See Rule 20.

Lights at B B, as markers, showing green at side and in direction engine is moving and red in opposite direction. See Rules 19 and *D*-19.

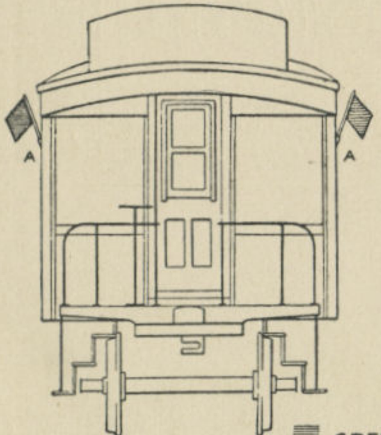


GREEN.

ENGINE RUNNING BACKWARD BY DAY, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS, AND DISPLAYING SIGNALS FOR A FOLLOWING SECTION.

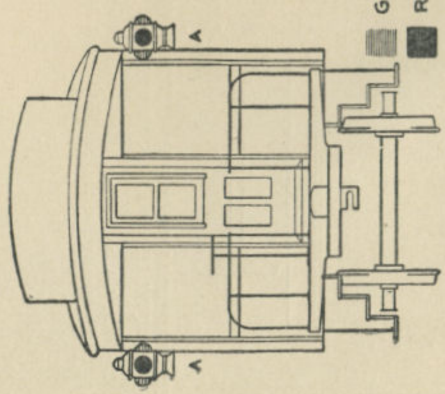
Green flags at A A. See Rule 20

Green flags at B B, as markers. See Rules 19 and *D*-19



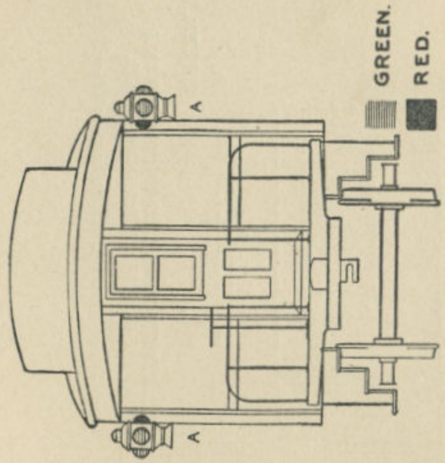
REAR OF TRAIN BY DAY.

Green flags at A A, as markers. See Rules 19 and *D*-19.



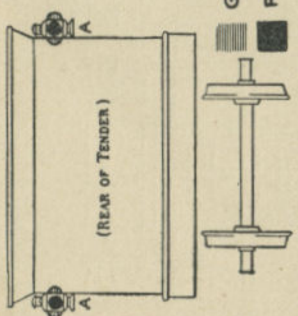
REAR OF TRAIN BY NIGHT WHILE RUNNNIG.

Lights at A A, as markers, showing green toward engine and side and red to rear. See Rules 19 and *D*-19.



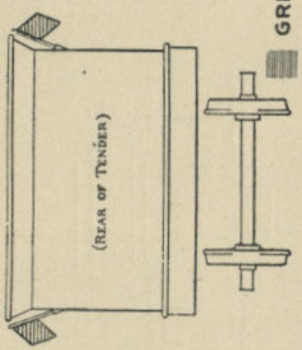
REAR OF TRAIN BY NIGHT WHEN ON SIDING TO BE PASSED BY ANOTHER TRAIN.

Lights at A A, as markers, showing green toward engine, side and to rear. See Rules 19 and *D*-19.



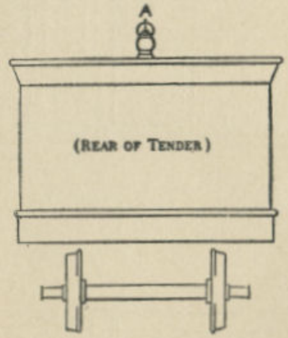
ENGINE RUNNING FORWARD BY NIGHT, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.

Lights at A A, as markers, showing green to the front and side and red to rear. See Rules 19 and *D*-19.



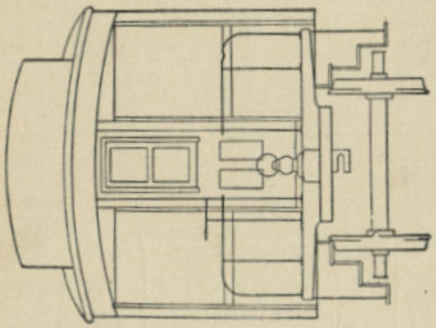
ENGINE RUNNING FORWARD BY DAY, WITHOUT CARS OR AT THE REAR OF A TRAIN PUSHING CARS.

Green flags, as markers. See Rules 19 and *D*-19.



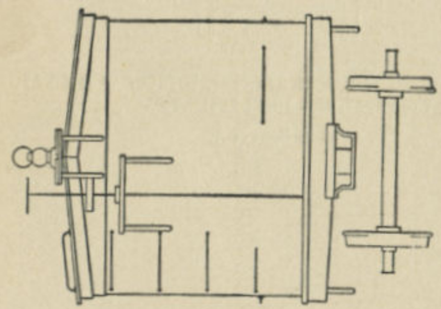
ENGINE RUNNING BACKWARD BY NIGHT, WITHOUT CARS OR AT THE FRONT OF A TRAIN PULLING CARS.

White light at A.



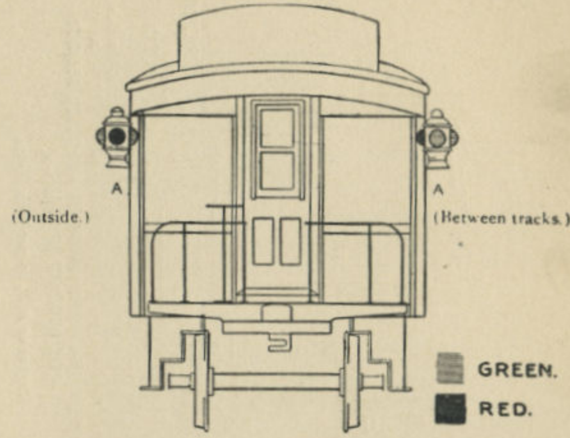
PASSENGER CARS BEING PUSHED BY AN ENGINE BY NIGHT.

White light on front of leading car. See Rule 24.



FREIGHT CARS BEING PUSHED BY AN ENGINE BY NIGHT.

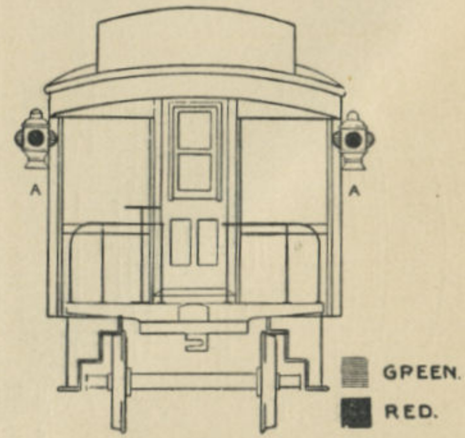
White light on front of leading car. See Rule 24.



REAR OF TRAIN BY NIGHT RUNNING AGAINST THE CURRENT OF TRAFFIC.

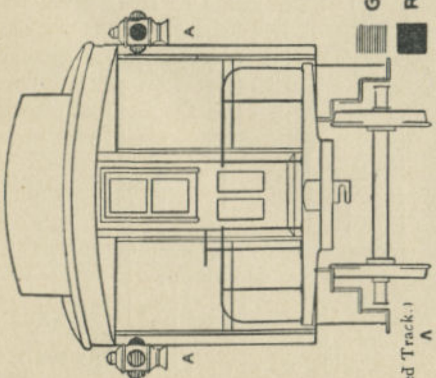
(This illustration is for a road which uses the right hand track.)

Lights at A A, as per Rule D-19.



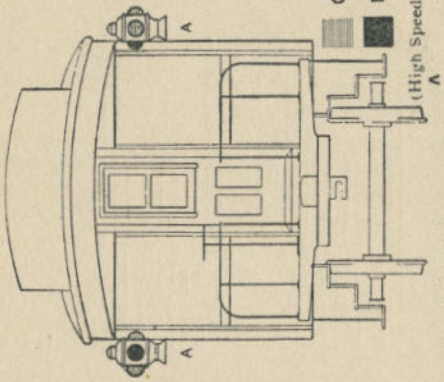
REAR OF TRAIN BY NIGHT RUNNING WITH THE CURRENT OF TRAFFIC ON A HIGH SPEED TRACK.

Lights at A A, as per Rule F-274



REAR OF TRAIN BY NIGHT RUNNING WITH THE CURRENT OF TRAFFIC ON A SLOW SPEED TRACK.

Lights at A A, as per Rule F-274.



REAR OF TRAIN BY NIGHT RUNNING ON ANY TRACK AGAINST THE CURRENT OF TRAFFIC.

Lights at A A, as per Rule F-274.

SECTION VII

Locomotives Using Oil for Fuel.

There is considerable curiosity in the East, where coal is used exclusively for fuel, about the oil burners on the Pacific Coast. A representative of *Locomotive Engineering* recently spent some time on these oil burners, and this article shows how a coal burner engineer looks at the operations of using oil for fuel. We will not go into the chemical questions involved in the matter of the perfect combustion of oil fuel, but treat of the mechanical side of it and the apparatus used.

On the Southern California Railroad—which is now a part of the Santa Fe route—Master Mechanic G. W. Prescott began burning oil in 1894, and they have used it more or less ever since. Various minor changes have been made with a view to improve the process; but in the main the arrangement has been about the same for the last three or four years; about all their engines burn oil now. The Southern Pacific Company also burn oil. Since the discoveries of oil near Bakerfield they are changing their engines from coal into oil rapidly, putting up supply tanks wherever needed, and it looks as if the use of coal there would fall off considerably. On the Southern California part of the Santa Fe route, to change from coal to oil fuel the grates are taken out and a cast-iron plate is placed 4 to 6 inches below the mud ring, extending over the entire space under the firebox. This plate has three openings for air to come up into the firebox, 9 x 15 inches, one of these air openings being in the middle of the firebox, one near the front end and one near the back end. This plate is protected from the heat of the fire above by a covering of fire brick. The ash pan and dampers are left the same as a coal burner. The sides of the firebox are also protected from the direct force of the intense heat by a fire-brick wall about 5 inches thick, which comes up to the flues in front, up above the flare of the firebox on the sides and to the bottom of the door at the back. There is a brick arch extending across the firebox from side to side, reaching back pretty well towards the door, just the same as in a soft coal burner. Some of the engines also have a narrow arch just under the door, which serves to keep the intense heat from the door ring.

The side walls of brick in the box do not last very long, some of them not over three weeks. They can be patched by putting in new brick when the holes are found in the old ones. Generally a whole new wall is put in at a time. With the oil burners the crown sheet lasts about as long as with coal, but the side sheets, even with the protection of the brick walls, give out at the flare of the box, near the door and at the top of the brick walls on the sides. The staybolts behind the brick walls leak some, but it does not seem to affect the steaming; the water runs down the sheet into the pan if it is not all evaporated at once. When the flues of an oil burner begin to leak badly they soon stop up, and she dies in short order. In this they are different from coal burners.

The atomizer which separates the oil into a fine spray and blows it into the firebox is located just under the mud ring, pointing a little upward, so the stream of oil spray and steam would strike the opposite wall of the box a few inches above the bottom, if it was to fly clear across the box. Deep fireboxes have the atomizer at the back end of the box, while the shallow and long fireboxes have it located at the front end, pointed back. The shallow boxes have the same arrangement of side walls that the deep ones have, but the arch is put in differently; some of them have three small arches extending from side to side, but lapping over each other from front to back, so as to divide the current of flame and heat into several parts and thus distribute

it over the long, shallow box more evenly. A good deal depends on the size and position of the arch, which has the same effect on the steaming of an oil burner that the diaphragm in the front end has on the draft of a coal burner. No air is admitted above the fire of the atomized oil.

The atomizers (one for each engine is used) are of brass, 12 inches long, 4½ inches wide from side to side and 2 inches thick from top to bottom, divided into two parts by a partition in the middle. Steam comes into the bottom part, heats the atomizer and issues through a slit 1-32 by 4 inches. The oil flows into the top part of the atomizer over the hot partition, and on running out of the front end is caught by the steam issuing from the slit in the bottom part, and is sprayed into the fire, which, when the engine is working, is a mass of flame, filling the firebox under the arch, and most of the time the whole box. If the supply of oil fed in is more than can be consumed in the box you will occasionally see little flashes of flame at the top of the stack.

The supply of steam and oil to the atomizer is regulated by the fireman from the cab, the handles for the steam and oil supply valves being placed where he can have his hands on them when on his seat box. He is located where he can see the gauge clearly, and as he sometimes pumps the engine with the left-hand injector, it has to be handy also.

Before the oil is fed into the atomizer it passes through a small heater made of brass, having a steam pipe through it; this same steam pipe also leads to a coil in the bottom of oil tank to warm the oil so it will flow easily. The oil on the Pacific Coast is not at all like the fuel oil we get from Indiana or the Lima field. Some of it has a generous portion of thick stuff like asphaltum in it, so it does not flow very easily; while other kinds are thin as water, and almost as clear.

The oil tank is located in the pit of the water tank, where we usually carry coal. In the tenders built especially for oil burners the oil tank is surrounded by the water. An air pipe leads from the main reservoir to the oil tank, with a reducing valve similar to the one used in the air signal line, but with a different spring box, so as to reduce the very high main reservoir pressures carried on the mountain engines down to 4 pounds, which is maintained in the oil tank, so the oil comes out freely. Self-closing valves are provided to shut off the flow of oil in case the engine breaks loose from the tender, as in case of accident the oil flowing into the wreck would make a bad matter worse. The exhaust tip is about the same size as the engine would have if she was burning good coal. Some of the engines have no changes made in the front end except to take out the netting; others have a low nozzle and petticoat pipe put in instead of high nozzle and a diaphragm or apron. I was somewhat surprised at this, as it would seem that more air could be drawn into the box through three openings 9 x 15 inches in size than could come through a coal fire. Another surprise was the fact that oil burners make considerable smoke, although it was stated by some of the enginemen that if properly handled they would make no smoke; others said it was no harm if they made a little smoke at times. The oil makes a sort of sticky deposit in the flues, which soon coats them and interferes with the steaming. To cure this difficulty, the fireman sticks a long tunnel through a hole in the fire box door made for that purpose, and gives the flues a dose of about four quarts of sand, which is drawn through the flues and scours them out. When this sand goes through a black cloud comes out of the stack as thick as from any soft coal burner.

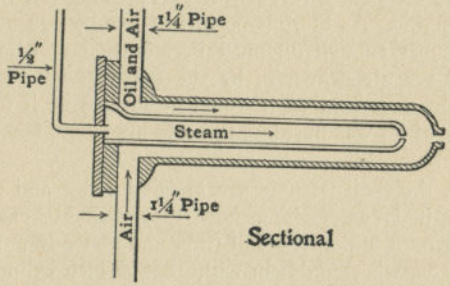
If this oil could be vaporized by heat as easily as it is atomized by steam, that is, changed into a gas instead of a spray, like gasoline is burned, it might be made smokeless; but the oil has a heavy residuum in it that cannot be vaporized very well. Then, the changing conditions under

which the engine is worked interferes with perfect combustion. At one time, when working hard, a large stream of oil flows into the atomizer; when switching or running shut off, a very little is used; so the fireman has to open and close the oil supply valve with every change in the work of the engine. As there is no bed of live coal to hold back the air, just enough oil must be admitted and burned to heat all the air drawn in by the exhaust, for if this air struck the flues cold, as it would be sure to do if too small a supply of oil was burning, the cold air would soon set the flues leaking.

When these oil burners are in good order and properly handled it is astonishing how they will steam. When working on a hill with a full train and a steady pull for 21 miles, a ten-wheel Baldwin with 21 x 28-inch cylinders and 56-inch drivers would pick right up with both injectors on full, and these injectors large enough so one of them would ordinarily supply her. Of course, if not properly handled, oil burners will lag on their steam, but ordinarily they steam "like a house afire," as one of the firemen expressed it.

Do not think that firing one of them is a soft snap because there is no real coal to handle. The fireman has to stay right on his box, with his hand on the handle of the oil supply valve, which is like the handle of F-6 brake valve, with very fine notches in the quadrant or ledge, he watches the gauge and the engineer and regulates the supply of oil to suit the work. When running shut off or switching at stations, it is a close matter to allow enough oil to go to the atomizer to keep the fire alive and not have too much.

There is a good deal of water in the oil, and they are so near the same specific gravity that the water comes through with the oil. When a charge of water comes through the fire goes out for an instant, but lights up again when the oil comes again. The end of the supply pipe for the oil is located a little way above the bottom of the oil tank, so as to draw oil only, but the water comes in also. There is a drain pipe in the bottom of the oil tank, which can be opened at any time to drain off the water.



SHEEDY-CARRICK OIL BURNER.

As to the relative expense of oil and coal for fuel, coal is so high priced there that oil does the work cheaper. Good coal at Los Angeles and San Bernardino costs $6.50 to $7.50; oil costs about $2 a ton less. Where they burn good coal it takes a little more than a ton of coal to equal a ton of oil, but at Barstow and east of there, where the coal is poor, it takes nearly two tons of coal to equal one ton of oil. The engines do not steam as freely with the coal, so they cannot make as good time or handle a large train at as high a rate of speed. Time in transit is of some account and is worth money.

In the East, the country of cheap coal and dear oil, we will not be apt to see any oil burners for some time, except for special purposes. If some of the poor steamers that handle heavy passenger trains were turned into oil burners it would enable the engines to do better work, for there is apparently no limit to the steaming power of an oil burner.

At terminals there is no waiting to clean fires, arches or flues before the engine can go back. If the machinery is all right they take oil and water at the same time, and the engine is ready to go out, which is a saving when short of power. The oil is fed into the tender from elevated tanks just the same as we take water, and as quickly. Storage tanks are located along the road where needed, the same as coal chutes. At San Bernardino the Santa Fe have a large main storage tank 96 feet in diameter and 30 feet high, which holds one and one-half million gallons. All the oil at this point is elevated and handled with compressed air with no waste.

The tanks along the road are much smaller affairs, like small water tanks.

The discovery of the extensive oil fields at Bakersfield has added such a large amount to the visible supply that there is no risk of its giving out very soon, and the engines between Kern City and Los Angeles on the Southern Pacific are to be turned into oil burners. The changes are now being made.

Firing Liquid Fuel.

Many people think that on locomotives burning liquid fuel the fireman has nothing more to do than open the valve admitting the oil and that the burners do the rest. From a letter of instruction issued by Mr. R. E. French, master mechanic of the Southern Pacific at Bakersfield, Cal., we judge that both care and skill are requisite to burn liquid fuel properly. The letter reads:

"Please see that following rules are adhered to in firing and management of oil-burning engines:

"Before departure see that oil tanks are full, oil heater in operation and oil heated to proper temperature as soon as possible; also that fire is burning, that no oil is dropping or lying in outer pan, and that no brick or other obstruction to the free passage of oil from the burner to front wall is lying on bottom of inner pan, and that sand buckets are full.

"STARTING THE FIRE.—When firebox is below igniting point, which is a dull red, open dampers, start blower and atomizer medium hard, throw a piece of saturated oily waste, after lighting same, on to the bottom of inner pan; close and fasten firebox door, then turn on oil very light, and see if it ignites at once. If not, shut off oil at once, and see if waste is burning. When oil has ignited reduce blower and atomizer to very light feed, also reduce oil flow until stack becomes almost clear. Starting the fire by the hot fire box, no waste is used.

"TEMPERATURE OF OIL.—Kern River or thick oil to be heated to from 150 to 170 degrees, McKittrick or thin oil from 100 to 120 degrees; temperature to be taken from measuring rod suspended in forward tank. Vents on top of oil tanks to be kept open at all times, except when tanks are very full and oil is liable to splash out, they may be closed until oil is reduced from 5 to 7 inches in tanks, care being taken not to have any lights in hands when they are first opened after having been closed any length of time.

"HEATING OIL BY DIRECT STEAM APPLICATION.—Put heater on strong until oil has reached the proper temperature, then close it off, give it another application. To keep the heater on light and constant might produce water enough in oil to become objectionable.

"HEATING BY THE COIL IN TANK.—Open cock on boiler head just sufficient to produce steam water at drain cock under tank. Superheater should be used constantly when weather is in any way chilly. Keep drain cock to superheater open just sufficient to keep cylinder dry.

"STARTING TRAIN OR ENGINE.—Engine should not be started until fireman is at firing valve. Remember that the care of firebox is as important as keeping up steam or making time. Start engine carefully, so, if possible, not to slip engine. Open firing valve sufficiently to make sure that action of exhaust will not put out fire, but not enough to make great volumes of black smoke. Increase atomizer and oil gradually until full speed is attained, keeping just

on verge of black smoke. When engine is hooked up, valves governing the admission of oil will be regulated according to required amount. It is well to use the blower about one-half turn while starting, so this will help to consume smoke between exhausts; also, keep engine hot.

"BLACK SMOKE.—Never make an excessively heavy smoke, as it only fills flues with soot, which is a great non-conductor of heat and produces no heat in itself.

"SANDING FLUES.—Sand as frequently as required, according to amount of smoke made. If engine has to be smoked anyway hard, sand every 10 or 12 miles. But if stack is kept clear, use sand every 30 to 50 miles. If any amount of switching is done at a station, sand immediately after leaving that station. How to sand: Having attained a fair rate of speed, use about one quart of sand, close all dampers, put reverse lever near full stroke, open throttle wide, allow sand to be drawn from funnel in a thin stream. Going into stations where stops are to be made great care must be exercised not to cut oil supply too low before throttle is closed.

"Any draft through firebox has a tendency to put fire out; the stronger the draft the stronger must be the oil supply. Consequently, there is great danger of fire being put entirely out before throttle is closed. When throttle is closed and oil reduced, the atomizer must be cut down at once, so it will just keep oil from dropping on bottom of inner pan, otherwise the intense heat of the firebox will be blown down through air inlet burning bottoms of pans.

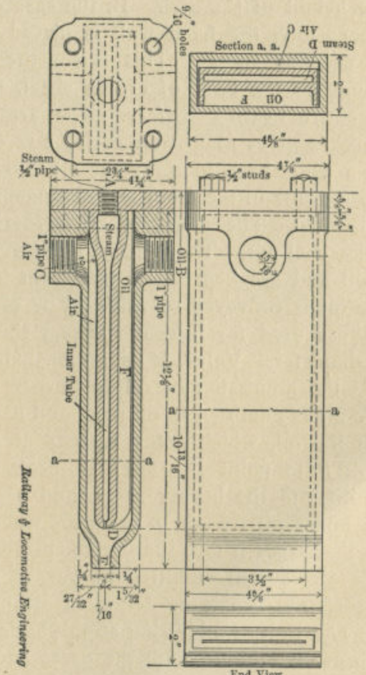
"Never allow fire to be put entirely out, except when giving up engine at end of run or when all hands are going away from engine. Then it must be put out. To put out fire, first close stop-cock under tank, allow oil to all be drawn from pipe and burner, then close firing valve atomizer and all dampers. To blow obstruction from oil line, close firing valve, open cock between heater line and oil line, close heater line and turn cock on boiler head to heater line on full. This will blow all obstruction back in tank. This arrangement may be used to heat oil in tank in case of a failure of coil heater. If any brick from walls or arches in firebox should fall in front of burner, it must be removed at once or pushed to the extreme front of firebox. Blue gas issuing from stack is indication that the fire is out or very nearly so. It is very objectionable and should be avoided if possible, especially so on passenger trains.

"Burners must be adjusted to that oil will strike about middle of front wall. If oil drags on bottom of pan, black smoke and poor steam will result. Burners are liable to clog up with sand that is in oil and by pieces of waste that are sucked up by air inlet. If trouble is found with it, the inner case or steam jet can be taken out in most cases without disturbing the outer case or adjustment of burner. In this manner any obstruction or defect may be readily located and remedied. The blower must never be used stronger than just sufficient to clear stack of black smoke. Any more is only a waste of fuel and a delay, as too strong a draft through firebox for the amount of oil admitted only absorbs heat and cools instead of heating firebox. At water tanks, where it is necessary to keep injector on all the time the train is standing, the oil supply must be left on a little heavy and blower on lightly. This will insure a full head of steam when ready to start. As the oil penetrates the arch brick and causes them to crumble away very fast, it is important to examine firebox frequently to know condition of it. As steam pressure increases on boiler, atomizer and blower will work stronger unless they are cut down. Be governed accordingly. Also remember that black smoke is very detrimental to steam generating, and that the more that is made the more it becomes necessary to make."

Burning Oil Fuel in Locomotives.

BY H. M. HONN, Trav. Fireman S. J. Div. S. P. R. R.

About the first question a man who has had no experience with oil fuel will ask himself is, How is it done? By



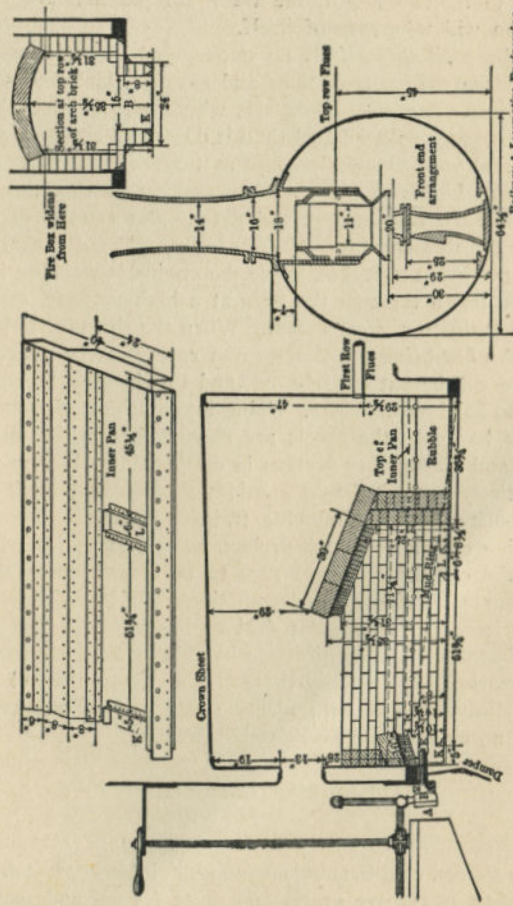
OIL BURNER.

a little study of the accompanying sketches it will be clear.

In equipping an engine for oil fuel, the grates are removed and the pan called inner pan is substituted. It is bolted to side sheets at about the same place as grates were, and extends 6 to 8 inches below foundation ring or position of the burner. This pan supports side walls and arches, and is covered with fire brick except at air inlets, *L* and *K*.

It will be noticed that the box is walled up all around to about the height of the arch. In the case of a firebox 7 feet or more long the front wall is placed back a distance from the flue sheet. This is for the purpose of throwing flame to the back of crown sheet, thus getting the use of entire heating surface. The arrangement of walls and arches gives almost an entire box of fire brick that gets to a white heat, to spray the oil into. But very little change is made in the front end arrangements, except no netting is used. The supply of oil is carried in tanks placed in the coal pit. They carry from 1,500 to 2,000 gallons of oil and are kept warm by steam heaters from boiler. The oil is conveyed to valve *H* by pipe and hose similar to those used for injectors except they are about 1¼ inches diameter. Valve *H* is an ordinary stop-cock and controls the admission of oil to burner and firebox. Atmospheric air is admitted to oil pipe, and passes through burner with the oil, which enters burner at *B*, and runs along trough *F* to point *D*. Here it meets a steam jet that is admitted to the burner at *A*, and passes through burner just under oil trough to point *D*, where it catches the oil and discharges it into the firebox through nozzle *E*. Atmospheric air is also admitted to burner at *C* and is drawn to discharge nozzle by action of steam jet (called atomizer). The plan of admitting atmospheric air through burner is to get it mingled with the gases and just at the time when it is needed. Air is also admitted to firebox through openings *K* and *L* in bottom of inner pan.

To start the fire when the firebox is cold, roundhouse steam is conveyed to burner through blower pipe, and a pipe from this to burner called atomizer pipe. A piece of oil-saturated and ignited waste is thrown in the firebox and oil turned on very light. The waste will keep up a



ARRANGEMENT OF OIL BURNER'S FIREBOX.

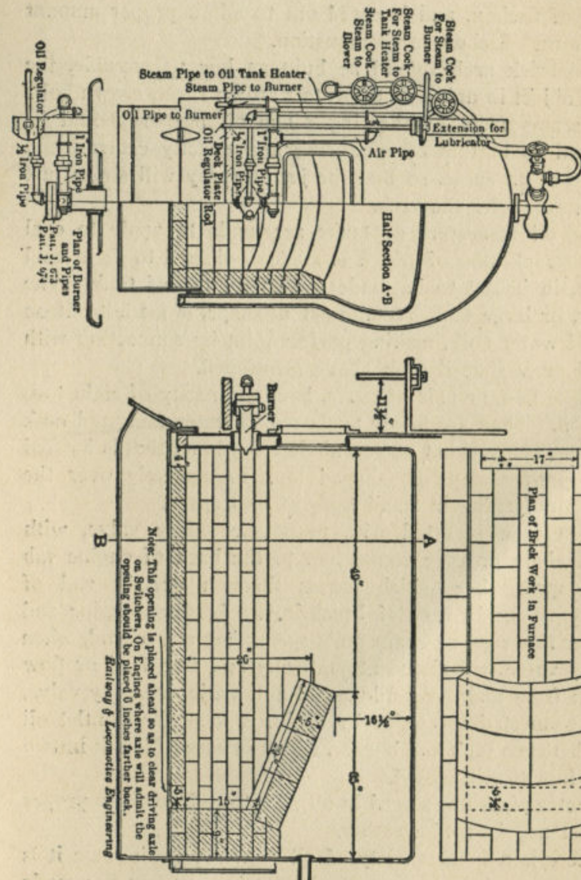
flame to ignite oil until the walls get red hot, and then ignition will take care of itself.

To burn oil successfully no smoke must be made, as this lays a coat of soot on flues and sheets, which keeps the heat away. A person might ask, why does soot accumulate on flues more with oil fuel than it does with coal? Simply with coal you have cinders and particles of coal to keep it cut off, while with oil you have nothing passing through the flues but smoke, heat and gases. But sand is carried along for this purpose. If flues become sooted a quart or so is put into the firebox while the engine is working hard and is drawn through the flues at a high velocity, cutting the soot off to a great extent. When the throttle is closed and the fire being cut down great care must be exercised or fire will be put entirely out, and this is what makes oil fuel so hard on fireboxes. Going into stations where stops are to be made, the sheets are expanded with the intense heat, and the careless fireman in cutting down his fire puts it entirely out. Take in consideration natural draft and add to it velocity of moving train and pump exhaust all drawing cold air through firebox, cooling sheets and flues, and the consequences are sure to be disastrous to them. Of course, burning oil in locomotives is in its infancy, and there is room for a great deal of improvement, but considering the length of time we have been at it, it certainly is remarkable to see how those engines go up the hill with their heavy trains, with plenty steam and no smoke, no dust, no cinders and no sweating fireman.

Oil-Burning Locomotives.

EQUIPMENT.

To convert coal-burning engine into oil burner it is necessary first to remove grates and grate frames and remodel the ashpan by applying suitable casting that will fit the inside of pan, to be riveted on sides and near the top of



pan, this casting to act as support for the brick work on sides of firebox, and is cored out to admit proper amount of air into firebox for combustion.

The brick arch should be built as low as possible, the main object in doing so to protect crown sheet, crown bolts and seams from overheating. The oil burner should be secured to bottom of mud ring and exactly central, and placed at an angle, so that the jet or spray will strike just below or under the arch.

The oil reservoirs or tanks are made to apply to coal burner tank, one of which is made V-shaped to fit in coal space, in height to be made flush with top of tank. The other, or large tank, rectangular in shape, is made to fit on top of water tank, making perfect joint by connecting with small or V-shaped tank above mentioned.

These two, or pair of tanks, have a capacity of eight tons fuel oil. They are firmly anchored to water tank and tank frame. There is but one manhole for oil and that is located on top of rectangular-shaped tank immediately over the joint or opening in small tank in coal space.

Each tank is fitted with automatic safety valve, with small chain or rope connection to the back of engine cab with spring key which passes through upright rod of safety valve; in case of break-in-two between engine and tender this rope or chain pulls spring key out of rod, when safety valve will close automatically and stop feed or flow of oil from tank. An additional automatic or safety valve, also connected to engine by chain, is located in outlet oil pipe between tank and burner, which in case of break-in-two is automatically closed.

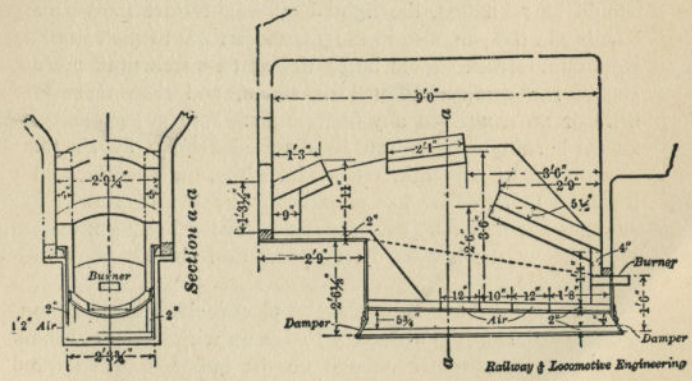
Heater pipes are placed in oil tank to reduce oil to proper consistency in cold weather.

There is a great variety of oil burners; with some it is necessary to have a separate heater box, others are made with heater box and burner combined.

In localities where heavy oil is used it is necessary to

carry above five pounds pressure in oil tanks to facilitate proper feed of oil. With light gravity and in warm weather pressure in tank is not necessary.

When new engines are furnished and built as oil burners,



FIREBOX ARRANGEMENT FOR SANTA FE OIL BURNERS.

would recommend equipping with what is known on Southern California Division as Standard Combination Oil and Water Tank. These are constructed with oil tank submerged inside water tank.

HANDLING AND OPERATING.

In firing up an oil burner, provided it is where steam pressure can be obtained for use as a blower, throw in firebox a piece of greasy lighted waste, then start oil lightly, then open atomizer valve enough to atomize what oil is passing from burner and oil will instantly ignite. Care should be taken not to turn on too much oil, for the explosion would drive the flame out of the firebox and might be the cause of injury to the operator.

After the fire has gotten to burning nicely, close the door tight and occasionally examine the engine to know that the fire is burning. Often, on account of water in the oil, the fire will be put out and oil will continue to run into the pan and from the pan into the pit; and then, if the fire should be rekindled, the lighted oil might start the oil to burning in the pan, also in the pit, and set fire to the engine. Roundhouse men should be particular to watch until after engine has commenced making steam, and then there is little or no danger of any bad results. Fire going out on an oil-burning engine can be detected readily by smoke coming out of the stack. It is of a white, milky color, and indicates that the fire has gone out and that the oil is still running out into the pan. Smoke is caused by the heat of the brick in the bottom of the pan. Can also be detected by the odor.

Firing up oil-burning engines at places where there is no steam available, it is necessary to fire up with enough wood to get steam pressure enough on the boiler to work the atomizer. Care should be exercised by the operative in throwing wood into the box not to injure the brick wall, or arch, and care should be exercised by engineer in starting out of terminal with an oil-burning engine which has been fired up with wood to see that there are no sparks to endanger equipment and surrounding country.

It is very important that proper amount of steam be admitted to burner as an atomizer. It is also very important that brick walls and arch be kept in perfect condition. Occasionally small pieces of brick will fall down and lodge in front of burner, which will interfere with engine steaming. All engines should be equipped with pair of light tongs or hook, so the foreman can remove these pieces of brick when necessary.

In oil-burning engines it is necessary to occasionally use sand for cleaning the gum off the end of flues in the firebox. This sand is applied through an elbow-shaped funnel made for the purpose; the nozzle of the funnel is inserted through

an aperture in the fire door, and when sand is being applied by the fireman the engineer drops the lever in the corner notch and has his throttle wide open. This is very effective, and is only used three or four times going over a long, hard division.

In handling oil burner on the road the engineers and fireman must work in harmony—*i. e.,* when an engineer wishes to shut off the throttle he should notify the fireman in time, so that the latter can close the oil valve in order to prevent waste of oil, black smoke and engine popping off; and again, in starting up, the engineer should notify the fireman, so the oil valve may be opened before the throttle that the fire may be burning before any cold air is drawn into the firebox by the exhaust. In opening the valve the oil should be gradually increased as the engineer increases the working of the engine. If this rule is carried out it will in a great measure prevent leaky flues, crown and staybolts. Firebox can be easily damaged by over-firing.

In a coal burner, if an engine drops back 5 to 10 pounds pressure it takes some little time to regain it; in an oil burner the fire can be crowded so as to bring it up almost instantly, and thereby overheat the plates and cause damage to the firebox. The right way is to consume about as much time in bringing up steam on an oil burner as you would consume in doing so with a coal burner; too much care cannot be exercised in this particular. It is possible to melt the rivets off the inside of an oil-burner firebox by over-firing.

While there are a few things to say against an oil-burning device on a locomotive, there are a great many things to say in its favor. It will reduce the life of flues and firebox about 25 per cent.; while on the other hand it is perfectly free from starting fires on the right-of-way or setting fire to equipment. The cost of handling fuel is at least 75 per cent. cheaper than that of coal. It does away with clinkering of engines at terminals and on the road; reduces the time consumed in turning power; does not have any cinders to take care of. If the oil crane and water tank are spotted at places so that the oil and water can be taken at the same time, there is no reason why an engine cannot be turned in from 20 to 25 minutes. There is little or nothing to get wrong with an oil burner, so far as the oil-burning apparatus is concerned; burner may stop up by sediment or burst from heat, but these are rare occurrences. We have had some failures on account of waste getting into the oil tank; these were caused by carelessness on the part of hostlers and helpers in measuring the oil and wiping the measuring stick off with waste. Use of waste for this purpose has since been discontinued.

DON'TS.

Do not approach manhole or vent holes of tank with lighted torch or lantern closer than ten (10) feet.

Do not take lighted torch or lantern to manhole to ascertain the amount of oil in tank, but ascertain with stick or rod, which is to be carried to a light, to find number of inches on stick or rod.

Do not, when making repairs or inspection of empty tank, place lighted lamp or torch inside of the same before tank has been thoroughly steamed and washed out, as gas will accumulate in an empty tank not so steamed and washed and explosion is liable.

Do not, in firing up, apply atomizer and oil before putting in the lighted waste, as gas may accumulate in firebox and cause an explosion.

FINIS.

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