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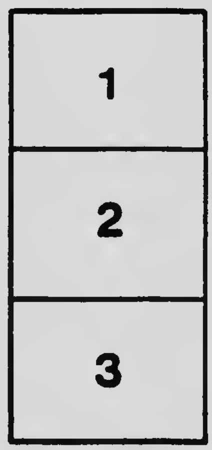
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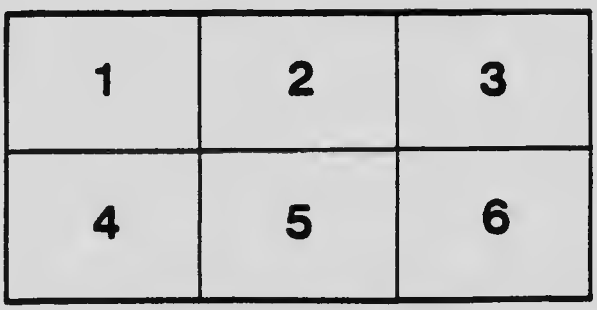
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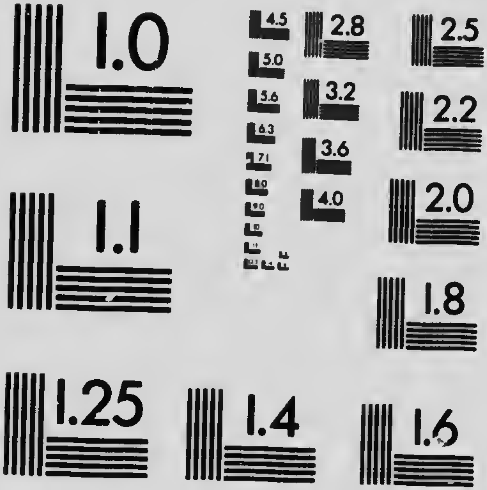

The Canadian New First, Second and Third Year Examinations

FOR

Engineers and Firemen

Complete Explanatory and Instructive Answers to the Three Series of Examination Questions, Covering in Detail Locomotive Firing, including Combustion and Care of the Boiler; the Care and Management of Simple and Compound Locomotives; Airbrake Handling; Breakdowns; Electric Headlights; Superheaters; Walschaert Valve Gear; Oil Burning Locomotives; together with Supplementary Questions and Answers

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Edited by
FREDERICK J. PRIOR

BEING ONE OF THE SERIES OF THE PRIOR SYSTEM OF SELF-EDUCATIONAL TEXT AND REFERENCE BOOKS

WESTERN PUBLISHING AND SUPPLY CO.,
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PRACTICAL BOOKS FOR RAILROAD MEN
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INTRODUCTORY.

Not all firemen become engineers, but all engineers were once firemen. The highly responsible position of locomotive engineer is becoming more and more exacting in its requirements and the educational standard is being continually raised higher and higher. Firemen who aspire to be engineers must make diligent preparation to qualify by experience gained during the apprenticeship period while firing a locomotive successfully and through study.

The purpose of examinations is to test the amount of knowledge a fireman has and thereby determine to some extent his fitness for promotion. Students should not imagine it is enough merely to learn the answers to the examinations without getting a thorough understanding of the principles. All the facts in connection with each and every question in each of the examinations should be so thoroughly mastered and understood that the question could be asked from any angle and a satisfactory answer be given.

While these answers are intended to aid and assist students to prepare for examinations they are not intended to be copied or learned by heart without a full and complete understanding of the subjects covered. This understanding can be acquired only by actual experience together with observation and study and it is for the purpose of helping the fireman to educate himself in that manner that this little book is sent forth upon its mission.

TABLE OF CONTENTS.

THE FIRST YEAR EXAMINATION

QUESTIONS AND ANSWERS

COMBUSTION AND GOOD FIRING

THE CANADIAN NEW FIRST. SECOND AND THIRD YEAR EXAMINATIONS FOR ENGINEERS AND FIREMEN

[First Year Examination]

Ques. 1: What are the duties of a fireman on his arrival at the engine house previous to his going out on trip?

Ans.: Examine the bulletin board or hook and ascertain to what engine he is assigned.

Ques. 2: Have you acquired the habit of comparing the time with your engineer, and do you insist on seeing the train orders?

Ans.: Yes, since it is in accordance with the rules and even if the rules did not require it, it is essential for a man's own safety to compare watches and understand all train orders.

Ques. 3: Upon reaching your engine what are your first duties?

Ans.: Examine the fire to see that it is clean; try the grates to see that they work properly; look at the flues and crown sheet to make sure there are no leaks, and in case there are leaks call the engineer's attention to them; see that the proper tools are on the engine, (scoop, shakebar, rake, etc.,) also the proper flags, fuses, torpedoes, red light and other supplies. See that there is plenty of coal and sand, and a full tank of water; build up the fire and get it in proper shape for the run, and if time permits, assist the engineer with such work as is customary.

Ques. 4: What is the composition of bituminous coal?

Ans.: Carbon, hydrogen, nitrogen, oxygen, sulphur, and ash; carbon about 80%; hydrogen about 5% and the remaining 15% waste or non-combustible. The percentage of each element varies with different qualities of coal.

Ques. 5: What are the heat producing substances in the coal?

Ans.: Carbon and hydrogen.

Ques. 6: Of what does burning or combustion consist and what three things are essential to produce it?

Ans.: Combustion, in simple language, means burning, the burning of anything being an illustration of the process of combustion. To give a more theoretical definition, it is the rapid chemical combination of any substance with what is known as oxygen. This combination produces light and heat. The three essential things are Carbon, Hydrogen and Oxygen.

Ques. 7: From what source do we draw the oxygen that burns the carbon and gases?

Ans.: The atmosphere.

Ques. 8: How is forced draft created in a fire-box and why is it necessary?

Ans.: The draft is created through the fire-box by the action of the exhaust steam passing through the nozzle in the front end and out the stack. This exhaust steam in its passage to the stack drives with it the air and gases in the front end, leaving a partially empty space or vacuum there. If the front end is tight, the only way this vacuum can be supplied is by the air forcing its way through the ash-pan, through the fire and flues and into the front end. This exhaust action being practically continuous, produces a constant draft on the fire during the time steam is being used.

Ques. 9: Describe the condition in which your fire should be when ready for the trip and say what you would do to get it in that condition?

Ans.: The fire should have a good, level bed of coke on the grates so as to keep up steam during the first few exhausts. Would build it up ready for the run by adding coal a little at a time, and often, putting on the blower, if necessary, so as to maintain a good head of steam.

Ques. 10: State how you would fire the engine while she was running along working to obtain the best results.

Ans.: To begin with, the fire should be built properly and an effort made to carry a light, level and bright fire. It should be fired light and often with coal well broken up, spreading the coal evenly on the bright spots and closing the door between each scoopful, adding fuel only often enough to keep up the necessary steam pressure.

Ques. 11: Describe the appearance of the fire when best results are being obtained.

Ans.: The fire should be a bright red, which will indicate a temperature of about 1,800 degrees F.

Ques. 12: Where should the coal, as a rule, be placed in the firebox?

Ans.: Generally speaking, the bright spots should be covered with fresh coal, because they indicate places where the fire is nearly burned out and where combustion is taking place most rapidly, therefore, they should be covered or they would burn out and leave dead spots in the fire.

Ques. 13: Why is it very important that the coal should be broken so that it will not be larger than an ordinary apple before being placed in the firebox?

Ans.: If coal is broken to about the size of an apple before firing, it gives better results than when in big lumps, for the reason that a greater surface is presented to the action of the fire, hence burning takes place more rapidly, the coal can be spread more evenly and a better fire can be maintained.

Ques. 14: In what condition should the fire be maintained in regard to its depth or thickness?

Ans.: The depth of the fire to be carried in an engine can only be determined from practical experience. It depends on the draft of the engine, on the quality of the coal and on the work which the engine will have to do in handling its train. The fire, however, should be as light as practicable to give good results and furnish sufficient steam for the work the engine is doing. Better results can be obtained with a reasonably light fire than with a heavy fire.

Ques. 15: Does the amount of air admitted to the firebox have any bearing on the amount of coal consumed or the heat produced? Say why.

Ans.: Yes, since theoretically perfect firing or perfection combustion, is obtained when each particle of carbon unites with two particles of oxygen, forming the mixture carbonic acid gas, producing nearly 15,000 heat units. Should the supply of air be too small for obtaining two parts of oxygen for each particle of carbon, one part of each would combine, producing carbonic oxide gas, producing only about 4,500 heat units

Ques. 16: In what way does the condition of the fire with regard to depth, holes, banks or clinkers, affect the admission of air?

Ans.: If the fire is too thin in depth, too much air coming through will tear holes in it; the admission of too much air through these holes would reduce the fire-box temperature; banks or clinkers would prevent air entering and so retard combustion.

Ques. 17: What are the evil effects of too strong a draft?

Ans.: Too strong a draft draws cold air through the flues, causing them to contract and leak.

Ques. 18: What bad effects would follow from carrying (a) too heavy a fire? (b) too light a fire?

Ans.: Too heavy a fire is likely to result in dead spots and banks. (b) Too light a fire would let too much air through, resulting in reducing the temperature below the ignition point.

Ques. 19: If, while the engine were standing, the fire were to become very light and thin and a heavy train were then to be lifted what would be the effect on the fire?

Ans.: The firebox door should be held open, letting in air enough to prevent tearing the fire, watching very closely to see that the engine does not slip when the door is closed, because if it does a large portion of the fire might be carried out of the stack.

Ques. 20: What harm is done from putting more than 3 or 4 scoops of coal on the fire at one time under ordinary working conditions?

Ans.: The effect is the more coal placed on the fire at one time, the more the temperature of the fire-box is reduced, causing it to fall below the igniting temperature of the gases, resulting in the large volume of gases thus liberated not mixing with the air in the fire box and being drawn through the flues unconsumed, causing expansion and contraction of the fire box and sheets and increasing the amount of black smoke. It is a waste of fuel to fire in this manner and besides it leads to leaky flues and causes the fire to become clinkered or dirty very quickly.

Ques. 21: Other conditions being the same which would give the better results in burning fuel, a wide firebox with 50 square feet of grate surface, or a narrow firebox with a grate area of 30 square feet? Why?

Ans.: A wide firebox with 50 square feet of grate surface; because more oxygen would be admitted with the air coming through the grate area to be mixed with the carbon and volatile gases, and being spread over the whole surface would greatly aid in combustion.

Ques. 22: What are the advantages of utilizing the total grate surface?

Ans.: It affords increased direct heating surface, the heat units are utilized better; a larger nozzle may be used thus reducing back pressure in the cylinders; a lighter draft may be used and thus a slower rate of combustion obtained, all contributing to fuel economy.

Ques. 23: How can you prevent good coal being pulled through the flues and out of the stack?

Ans.: By firing properly and by taking care t admit sufficient air at the right times and at th right places to ensure as nearly as possible, perfec combustion.

Ques. 24: Is there a serious loss from this cause If so, what conditions are there that increase it o make it less?

Ans.: Yes, there is. Careless firing increases it careful firing makes it less. By firing carefully enough air is admitted just as it is needed; the temperature of the firebox being kept at the ignition degree which is done by properly maintaining the fire in good condition.

Quer. 25: What causes a pull on the firebox door when the engine is working?

Ans.: The partial vacuum in the front end; excessive "pull" indicates dampers closed, grates clinkered or stopped up.

Ques. 26: Do you consider it beneficial or otherwise to have banks or holes in the fire and why?

Ans.: It is not beneficial; indeed, it is harmful to have banks or holes in the fire because either would cause sudden changes in the firebox temperature, resulting in leaky flues due to the contraction and expansion of the metal.

Ques. 27: What will cause the engine to tear holes in the fire?

Ans.: Improper or careless firing; or the engine being improperly drafted in the latter case there would be an uneven pull on the fire. Working the engine hard, or slipping the drivers with the dampers open, door closed and too thin a fire.

Ques. 28: What causes an engine to bank her fire, and how would you guard against them and remove them when formed?

Ans.: Too heavy firing, insufficient air; firebox temperature too low; would guard against them by careful firing. When formed would remove them with the rake by breaking their crusts and spreading over the top of the fire.

Ques. 29: When fire burns most in front of firebox what does it denote?

Ans.: It denotes that the diaphragm should be slightly raised.

Ques. 30: When fire burns most in back of firebox what does it denote?

Ans.: The diaphragm should be lowered slightly.

Ques. 31: If an engine burns her fire in either way what can you do to make it work better?

Ans.: Adjust the diaphragm properly.

Ques. 32: When and for what purpose is the use of the rake on the fire allowable?

Ans.: The use of a rake should not be necessary, but in case a bank forms in the fire or there is a dead spot or clinker to be removed, the rake may be used. In case of a bank its crust should be broken up and spread over the top of the fire. The rake should not be thrust down through the fire so as to affect its bed, unless when pulling out clinkers or filling up dead spots, as the surest way to form clinkers is to disturb the bed of the fire with the rake.

Ques. 33: What are the effects, good and bad, of raking the fire while the engine is working?

Ans.: The good effects are the removal of banks; and when necessary, the removal of clinkers, and the filling up of dead spots. The bad effects are the disturbance of the bed of coke and by letting fresh coal down to the grates, the formation of clinkers.

Ques. 34: Describe the ash-pan and say what its uses are.

Ans.: It is a receptacle secured to the bottom of the fire-box and is provided with two or more dampers, designed to regulate the admission of air to the fire. It holds the ashes dropped from the fire-box and thus prevents their setting fire to bridges, cattle-guards and other property elsewhere along the road.

Ques. 35: Why are the dampers and netting provided in the ash-pan?

Ans.: The dampers are for regulating the admission of air to the fire, through which it passes to the fire-box; the netting is to prevent hot ashes or cinders from falling out upon the right-of-way.

Ques. 36: Why are the grates made to shake, and when should they be shaken?

Ans.: The grates are so made in order that the fire may be kept clean and the ashes be shaken into the ash-pan. Grates should be shaken often enough to keep the fire clean and in good condition.

Ques. 37: Does any loss occur from a too frequent shaking of the grates? From too severe a shaking?

Ans.: Yes; too frequent or too severe shaking causes the hot coke to fall from the fire-box, resulting in the loss of unconsumed carbon.

Ques. 38: If clinkers form on the grates what will be the effect on the burning? Say how you would avoid them.

Ans.: Clinkers on the grates obstruct air from entering at those places where clinkers are, producing dead spots and loss of heat. Would avoid them by careful firing and by keeping grates shaken as necessary.

Ques. 39: What will be the effect of allowing the ash-pan to become filled with ashes and clinkers?

Ans.: The fireman should examine his ash-pan frequently and clean it whenever necessary. If the ash-pan gets too full it does not allow the proper amount of air to come through the fire and, consequently, the fire does not burn properly. There is also danger of warping or burning the ash-pan and grates if it is allowed to get too full.

Ques. 40: Do you consider it beneficial or otherwise to admit air to the fire-box above the surface of the fire? Give your reasons.

Ans.: It is beneficial to admit it above the surface of the fire at certain times only, and then only in small quantities. Only enough should be admitted to aid combustion after a fresh charge of coal is put in, for the reason that too much would cool the fire-box temperature and retard instead of aid combustion.

Ques. 41: What effect does the opening of the fire box door have on the fire?

Ans.: It has a deadening effect, because the great volume of cold air admitted reduces the temperature below the ignition point, causing imperfect combustion. It also allows the air to enter the fire box above the fire instead of passing up through it, thus reducing the draft on the fire. It also admits air in such large quantities as in some cases to stop the combustion of the gases above the fire. It also causes leaky flues. The good effect if air is admitted in small quantities above the fire is that the oxygen mixes with the gases and aids in burning them.

Ques. 42: Is it a good practice to leave the fire box door open longer than is absolutely necessary while the engine is working? Say why.

Ans.: It is not, because it interferes with proper combustion by letting into the fire box more oxygen than the gases from the carbon can utilize above the fire.

Ques. 43: What is black smoke and is it combustible?

Ans.: Black smoke consists of a mixture of gases and carbon, the greater part being carbon. It is combustible but in locomotive service cannot be consumed after it has once formed.

Ques. 44: Why does black smoke clear up so quickly when fire box door is opened?

Ans.: Because the gases from the carbon are swiftly carried away unconsumed by the great inrush of air above the fire, combustion ceases almost entirely and a red fire results from which no volatile gases are obtained because of the low temperature.

Ques. 45: What effect has the stoppage of a number of tubes?

Ans.: It would interfere with the even burning of the fire, increase the speed of gases through flues, and, in consequence, reduce the number of heat units, seriously diminishing heat efficiency for making steam, and it also materially reduces the heating surface of the boiler, because a large proportion of the heating surface is in the flues.

Ques. 46: What harm may follow if a bank

were allowed to form and remain against the tube sheet?

Ans.: Leaky tubes might result.

Ques. 47: Has improper firing any tendency to cause the tubes to leak, and how?

Ans.: Yes; because improper firing may result in holes or dead spots or banks in the fire, which would cause sudden changes in the temperature of the fire box, resulting often in leaky flues, because of the expansion and contraction in the metal, due to sudden temperature changes. When firing locomotives having wide fire boxes one has to be extra careful in this respect, as the danger of leaky flues, due to this cause, is greater.

Ques. 48: How would you care for a boiler with leaky tubes or fire box?

Ans.: The fire should be maintained at a temperature as nearly uniform as possible. The fire door should be kept closed as much as possible, the blower used but little and the firing done evenly with coal broken into small pieces. The injector should not be worked very long at a time when the engine is shut off; care should be taken to keep the grates free from clinkers and the dampers should be used with intelligent judgment.

Ques. 49: What advantages are derived from an arch in a locomotive fire box?

Ans.: It induces a more perfect combustion by retaining the gases in the fire box until they have reached the igniting point. It thus prevents, partially at least, black smoke, by giving the fire time to consume the carbon and gases. It also partially heats the cold air before it enters the flues, and otherwise acts as a deflector on the fire.

Ques. 50: (a) What is meant by atmospheric pressure? (b) What pressure is indicated by the steam gauge?

Ans.: Atmospheric pressure is the weight or pressure of the atmosphere (or air) which surrounds the earth—about 15 pounds per square inch at sea level. (b) The steam gauge indicates the pressure in the boiler above the ordinary atmospheric pressure.

Ques. 51: At what temperature does water boil under atmospheric pressure at sea level?

Ans.: 212 degrees F.

Ques. 52: Is there any difference in the temperature of water at the boiling point under atmospheric pressure and under a pressure of 200 pounds?

Ans.: No, there is not.

Ques. 53: About what is a fair average quantity of water which should be evaporated in a locomotive boiler per pound of coal consumed?

Ans.: Seven to eight pounds to each pound of bituminous coal; six to seven pounds to each pound of anthracite coal.

Ques. 54: About what should be the height of the water level in the boiler when all is ready for starting on the trip?

Ans.: As high as practicable without danger of flooding the cylinders; the level should be closely watched while firing to prevent popping off.

Ques. 55: Can the firing be done more intelligently if the water level is observed closely? Why?

Ans.: Yes; if upon approaching a station or the summit of a grade the water level is high, the fire can be burned low before shutting off to prevent the engine popping off, but if the water level is low a bright fire should be maintained while the boiler is being filled. There are also many other reasons why the water level should be closely watched at all times. In some cases engineers allow firemen to pump the engine in order that they may be able to regulate the fire to correspond with the amount of water in the boiler.

Ques. 56: Why is it desirable that a uniform boiler pressure be maintained?

Ans.: Because increases in pressures cause increases in temperature, which often results in unequal expansion. Too great an excess also causes waste of steam and of fuel.

Ques. 57: Is it any advantage to a fireman to know the grades of the road and the location of the stations?

Ans.: Yes, it is, because knowledge of grades enables him to manage his fire in accordance with the demands made upon the steam in proportion to the power required in ascending grades. Knowing the location of stations enables him to prevent waste of fuel through unnecessary popping of the safety or pop valves, and it enables him to fire intelligently with reference to the station stops.

Ques. 58: What is the purpose of a safety valve on a locomotive boiler? Why is more than one used?

Ans.: To insure safety by providing an outlet for steam when the pressure is greater than that which the boiler is designed to withstand. Safety valves operate automatically and more than one is used, so that in case one should fail to open, the others will relieve the excess pressure within the boiler.

Ques. 59: What should be done to prevent waste of steam through the safety valve?

Ans.: The last charge of fuel should have been put in far enough away from the station to give time for the gases to have burned before steam is shut off. Care should be taken, however, to have a good bed of fire, so that it may be quickly built up again when starting away in order to maintain the steam pressure.

Ques. 60: What is the estimated waste of coal for each minute the safety valve is open?

Ans.: About fifteen pounds of coal are wasted each minute the safety valve is open; this is equivalent to one scoopful of coal each minute.

Ques. 61: Is it not a waste of fuel to open fire box door to prevent pops from opening? How can this be prevented more economically?

Ans.: Yes it is. This can be prevented by maintaining the fire in proper condition.

Ques. 62: What should be the condition of the fire when passing over the summit of a long grade?

Ans.: When passing over the summit of a long grade the gases should be sufficiently burned out of the coal so that when the engine is shut off in tipping over the summit there will be a good, bright bed of fire left and but little smoke produced. In case there is plenty of water in the boiler the fire should be allowed to burn down sufficiently so that the engine will not pop off while drifting down the hill.

Ques. 63: What should be the condition of the fire when arriving at a station where a stop is to be made? When arriving at a terminal?

Ans.: When a stop is to be made at a station the last fire should have been put in far enough from the station so that the gases are burned out from the coal when steam is shut off. There should be a good bed of fire in the fire box, however, so that the fire can be built up quickly and the steam pressure maintained when starting away from the station. The fire should have been left in such condition that it may be cleaned properly. The water level should be as high as it is practicable to carry without flooding the cylinders.

Ques. 64: What are the duties of a fireman on arrival at the terminal?

Ans.: His duties are, first, to see that the fire has been left in proper condition, so it may be cleaned properly; second, that the tools are put away, so that when the tank is filled with coal none of them will be buried; and, third, to attend to any other duties as prescribed by the company.

AIR BRAKE

FIRST YEAR QUESTIONS AND ANSWERS

AIR BRAKE QUESTIONS.
(FIRST YEAR)

Ques. 1: What are the essential parts of the air brake as applied to a locomotive?

Ans.: The air pump, pump governor, main drum, auxiliary reservoirs, engineer's brake valve, air gauge, triple valves, brake cylinders and train pipe, with its cock.

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

Ans.: By the steam driven air pump.

Ques. 3: How many kinds of triple valves are there in use?

Ans.: Three; the plain, quick-action and "K" triple.

Ques. 4: What is the main reservoir used for and where is it usually located?

Ans.: For storing the compressed air. It is usually located on the locomotive.

Ques. 5: What is the usual standard train pipe pressure?

Ans.: 70 pounds per square inch.

Ques. 6: What is the standard main reservoir pressure carried on this system: (a) with ordinary governor? (b) With duplex governor?

Ans.: This question the student must answer from his own knowledge. The main reservoir standard pressure usually carried is 90 to 110 pounds.

Ques. 7: Why is it important that all air brake apparatus should be kept tight and free from leaks?

Ans.: Because any leakages reduce the pressure and if sufficiently large would, if from the train line, result in applying the brakes.

Ques. 8: Where does the air come from that operates the sand blower, bellringer, air signal whistle and other devices?

Ans.: From the main reservoir.

Ques. 9: Explain how an air pump should be started and run on the road?

Ans.: It should be started slowly, allowing the condensation to be drained off and worked slowly until about twenty pounds of air is obtained, which will act as a cushion for the pump; then open it up and pump up the required pressure.

Ques. 10: How should the steam end be oiled?

Ans.: The lubricator should be opened as soon as the pump is started, giving the pump five or six drops at once, then reduce it so it will feed as it should.

Ques. 11: How should the air end of the pump be oiled and what kind of oil used?

Ans.: 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 the 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.

Ques. 12: How is the automatic brake applied and released?

Ans.: By the triple valve, which operates in response to the manually operated engineer's brake valve.

Ques. 13: (a) How many positions are there of the brake valve? (b) What are they?

Ans.: (a) Five. (b) Release, running, lap, service and emergency.

THE SECOND YEAR EXAMINATION

QUESTIONS AND ANSWERS

The Boiler; Injectors, Lubricators and Other Appliances

SECOND YEAR EXAMINATION.
(THE LOCOMOTIVE)

Ques. 1: Name the different types of boilers in use on the road.

Ans.: This question must be answered in accordance with the facts as known to the student.

Ques. 2: What is a wide fire box boiler? A narrow fire box boiler?

Ans.: A wide fire box boiler has the fire box set above the frames and extending out on each side beyond the driving wheels. A narrow fire box boiler has the fire box placed on top of the frames, but between the drivers.

Ques. 3: Describe the different methods of supporting the crown sheet of the fire box by crown stays and radial stays.

Ans.: Two methods of supporting the crown sheets are generally employed. One is the crown bar method, the other the radial stay method. In the crown bar method, heavy iron bars are riveted together, with sufficient space between for the crown bolts to pass through them. They are placed so that their curved ends rest on each side of the crown sheet, near its edge. The crown bolts passing between these bars extend through the crown sheet and are bolted tight, and the sets of the crown bars are placed close enough to form a solid brace for the crown sheet. The crown bars, in turn, are supported by sling stays, which extend from the crown bars to the outer shell of the boiler, and are securely fastened there. In the radial stay method, stay bolts are passed through the outer shell, or through the crown sheet itself as near radial to the curves of the two sheets as possible. These radial stays are placed close enough to provide sufficient strength to withstand the pressure the boiler is expected to carry.

Ques. 4: How is the fire box stayed to the side sheets?

Ans.: By stay-bolts extending from the sheets to the outer shell of the boiler.

Ques. 5: How do you tell when a stay bolt is broken?

Ans.: A small hole is drilled in the outer end of most stay-bolts to provide a means of determining when it is broken, because as these bolts usually break near the outer shell, the steam escaping through the small hole will indicate a break.

Ques. 6: How are the tubes fastened in the front end? In the back end?

Ans.: The tubes or flues are usually expanded in the holes drilled in the front and back sheets. After a copper ferrule has been slipped around the end of the tube it is expanded by means of an "expander," usually the "prosser;" the projecting ends of the tubes are turned back into the sheet and by means of a caulking tool are beaded. Front and back ends are fastened alike.

Ques. 7: What action takes place between the flue and the flue sheet when the flue commences to leak?

Ans.: The flue contracts and becomes loosened from the flue sheet, the steam-tight joint is opened and the leak follows.

Ques. 8: What causes this action in the first place?

Ans.: Usually it is caused by too great and sudden reductions in fire-box temperature; and sometimes by "honeycombing" of cinders at the end of the flue.

Ques. 9: To what strains is a fire box subjected in addition to those caused by the steam pressure?

Ans.: To the strains of unequal expansion and contraction

Ques. 10: What are the two main causes of unequal expansion and contraction in the fire box and flues?

Ans.: Admitting too much cold air above the fire by opening the fire door at the wrong time and for too long, causing a sudden and great reduction in fire box temperature. Putting into the boiler large quantities of cold water.

Ques. 11: Why is the admission of an excessive amount of cold air through the grates and fire door injurious?

Ans.: Because it affects the temperature and causes contraction of the flues; and besides, it affects the steaming efficiency of the boiler.

Ques. 12: How should an engine be handled on an ashpit to prevent injury to the fire box?

Ans.: The air-pump should not be run while engine is on an ashpit.

Ques. 13: What is meant by circulation in a locomotive boiler?

Ans.: When water in a boiler is boiling it is in constant motion because steam, being gaseous, rises to the top. The weight of the water diminishes in proportion to its heat; the hotter it gets the less its weight; therefore, as its temperature increases it rises higher and higher in the boiler, until the hottest of it is at the top. So when cold water is put into a boiler it goes to the bottom at once because of its heavy weight, but no sooner does it get there than it begins to absorb heat and immediately starts upon its upward movement continuing until it is so hot that it gets to the top, replacing the water which has passed out in the form of steam or gas.

Ques. 14: Is the water put in by the injector hotter or colder than that in the boiler?

Ans.: Colder.

Ques. 15: Where does this water flow to?

Ans.: It flowes downward as soon as it enters the boiler.

Ques. 16: Is there any difference in temperature between the water in the top and bottom of a boiler? If so, is it the same when the engine is steaming as when it is shut off? If different, why?

Ans.: It is claimed that when water in a boiler is circulating properly the temperature is nearly uniform, but it seems only reasonable to assume that it is coldest at the bottom. It is not the same when engine is shut off as when it is steaming, because of the absence of circulation due to the rapid evaporating of steam when it is steaming.

Ques. 17: How should the injector be used in order to prevent as far as possible damage to the boiler?

Ans.: Just hard enough to maintain the water level in the boiler.

Ques. 18: How much water should you have in the boiler when it is given up at the roundhouse?

Ans.: The glass should show nearly full.

Ques. 19: When should this water be put in?

Ans.: Whilst coming into the terminal, and switching over to the ashpit.

Ques. 20: What is scale caused by?

Ans.: Deposits of lime or other matter carried in solution in the water used in the boiler.

Ques. 21: What is the effect of scale in a boiler?

Ans.: It results in the flues becoming overheated, in the sheets becoming "mud-burned," and might, if not attended to, result in the tubes bursting or collapsing.

Ques. 22: What difference does scale make on the temperature of the flues and fire box sheets?

Ans.: It greatly increases the temperature, sometimes causing the sheets to become red hot and the crown-sheet to sag down in spots.

Ques. 23: Why do locomotives require more careful handling with the blower and injector when using water that causes scale?

Ans.: Because of the greater liability to foam and prime.

Ques. 24: How can you detect the presence of scale or mud on the sheets of a fire box?

Ans.: The flue sheet will become "honeycombed" or coated over when on the road. Another indication is small pieces of unburned coal clinging to the sheets.

Ques. 25: Explain the construction of the blow-off cock.

Ans.: A blow-off cock may be either a glove valve operated by a screw, a taper plug valve operated by a lever, a sliding disc 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 opened is to permit the escape of sediment and impurities from the boiler, and for that reason they are located at the bottom or "legs" of the boiler.

Ques. 26: When should it be used?

Ans.: This depends altogether on the kind of water being used and on how often the boiler is washed out. Speaking generally, care should always be taken to see that the blow-off cock is not open where it will do injury to persons standing near. The boiler should be well filled before the blow-off cock is opened. One or two gauges of water can be blown out if conditions warrant it. Unnec[illegible]y use of the blow-off should be avoided, however, as considerable coal is used in producing the heat that is wasted when the boiler is blown off.

Ques. 27: How should the draft be distributed in the fire box?

Ans.: The draft should be equally distributed.

Ques. 28: Name the various adjustable appliances in front end, by which the fire is regulated.

Ans.: The exhaust nozzle, the diaphragm and the draft pipes, or "petticoat pipes."

Ques. 29: What does it indicate when the exhaust issues strongest from one side of the stack?

Ans.: It indicates that the exhaust pipe or the petticoat pipes are out of plumb.

Ques. 30: Why is it important that there be no holes through smoke-box sheets, or front end, and none in smoke-box seams or joints?

Ans.: 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 any fire that may be in the smoke-box, which warps and destroys the sheets or front-end.

Ques. 31: Explain the principle upon which the steam gauge works.

Ans.: The elliptical shaped tube curved in a circle constituting a gauge is attached to a lever and ratchet connecting with the pointer on the dial. The steam pressing within the tube tends to straighten it—the higher the pressure is the greater is the tendency to straighten out. Therefore, as the tube moves in its effort to straighten out, the pointer on the dial moves with it. The dial markings are arranged so that any given pressure of steam put on the tube is indicated by the pointer.

Ques. 32: What is the cause of the drumming noise when engine is shut off? How do you avoid it?

Ans.: It is said to be a succession of minute explosions of gases in the fire box; it can and should be avoided by dropping the dampers or opening the doors, because the noise is extremely disagreeable to those within hearing.

Ques. 33: Describe the principle upon which the injectors work.

Ans.: The action of the injector is due, first, to the difference between "kinetic" (or moving energy) and "static" (or standing energy); second, to the fact that steam at a pressure travels at a tremendous velocity and if placed in contact with a stream of water imparts to that stream much of its velocity and in addition becomes itself condensed to water.

Ques. 34: What is the difference between a lifting and non-lifting injector?

Ans.: A lifting injector will create sufficient vacuum to raise the water from the level of the tank. The tubes in a non-lifting injector are shaped differently and will not draw or lift the water, but merely force it into the boiler.

Ques. 35: Will injector work with a leak between injector and tank? Why? Will it prime?

Ans.: Not if a bad leak, it will not prime, because the air admitted to the leak destroys the vacuum necessary to raise the water to the injector level. A non-lifting injector will often work as the water will escape from the leak instead of air being admitted through it.

Ques. 36: If it primes good, but breaks when

steam is turned on, where would you look for the trouble?

Ans.: Would expect to find it was caused by an insufficient water supply, due possibly to the tank valve not being open or the strainer stopped up, or the hose kinked, etc., or the injector tubes may be out of line, lined up or the combining nozzle cut out, or wet steam from the throttle.

Ques. 37: If it will not prime, where would you expect to find the trouble?

Ans.: If the injector would not prime, would expect to find the cause of the trouble to be any one of the reasons given in answer to question 36, or possibly the priming valve might be out of order.

Ques. 38: Will injector prime if checks leak badly or are stuck up? If injector throttle leaks badly?

Ans.: No, it will not if either should leak badly.

Ques. 39: If steam or water show at overflow pipe when injector is not working, how do you tell whether leak is from check or injector throttle?

Ans.: If steam showed at the overflow pipe of the injector when injector was not working, would know it was the throttle leaking; if water and steam both showed, would know it was the check valve. Would close the main steam valve on the fountain, which would stop the leak if it were the throttle.

Ques. 40: Will injector prime if primer valves leak? Will it prevent its working?

Ans.: No, it will not, but may waste some from the overflow. It will not prevent its working.

Ques. 41: Will an injector work if air cannot get into tank as fast as the water is taken out?

Ans.: It will not work for any great length of time, but this is something that seldom happens, anld when it does it is usually in very cold weather, when the man-hole cover is frozen down air-tight.

Ques. 42: Will an injector work if all of the steam is not condensed by the water?

Ans.: It will not, and this is the reason the injector will not work when the water in the tender is too hot.

Ques. 43: What precaution should be taken to prevent injector from freezing when not being used?

Ans.: Would prevent it by using the heater, having the steam valves slightly open, with the overflow valve closed; thus steam would flow back into the tender through the feed pipe and at the same time flow forward into the branch pipe. The heater cock should be opened to drain the condensed steam or water from the delivery pipe, otherwise it would fill with water and freeze. The steam valve should not be opened far enough to cause water to become overheated in the tender, as that would prevent the injector from working and might damage the paint on the outside of the tender. By opening the overflow valve occasionally the injector waste-pipe may be prevented from freezing.

Ques. 44: How would you set a heater on: (a) A Hancock Inspirator? (b) A Gresham Injector?

Ans.: (a) When there is sufficient water in your boiler and you have an excess of steam make a heater out of your injector, and heat the water in the tank instead of allowing the steam to go to waste through the pop valve. (b) Close overflow or waste cock, all but close lazy cock, leaving it open only sufficient to keep hose bag thawed out, opening injector throttle sufficiently.

Ques. 45: Is there any more water used when a boiler primes than when the water is solid?

Aus.: Yes, very much more; one cubic inch of water is equal in weight to one cubic foot of steam. When the water is priming in the boiler on account of the water not being solid, small particles are carried with the steam into the cylinders, and in this way more water is consumed when it is priming in the boiler.

Ques. 46: How should the lubricator be filled?

Ans.: Shut off feed, steam and water valves. Open drain plug and drain out water in body of lubricator. Remove filling plug and close drain plug. Fill lubricator with clean oil, as any foreign substance will disarrange the feed. Replace filling plug. Open steam and water valves and, when desired, feed valves. A small air pocket is provided in the top of the lubricator to care for the expansion of the oil, which is considerable when cold oil is used, and even with this it is not best to fill the oil reservoir too full, as cases are on record where the bodies of lubricators have been bulged out and even split by the pressure of the oil under expansion. If lubricator is only filled moderately it may be necessary to wait a few moments until condensation takes place and raises the oil in the oil reservoir to the top of the feed pipes before the feeds will work. The natural expansion of the oil will also aid in doing this

Ques. 47: How often should a lubricator be blown out?

Ans.: At least once a week, and in "bad water" districts oftener.

Ques. 48: How long before leaving terminal should feed valve be opened?

Ans.: A few minutes and see that it feeds regularly before starting out.

Ques. 49: How many drops should be fed per minute?

Ans.: For average conditions about six drops per minute for the valves and one drop per minute for the air pump.

Ques. 50: Describe the manner in which a sight feed lubricator operates.

Ans.: After the lubricator has been filled with oil and its steam and water valves opened steam enters the lubricator and is condensed; water being heavier than the oil permits the oil to rise to the top of the oil reservoir, where it enters a tube or pipe leading to the cavity around the regulating feed-valves under the sight-feed glass and nipple. At the same time the steam in the condensing chamber condenses until the level of the water in that chamber equals the height of the top of the equalizing tubes, when water flows into the feed-glass and the chamber above it, until the water becomes level with the hole in the choke plug. Thus the pressure of steam in the equalizing tube and the pressure of steam in the main reservoir of the lubricator equalizes and the height of the water in the condensing chamber causes a pressure on the oil in the oil cavity equal to its weight in height to force the oil through the feed-valve when it is open, and the buoyancy of the oil (being the lighter) causes it to rise to the surface of the water in the chamber above the sight-feed glass level with the hole in the choke plug. It is then carried by the steam that enters the equalizing tube through the choke plug to the steam chest, when the pressure on the lubricator end of the pipe is the greatest.

Ques. 51: Does the draught from an open cab window affect the working of the lubricator? Why?

Ans.: Yes, the cold air chills the oil and it will not flow regularly, unless it is of uniform temperature, thus causing it to feed irregularly.

Ques. 52: What else might cause irregularity of feed?

Ans.: Worn choke plugs. Irregularity of feed is sometimes due to the pressure backing up to the choke plugs from the steam chest, because when the throttle is shut off the steam escapes through the worn choke plugs so fast that the pressure is not maintained above the water in the feed glass.

Ques. 53: When and in what order should you open and close the steam and water valves to a lubricator?

Ans.: First, be sure that the regular boiler valve is open. Then open the steam valve at top of condenser wide open, and keep it wide open while the lubricator is working. Second, open the water valve. Third, regulate flow of oil to right and left cylinders and to air pump by the valves placed for that purpose. Fourth, to refill always close the feed valves before closing water valve. After closing water valve open the drain plug.

Ques. 54: Will any bad results ensue from filling a lubricator full with cold oil? Why?

Ans.: Yes, most likely because when the oil becomes hot it would expand, causing the lubricator to bulge or burst. Many types of lubricators are, however, provided with expansion chambers to allow for bulging, and if the water valve is opened, the expansion of the oil would simply cause it to back up into the condensing chamber; in this latter event there should be no bad results.

Ques. 55: If the sight feeds get stopped up, how would you clean them out?

Ans.: It would depend upon the make of the lubricator. As a rule would clean them out by closing the regulating valve on the other feeds and the water valve between the condensor and the oil reservoir; open the drain cock at the bottom of reservoir, and then if steam valve is open steam would blow through the equalizing tube, through the sight-feed glass, through the nipple into the oil reservoir, and out through the drain cock, carrying the obstructions with it; or would remove the regulating valve and run a small wire through the nipple.

Ques. 56: How would you clean out chokes?

Ans.: If the obstruction could not be blown out when the lubricator is shut off, and the throttle drain cock and regulating valve open, would disconnect the oil pipe from the lubricator and clean out the choke with a small wire or pin.

Ques. 57: Which is the better practice, to close feed valves or water valves while waiting on sidings?

Ans.: The feed valves always, because the water valve might leak.

Ques. 58: How can you tell if equalizing tubes become stopped up?

Ans.: A stopped up equalizing tube would cause the oil to spurt in a stream through the glass, because the pressure of water above the feed glass would be reduced, and when the steam chest pressure is less than the boiler pressure or when the throttle is closed boiler pressure and pressure of water in the condensing chamber force the oil through the feed valves in a stream, and hence the lubricator would feed out the oil very quickly.

AIR BRAKE

SECOND YEAR QUESTIONS AND ANSWERS

AIR BRAKE QUESTIONS.
(SECOND YEAR)

Ques. 1: Explain the operation of the steam end of pump on an up-stroke, on a down-stroke.

Ans.: When first admitting steam to the 9½-inch pump, if the main piston is at the bottom of the cylinder (as it usually is, due to gravity), the main valve moves to the right-hand position, pulling with it the side valve and thus admitting steam to bottom of the cylinder under the piston, forcing it up; when the main piston is nearly at the top of the stroke the reversing plate catches the shoulder on the reversing-valve rod, moving the reversing rod and valve to their upper positions, where it admits 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 at the same time exhausts it from the bottom end, thereby reversing the stroke of the pump.

Ques. 2: Explain the operation of the air end of pump on an up-stroke, on a down-stroke.

Ans.: The air piston is directly connected with the steam piston and any movement of the steam piston will, consequently, be transmitted 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.

Ques. 3: At how many strokes per minute should pump be run to give best service?

Ans.: It should be run not to exceed 140 strokes per minute, nor below 40 strokes per minute. Generally speaking, it should be run only fast enough to maintain the pressure.

Ques. 4: What is the duty of the pump governor?

Ans.: The air pump governor automatically stops the supply of steam to the air pump when a sufficient amount of air pressure has been obtained. It also automatically starts the pump again when the air pressure has been reduced below the desired amount.

Ques. 5: Explain how the governor operates.

Ans.: All the steam from the boiler to the air pump passes through the bottom of the governor containing the steam valve; this valve is closed by a piston operated upon by air pressure above it; when there is no air pressure above the piston it is held open by the combined action of the spring below it and by boiler pressure below the steam valve. As the boiler pressure and spring act constantly, it is only necessary to see how the air pressure is admitted to and taken from the top of the piston to understand the working of the governor. The top of the governor contains a thin, flexible diaphragm, holding a small pin-valve, which regulates the port leading to the top of the piston. The diaphragm is held firmly at outside edge by spring casing; the diaphragm has an adjustable spring above it and air pressure underneath it. The center of it is free to move up and down as conditions may require. In order to stop the pump air pressure must be admitted past the valve in the diaphragm body to the chamber on top of the piston, so it may force it and the steam valve downward. This air valve is held to its seat by the tension of the adjusting spring on top of the diaphragm body. In order to open it the air pressure under the diaphragm must be slightly stronger than the tension of the spring, so it may raise the diaphragm and valve. When this amount of air pressure is obtained the diaphragm raises, opening the valve and allowing the air pressure to pass into the chamber on top of the piston, forcing it downward and closing the steam valve. To start the pump again, as soon as the pressure reduces below the required amount, through leakage or other cause, the spring overcomes the weaker air pressure and forcing the diaphragm down seats the diaphragm valve, and so cuts off the supply of air from the chamber above the piston. A suitable opening then allows the pressure remaining above the piston to escape. The piston is raised by a spring under it, with the assistance of the steam pressure under the steam valve, and as it raises it opens the steam valve and so admits steam to the pump.

Ques. 6: Name the different positions of the brake valve and trace the flow of air through it in each position.

Ans.: Full release, running position, lap, service application and emergency application. In full release there is a large direct communication between the main reservoir and the train pipe. In running position the air passes from the main reservoir indirectly to the train pipe, that is, through the ports and passages of the excess-pressure valve or through the feed-valve, as the case may be. In lap position all ports are closed. In service application first the air from the equalizing discharge reservoir and cavity "D" escapes to the atmosphere, then, when the equalizing discharge piston raises, the air from the train pipe escapes to the atmosphere through the train line exhaust elbow. In emergency position a large direct opening is made between the train pipe and the atmosphere.

Ques. 7: Where does the main reservoir pressure begin and end? Where does the train line pressure begin and end?

Ans.: The main reservoir pressure begins at the pump discharge pipe and ends at the connection to the brake valve. The train pipe pressure begins at the brake valve and extends to the rear cock on the train, with branches to the triple valve under each car, the tender and the engine.

Ques. 8: How do you regulate the train line pressure?

Ans.: The train line pressure is regulated by the governor with the D-8 brake valve; and by the feed-valve attachment with all later types of brake valves.

Ques. 9: How would you clean the feed valve?

Ans.: On the old-style feed valve there is but one valve that requires cleaning and it can be reached by unscrewing the top cap.

Ques. 10: (a) Where is the first air taken from in making a service application? Where does it blow out? (b) Where next does the air come from and where does it blow out?

Ans.: (a) From chamber "D" and the equalizing reservoir. It blows out of the preliminary exhaust.

(b) Next the train pipe pressure escapes from the train line and blows out of the exhaust nipple.

Ques. 11: What pressures do the red hand and black hand of gauge indicate?

Ans.: Red hand, main reservoir; black hand, chamber "D" pressure.

Ques. 12: Does the black hand of the gauge also show the train pipe pressure at all times?

Ans.: No. Only when chamber "D" and the train line are connected, as in full release and running position. On lap or in service positions at the instant the train line exhaust starts or stops, they are also practically equal.

Ques. 13: What additional parts are needed on an engine and tender to have the straight air brake in connection with the automatic brake?

Ans.: 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 valve; 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.

Ques. 14: What is the duty of the triple valve?

Ans.: As its name implies, the triple valve is a combination valve, which performs three distinct functions. First, it takes air from the train line to charge the auxiliary; second, when pressure is reduced from the train line the feed to the auxiliary closes and another part of the valve opens, which allows the pressure stored in the auxiliary to pass into the brake cylinder, thus applying the brakes; and, third, when the pressure is again restored to the train line it opens communication from the brake cylinder, allowing the pressure there to escape to the atmosphere, thus releasing brakes, hence it does three things, charges the auxiliary reservoir, applies the brakes and releases the brakes.

Ques. 15: By what is it connected to the brake valve?

Ans.: By the branch pipe and the train line with hose..

Ques. 16: Explain the duty of the triple piston, the slide valve and the graduating valve.

Ans.: The duty 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 position, and to open and close the feed groove in the piston bushing. The function of the slide valve is, by its 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 its 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.

Ques. 17: Explain where the air that enters the brake cylinder comes from with each kind of triple valve, (a) in a service application; (b) in an emergency application.

Ans.: In service application with either type of triple valve the air that enters the brake cylinder comes from the auxiliary reservoir; with the quick action triple only part of the train pipe air first enters the brake cylinder quickly, later followed by the auxiliary pressure.

Ques. 18: Trace the air through the air brake system.

Ans.: The air is received from the atmosphere through the air cylinder of the pump; from there it passes through the discharge valve and pipe to the main reservoir, thence through the brake valve to the train pipe; through the branch pipe, cut-out cock and triple valve to the auxiliary reservoir (to charge); then from the auxiliary through the triple valve to the brake cylinder (to set the brake); from the cylinder again back through the triple to the atmosphere (to release the brake). When a retainer is used the final exhaust from the triple has to pass through the retaining valve.

Ques. 19: What is the leakage groove in the brake cylinder for?

Ans.: To allow the air to pass by the piston and not set the brake when the train pipe pressure is reduced slowly by ordinary leakage. This groove is long enough so that the piston has to travel over three inches to cover it, and is in the back end of all cylinders except driver brakes.

THE THIRD YEAR EXAMINATION

QUESTIONS AND ANSWERS

Locomotive Operation, Simple and Compound, Caring for Breakdowns, Lubrication, etc.

THIRD YEAR EXAMINATION.

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

Ans.: He should thoroughly inspect the engine for possible defects of machinery. Should satisfy himself concerning the condition of the fire box, grates, etc. He should see that the gauge and water-glass cocks are open and freely working; that the crown sheet is covered with enough water to insure it from injury, and that the tender has been supplied with fuel and water. He should also know the condition of the engineer's brake-valve and the air-pump and should take such other precautions as are necessary to prevent an engine failure.

Ques. 2: What tools should there be on a locomotive?

Ans.: The engine should be provided with such tools as are found necessary in every-day work. This includes also tools with which to make repairs in case of accident. Clinker bar, ash hoe, coal pick, shovel and broom are classed as tools.

Ques. 3: What examination should be made after any work or repairs have been done on valves, brasses, etc.?

Ans.: The engineman 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 set screws or otherwise.

Ques. 4: What attention should be given to boiler attachments, such as gauge cocks, water glasses, etc.?

Ans.: They should be blown out and inspected often enough to insure that they are working properly.

Ques. 5: Is the water glass safe to run by if the water line in the glass is not moving up and down when the engine is in motion?

Ans.: No. If the water glass is working properly the water will be continually moving up and down in the glass.

Ques. 6: What is (a) Saturated steam? (b) Wet steam? (c) Superheated steam? (d) Wire drawn steam?

Ans.: (a) Saturated steam is steam in contact with the boiling water. (b) Wet steam is steam which carries considerable water. (c) Superheated steam contains an excess of heat above that of saturated steam, and this excess may be lost without resulting in condensation. (d) Wire drawn steam is steam admitted to the cylinders through a restricted or partially closed opening. Throttling a locomotive "wire-draws" the steam.

Ques. 7: Does water expand in passing into steam, and, if so, how many times its own volume?

Ans.: Yes, it does. A teacupful of water will under ordinary conditions produce eighteen hundred (1,800) teacupsful of steam, which serves to illustrate its great expansive force; when confined within a given space it seeks a larger space in which to expand.

Ques. 8: Trace the steam from the boiler through the cylinders to the atmosphere, and explain how it transmits power.

Ans.: From the boiler steam passes into the dome, and from it, by means of the throttle valve, it goes through the dry pipe and steam pipes into the steam chest. From the steam chest it passes by means of the valves into the cylinder, where it expands and exerts its energy and does its work after which it is exhausted from the cylinder through the exhaust cavity of the valve and the exhaust passage in the cylinder saddle to the exhaust stand in the front end, and from there through the nozzle it passes out of the stack. Its power is transmitted to the locomotive by expanding with terrific force against the piston in the cylinder, causing the piston to work back and forth with great rapidity, and as the piston is connected with a rod (called a piston rod), and it connects with the crosshead and main-rod to the crank-pin on the driving wheel, the power thus exerted in the cylinder is transmitted to the locomotive.

Ques. 9: How should the locomotive be started, to avoid jerks, and what train signals should be looked for immediately after starting?

Ans.: It should be started so as to move slowly until all the slack between the cars has been taken up, after which the full power may be applied without liability of jerking the train. The "all right" signal from the rear should be looked for immediately after starting, to make sure that the train is intact.

Ques. 10: After a locomotive has been started, how can it be run most economically?

Ans.: By working steam expansively, that is, with the reverse lever hooked back to a point where the engine will handle her train with a full or nearly a full throttle.

Ques. 11: What is meant by "working steam expansively"?

Ans.: 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 upon the piston from the time that cut-off took place up to the point where release occurs.

Ques. 12: How rapidly should water be supplied to the boiler?

Ans.: Water should be delivered to the boiler steadily and in just sufficient quantity to replace the water which has been evaporated in doing work.

Ques. 13: How high should water be carried in a locomotive boiler to obtain best results? Explain.

Ans.: About half a glass; it is best to carry as much as possible without having it high enough to flood the cylinders. Only enough need be carried to furnish steam, provided a steady supply takes the place of that which is evaporated.

Ques. 14: What is the difference between priming and foaming of water in a locomotive boiler?

Ans.: Priming is caused by the boiler being too full of water and has a tendency to raise the water in a solid mass, while foaming is caused by foreign substances in the water, such as oil, soap, alkali, etc. In both cases water is carried with the steam into the cylinder.

Ques. 15: What should you do in case of foaming? What in case of priming?

Ans.: 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. In case of priming, lower the water level and keep it lower thereafter.

Ques. 16: What danger is there when the water foams badly? When it primes badly?

Ans.: From foaming there is danger of exposing the crown sheet to the intense heat and the liability of burning it. From priming there is danger of knocking out a cylinder head.

Ques. 17: Suppose that immediately after closing throttle the water disappeared from water gauge glass, what should be done?

Ans.: 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 engineer 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. The injectors should be kept at work until the water reappears in the glass before fire is rekindled.

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

Ans.: He should set up the wedges and key up the rod brasses and see that all nuts and bolts are tight.

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

Ans.: 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. 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. Block the wheels, and with the reverse lever in the forward motion apply a small quantity of steam. 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.

Ques. 20: How should main-rod brasses be keyed?

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

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

Ans.: That depends entirely upon 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 those positions present the greatest diameter of the pin to the rod brass and guarantee a free movement at all points without binding.

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

Ans.: To prevent unnecessary shocks and heating of rod brasses and pounding in driving boxes, which in time causes undue strain on the entire engine with disastrous consequences.

Ques. 23: How should the side rod brasses on a 10-wheel or consolidation locomotive be keyed?

Ans.: 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 the 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.

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

Ans.: 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.

Ques. 25: Describe a piston valve.

Ans.: 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.

Ques. 26: What is a balanced slide valve? How is it balanced and why? For what purpose is the hole drilled through top of the valve?

Ans.: A balanced slide valve is one where a certain percentage of the steam pressure exerted on the top of the ordinary slide valve has been removed. 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 makes a steam-tight joint and prevents any considerable pressure reaching the enclosed part of the valve. The American balanced 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 which may have accumulated on the top of the valve from whatever cause to escape to the exhaust port.

Ques. 27: **What is meant by inside and outside** admission valves?

Ans.: 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.

Ques. 28: What is the relative motion of main piston and valve for inside admission valve, and for outside admission valve?

Ans.: 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.

Ques. 29: What is an Allen ported valve and what is its object?

Ans.: An Allen ported valve is a D slide valve having an auxiliary port cored in the valve and extending nearly from one edge of the valve to the other. The object of this port is to give rapid admission of steam to the cylinder; also in some instances it is so designed as to give a more rapid exhaust.

Ques. 30: What is a direct motion valve gear? What is an indirect motion valve gear?

Ans.: 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 a rocker shaft upon which both rocker arms hang suspended in the same direction. An indirect motion valve gear is one where the power is transmitted from the eccentric to the lower rocker arm, which by its motion forward forces the upper arm backward, so that the travel of the eccentric is diametrically opposite to the travel of the valve.

Ques. 31: What is meant by lead?

Ans: Lead is the amount of opening a valve has when the piston is at the beginning of its stroke.

Ques. 32: What is meant by steam lap?

Ans.: By steam lap is meant the amount the valve overlaps the steam ports, when the valve is in the center of its seat.

Ques. 33: What is meant by exhaust lap and exhaust clearance?

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

Ques. 34: (a) With an indirect valve motion, with outside admission, what would be the position of the eccentrics relative to the crank pin? (b) With in-

direct valve motion, with inside admission, what would be the position of the eccentrics relative to the crank pin? (c) With a direct valve motion, with outside admission, what would be the position of the eccentrics relative to the crank pin? (d) With a direct valve motion, with inside admission, what would be the position of the eccentrics relative to the crank pin?

Ans.: (a) The eccentrics are set at right angles to the pin and advanced toward the pin the amount of lap and lead of the valve. (b) The eccentrics are set at right angles to the pin, and advanced away from the pin the amount of lap and lead of the valve. (c) The eccentrics are set at right angles to the pin and advanced away from the pin the amount of lap and lead of the valve. (d) The eccentrics are set at right angles to the pin and advanced toward the pin the amount of lap and lead of the valve.

Ques. 35: What effect would be produced upon the lap and lead by changing the length of eccentric rods?

Ans: 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 lengths 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.

Ques. 36: Why is it necessary to keep the cylinders free from water?

Ans.: To prevent rupture of the cylinder and its 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, especially with piston valves which cannot be lifted off their seats, as can slide valves.

Ques. 37: Where is piston rod packing located? Where are piston packing rings?

Ans.: The piston rod packing is located in the back cylinder head? Piston packing rings are to be found in the grooved receptacles provided for that purpose in the circular surface of the piston.

Ques. 38: Explain construction of "Lewis and Kunzer" piston rod and valve stem packing.

Ans.: L and K packing consists of four sections of a metallic composition, which, when assembled, form a ring with a groove in the outer rim. In this groove is placed a wire spring ring, which holds the sections of packing together, as well as binds them closely to valve or piston rods. Two rings form one set and each is placed in a separate and independent stuffing box made large enough to allow of the free movement of the rings.

Ques. 39: In case a locomotive in your care became disabled on the road, what should you do?

Ans.: 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 blockading of 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, giving full particulars.

Ques. 40: Suppose a wash-out plug blew out, or a blow-off cock would not close, what would you do?

Ans.: First put both injectors to work and endeavor to overcome the leak until you can get in to clear. That failing, 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 or pump.

Ques. 41: What should be done if grates burned out or became broken while out on the road?

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

Ques. 42: What action should be taken in case of a locomotive throwing fire?

Ans.: In order to prevent engines from throwing fire the netting in the smoke arch must 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 ashpan 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.

Ques. 43: What should be done with a badly leaking or burst tube?

Ans.: 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 flue is burst, it must be plugged at both ends. If it is simply a case of leaky flue at flue sheet, the above is not necessary—simply plug the flue. Bran or any starchy substance admitted through the heater cock on the injector after the injector has been started will aid in stopping a bad leak.

Ques. 44: What should be done in case the throttle valve stem became disconnected while valve was closed? If it became disconnected while open?

Ans.: 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 any train. If the throttle is disconnected and open, reduce pressure to a point where the 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.

Ques. 45: In case a slide valve yoke or stem became broken inside of steam chest, how could the breakage be located?

Ans.: After ascertaining that the eccentrics and visible parts of the valve motion were intact, would 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 would remove them first and watch movement of valve.

Ques. 46: After locating a break of this kind, how should one proceed to put the engine into safe running condition?

Ans.: If the engine had relief valves on the front end of the steam 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 the valve in place, leave up main rod and proceed. If relief valve were on the back end, the chest cover would not have to be taken up, but the back end of main rod would have to be disconnected and crosshead blocked ahead. The disconnected valve rod would hold the valve against the forward end of the steam chest.

Ques. 47: If a slide valve is broken, what can be done to run the engine with one side?

Ans.: 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 aft. The balance plate will then come down solid on valve and prevent leakage to the 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 cover will close down on it firmly and make a steam-tight joint, proceed on one side without disturbing anything except the valve rod.

Ques, 48: What should be done in case of link saddle pin breaking?

Ans.: 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 the link block and the link. Have another block ready of sufficient length to raise the link enough should it be necessary to back up the engine.

Ques. 49: With one link blocked up, what should be guarded against?

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

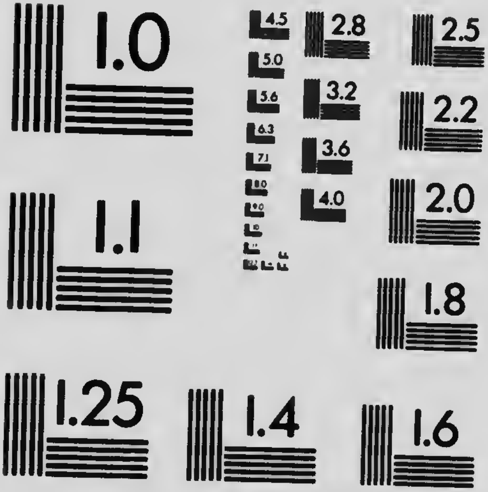
Ques. 50: How can it be known if the eccentric has slipped on the axle?

Ans.: 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.

Ques. 51: What should be done in case of a broken eccentric strap or rod?

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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

Ques. 52: How should the engine be disconnected if lower rocker arm became broken? If link pin?

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

Ques. 53: What would be considered a bad engine or tender truck wheel?

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

Ques. 54: What thickness of flange is allowed to run (a) on steel tired engine and tender truck wheels and on cast iron tender wheels with 4¼x8 journals and under? (b) On cast iron tender wheels with 5x9 journals and over and cast iron engine truck wheels?

Ans.: (a) 1 inch. (b) 1⅛ inch.

Ques. 55: What is your proper course if you find cast iron wheels with chipped flange or rim or wheels slid flat?

Ans.: If the condition is not dangerous, cut out brake, run carefully, especially around curves, and report on arrival the defects for examination and repairs to be made.

Ques. 56: Is there a limit on the height of sharpened flanges, if so what is it? (a) For steel tired engine and tender truck wheels and for cast iron tender wheels with 4¼x8 journals and under? (b) For cast iron engine truck wheels and cast iron tender wheels with journals 5x9 and over?

Ans.: (a) 1 inch. (b) ⅞ inch.

Ques. 57: What should be done if an engine truck wheel or axle should break?

Ans.: 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.

Ques. 58: What should be done if a tender truck wheel or axle should break?

Ans.: The same 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.

Ques. 59: How should an engine be blocked for a broken engine truck spring or equalizer? For a broken tender truck spring?

Ans.: If the pilot will not be too low, let the truck frame ride on the boxes; otherwise, block between the top of the boxes and the 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 the spring resting on the arch bar over the 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 the truck bolster and the tender frame; and with the third, between the truck bolster and the sand plank.

Ques. 60: For what breakdowns is it necessary to take down the main rods? The side rods?

Ans.: With regard to taking down the main rod, instructions differ on the various railroads and an engineer should ascertain from the Traveling Engineer, Road Foreman, or Master Mechanic what is their practice. Where very large power is used it is practically impossible for two men to take down and load up a main rod. But when the main rod is left up, be sure to leave good openings in the cylinder and oil the latter well. As regards side rods, if one is broken or has to come off, take down the same rod on the opposite side, also remove rods on both sides with knuckles in them, provided the next section of side rod is disabled.

Ques. 61: If it is not necessary to take down the main rod on disabled side of the engine, how would you arrange to lubricate the cylinders?

Ans.: By removing the indicator plugs, if the engine is equipped with them, oiling through them and replacing the plugs. If the engine has no plugs, shift the valve just enough to show a little steam at the cylinder cocks and oil with the lubricator.

Ques. 62: What should be done if a R. M. driving spring should break on a ten-wheel or consolidation engine?

Ans.: When the springs are over the boxes the equalizers are usually between the rails of the frame. Would first put a block in between the top of the main box and the frame and run the driver up upon a wedge in order to relieve the front and back wheels of a portion of the weight. Would then raise the ends of the equalizers and put blocks in between their inner ends and the lower rail of the frame. Would then run the main wheel off the wedge and the forward driver upon it so as to relieve the main box of the load and make it possible to put in a thicker block to raise the frame more nearly to its former height. This done, the wedge under the forward wheel may be removed and the engine again started on its journey.

Ques. 63: What should be done if a R. M. driving spring hanger should break on a ten-wheel or consolidation engine?

Ans.: Blocking must be done to relieve the broken part of the load and the frame blocked so the engine can run.

Ques. 64: What should be done if a R. M. equalizer should break on a ten-wheel or consolidation engine?

Ans.: First raise the engine either by jacking it up, or by means of wedges; jacking up the back end of the frame on the side where the break has occurred. Remove all parts liable to shake loose, place blocking over both driver boxes to carry the frame and block under boiler and over the cross equalizer.

Ques. 65: How should an engine be moved if the reverse lever or reach rod were caught at short cut-off by a broken spring or hanger?

Ans.: By disconnecting the tumbling shaft arm and blocking that would permit sufficient power to be used to start the train.

Ques. 66: How can you distinguish between a valve, cylinder packing or valve strip blow, and locate which side it is on?

Ans.: When the valve has been placed to cover both steam ports and no steam escapes from the cylinder cock, but escapes through the exhaust port, to stack, it indicates that valve strips are down or broken and permits steam to escape through the small hole in the valve to the exhaust port. If the valve covers the ports and steam appears at both cylinder cocks, it indicates a cut valve or seat. If a piston is at the beginning of stroke and the valve uncovered and steam escapes from the cylinder cocks at the 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 the valve, while a cylinder blow is strongest when the piston is at the beginning of its stroke and gradually diminishes until cut-off takes place as the piston nears end of its stroke.

Ques. 67: If an engine should blow badly, and be unable to start the train when on the right hand dead centre, on which side would be the blow generally?

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

Ques. 68: If throttle were closed and steam came out of cylinder cocks, what might be the cause?

Ans.: Leaky throttle or leaky dry pipe.

Ques. 69: How can you distinguish between a leaky throttle and a leaky dry pipe?

Ans.: A leaky throttle will show dry steam only, while a leaky dry pipe will show more or less water passing 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, particularly with a full boiler of water.

Ques. 70: What effect have leaky steam pipes, and should they be tested?

Ans.: They interfere with the draft on the fire and prevent the engine from making steam. Place the lever on the center, set the air brake, open the throttle and watch the joints of the steam pipes top and bottom. The proper test is the hydraulic test made in the shop.

Ques. 71: How should test for leaky steam pipes be made?

Ans.: Would place the lever on the center and apply the brakes, then would open the throttle and watch the joints of the steam pipes both top and bottom.

Ques. 72: How should the test for leaky exhaust pipe joint or a leaky nozzle joint be made?

Ans.: 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.

Ques. 73: What should be done if a steam chest cracks?

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

Ques. 74: What should be done if a steam chest breaks?

Ans.: 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 on them.

Ques. 75: If a link or arm were broken, what should be done?

Ans.: Block the same as for broken link saddle pin.

Ques. 76: If the reverse lever or reach rod should break, what should be done?

Ans.: Follow the same method as for broken link saddle pin.

Ques. 77: What should be done if the piston, crosshead, main rod, or main crank pin is bent or broken?

Ans.: If the piston is broken or the piston rod bent, remove both, disconnect valve, the 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 the piston ahead or back, this depends on the type of engine, and then shift valve to force steam against the piston in the direction in which it was desired to hold the piston; clamp the 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.

Ques. 78: What should be done if a safety valve spring breaks?

Ans.: Remove the spring and block between the valve and its cap, allowing the other valve to do the work.

Ques. 79: What should be done where there is a loose or lost cylinder key?

Ans.: If the key is loose and can be shinned up, it is safe to go on. If the key is lost and nothing available, such as track spike or cold chisel in its place, disconnect that side to prevent further damage.

Ques. 80: How can an engine be brought in with a broken front end or stack?

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

Ques. 81: What should be done if a frame is broken between the main driver and the cylinder?

Ans.: 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.

Ques. 82: What should be done if a frame is broken back of main driver?

Ans.: Take own side rods on both sides back of main driver and proceed.

Ques. 83: In case of broken side rods what should be done? Why?

Ans.: In case of broken side rods, would remove the broken parts and would always remove the corresponding rods on the opposite side of the engine. If the corresponding rods on the opposite side of the engine are not removed it is almost certain that, in passing over a frog or bad place in the track, or if the engine slips, the wheels will commence turning in opposite directions with the result that the rods will be all twisted up and the pins bent or broken.

Ques. 84: What should be done to bring an engine in in case of a very loose or broken (a) forward tire? (b) main tire? (c) intermediate tire? (d) back tire? (e) trailer tire?

Ans.: The same remedy will apply to all of these breakages, viz.: run the wheel up on 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 the bottom of the box and the pedestal binder. Also block under the equalizers nearest the disabled wheel to take the weight off the journal.

Ques. 85: What would you do in case of a broken "aleck" bolt?

Ans.: Block up between truck axle and front end of long equalizer, place a truck brass on the axle and allow the end of the equalizer to rest upon it. Would oil the brass well.

Ques. 86: What is a good method of raising a wheel when jacks are not available?

Ans.: Run them up on frogs or wedges.

Ques. 87: 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?

Ans.: 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. Pull them down by the wedge bolts or if stuck tight, first jar the wheel by running over a nut on the rail.

Ques. 88: What are some of the various causes for pounds?

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

Ques. 89: How can a pound in driving box, wedges, or rod brasses be located?

Ans.: 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.

Ques. 90: When should you report crossheads to be rebabitted, or guides to be closed?

Ans.: 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.

Ques. 91: When should driving box wedges be reported to be lined?

Ans.: 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.

Ques. 92: When should rod brasses be reported to be filed? To be lined?

Ans.: When there is sufficient lost motion to cause pounding. When the key is down to a point where it cannot be forced down further to prevent the brass working in the strap.

Ques. 93: What is generally the cause of failure of the second injector and what should be done to obviate this failure?

Ans.: Infrequent use causes the various parts to corrode and the check to line up and stick. Frequent use and a trial before starting on the trip will guard against such failures.

Ques. 94: What are the advantages of the combination boiler check?

Ans.: It reduces the number of boiler check and injector failures.

Ques. 95: If an injector stops working while on the road, what should be done?

Ans.: 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.

Ques. 96: How can a disconnected tank valve be opened without stopping?

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

Ques. 97: How are accidents and breakdowns best prevented?

Ans.: By frequent and careful inspection before starting and during each trip.

Ques. 98: What are the duties of an engineman when giving up his engine at the terminal.

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

Ques. 99: In what manner should an engine be inspeoted on arrival at terminal?

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

Ques. 100: In reporting work on any wheel or truck on engine or tender, how should it be designated?

Ans.: 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 mistakes, by numbering the wheels, beginning at the forward engine truck wheel and numbering it No. 1 and so on in consecutive numbers (not including the drivers) back to the rear tank wheel. Also state whether right or left side, as R. No. 5 wheel.

Ques. 101: 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 won't steam," "Engine blows, etc.?"

Ans.: No, the report should be explicit and assign a cause for every failure so as to assist the shop force in remedying the defect.

Ques. 102: Wherein do compound locomotives differ from ordinary or simple engines?

Ans.: A simple locomotive has only one set of cylinders and they are of the same diameter. The steam is used only once. Whereas in a compound the steam is used twice because it has two or four cylinders (as the case may be) not of the same diameter. The steam passes through one cylinder where it loses part of its energy, then it passes into the second cylinder where its remaining energy is used. It is in fact using the steam expansively in a double expansion engine.

Ques. 103: Why is one cylinder on a compound locomotive called the high pressure cylinder, and the other the low pressure cylinder?

Ans.: The steam enters the high-pressure cylinder directly from the boiler at nearly initial boiler pressure, and goes into the low-pressure cylinder from the high-pressure cylinder at a pressure much reduced, when the engine is working under ordinary conditions.

Ques. 104: What are the principal advantages claimed for compound locomotives?

Ans.: More work with the same amount of steam than can be done with a simple engine and a saving in fuel and water.

Ques. 105: In the Schenectady two-cylinder compound, what is the duty of the oil dash pot?

Ans.: It insures a steady movement of the valve without any shock.

Ques. 106: Is it necessary to know that the dash pot contains sufficient oil and why?

Ans.: Yes it is, because the dash pot should be kept filled with engine oil in order to prevent the slamming of the intercepting valve. Lack of oil in the dash pot often results in failure or breakage of the intercepting valve.

Ques. 107: Explain how (a) a Schenectady two-cylinder compound may be operated as a simple engine (b) a Richmond (c) a Pittsburg?

Ans.: The handle of the three-way cock must be moved so that air or steam pressure is admitted into the pipe which leads to one end of the separate exhaust valve from the right to the left in the direction of the intercepting valve. Ordinarily the separate valve is held in its place by a spring, hence the reason for its being thus forced. Thus, as the throttle opens steam comes directly from the boiler into the passage connecting with the intercepting valve, forces it from left to right, and so allows the steam to pass through by the ports and passages, thence it goes through the reducing valve and into the low pressure steam chest, and at the same time steam is being admitted direct from the steam pipe to the high pressure cylinder. From the high pressure cylinder steam is exhausted direct to the atmosphere through the receiver and separate exhaust passage. But from the low pressure cylinder steam is exhausted direct to the atmosphere in the usual manner. (b). This compound is convertible. That is to say, it starts with the admission of live steam to both cylinders, first as a simple and thereafter automatically changes to compound, but it may be converted back to simple at the will of the engineer at any time. It is changed to simple by movement of the three-way cock in the cab which causes the separate exhaust valve (sometimes called the "emergency valve") for the high-pressure cylinder to open. This valve is really the intercepting valve. (c) This compound also starts by the admission of live steam into both cylinders, there being an open exhaust passage from each to the stack. The live steam admitted to the low-pressure cylinder is sufficiently reduced by passing through a reducing valve to cause the engine to have the same power that a simple would have with two cylinders the size of the high pressure cylinder. When the reverse lever is "hooked up" or drawn toward the center one or more notches it mechanically works an operating valve and piston near the cab, which puts the intercepting valve into position for working compound. The intercepting valve does not automatically assume simple position when the engine is starting, hence it will start simple only when it is placed in proper position. To change from compound to simple the intercepting valve is moved to the left.

Ques. 108: When should a two-cylinder or cross-over compound be operated as a simple engine?

Ans.: In starting with a very heavy train, whenever there is danger of being stalled, and only at very slow speeds.

Ques. 109: Why not operate as simple when running faster?

Ans.: Because there would result a waste of steam, an increased consumption of fuel, and an unnecessary wear and tear and consequent strain to the machinery of the locomotive.

Ques. 110: Explain how you would change from simple to compound (a) a Schenectady crossover compound (b) a Richmond (c) a Pittsburg.

Ans.: (a) First, the three-way cock would be returned to its normal position allowing the pressure to be withdrawn from the piston head of the separate exhaust valve. The compressed spring being released as the pressure is exhausted to the atmosphere forces the separate exhaust valve to its normal position and closes communication. The pressure in the receiver, owing to the exhaust in the high pressure cylinder, rises and forces the intercepting valve to the left, and that opens the passage through which the exhaust steam from the high pressure cylinder passes through the receiver to the low pressure steam chest. Live steam is shut off between the boiler and the low pressure steam chest by the movement of the intercepting valve to the left. (b) The Richmond compound automatically changes from simple to compound after it has been first started as a simple engine. If the engine has been changed from compound to simple and it is desired to change it back again from simple to compound it is done by simply closing the separate exhaust valve which action would permit the valves to automatically assume compound working by the accumulation of pressure in the receiver. (c) The Pittsburg compound is changed from simple to compound after it has been started through the hooking up of the reverse lever which sets in operation an operating valve and piston near the cab, which serves to throw the intercepting valve into position for working compound. In the cab is a hand lever by means of which the intercepting valve may be moved in case of necessity. By moving the intercepting valve ahead the high pressure exhaust becomes the supply steam for the low pressure cylinder and the engine works as a compound.

Ques. 111: What moves the intercepting valve of (a) a Schenectady compound (b) a Richmond (c) a Pittsburg (d) an improved Pittsburg?

Ans.: Because of the different areas of the ends of the valve the intercepting valve of a Schenectady compound is automatically operated by the steam pressure to which it is subjected. (b) When the throttle is opened steam passes to the high pressure side in the usual manner and also through a branch steam pipe to the annular cavity, bears against the shoulder of the reducing valve at its seat, forcing it to the right and with it is intercepting valve. This, briefly, is the operation of the valves assuming they are set in motion after the engine had come to rest after having been running compound. In short, the intercepting valve is moved by the increase or reduction of steam pressures. (c) The intercepting valve is moved either by the action of the operating valve and piston or by the hand lever for use in case of derangement of the operating device. (d) Unequal pressure of steam on intercepting valve.

Ques. 112: Is there any more danger in carrying too high a water level in the boiler of a compound than in that of a simple engine? Explain.

Ans.: Only enough water should be carried in the boiler of a compound to insure positive safety against overheating the firebox regardless of the different service conditions. This is necessary in order that delivery of dry steam may be made to the cylinders. Wet steam should be prevented as it is very injurious to compounds.

Ques. 113: How should a compound engine be lubricated?

Ans.: While using steam two-thirds of the allowance for cylinder lubrication should be fed to the high pressure cylinder. But this rule should be reversed when drifting for long distances, because of the increased surface which is exposed in the low pressure cylinder and also because of there being no steam in the cylinders.

Ques. 114: Why feed more oil to a high, than to a low pressure cylinder?

Ans.: Because some of the oil fed to a high pressure cylinder is taken by the steam to the low pressure cylinder. More friction is caused in the high pressure than in the low pressure cylinder by reason of the high pressure of the steam, so more oil is needed to offset it.

Ques. 115: How should a compound locomotive be started with a train?

Ans.: In simple position; that is, it should be operated as a simple expansion locomotive.

Ques. 116: When drifting what should be the position of the separate exhaust or emergency valve?

Ans.: The three-way cock in the cab should be in the position for working simple, thus causing the separate exhaust valve to open and the cylinder port cock should also be open.

Ques. 117: What will cause two exhausts of air to blow from the three-way cock of a Schenectady compound when the engine is being changed to compound?

Ans.: The exhaust valve spring may be loose, or the exhaust valve may itself be sticking.

Ques. 118: What does steam blowing at three-way cock of a Schenectady compound indicate?

Ans.: Exhaust valve seat leaking and steam passing by the exhaust valve piston packing rings.

Ques. 119: What can be done if the engine will not operate as compound, when air pressure in the separate exhaust valve is released by the three-way cock?

Ans.: It usually results from the separate exhaust valve being stuck and so communication with the separate exhaust valve is not closed. A little headlight oil through the oil-plug at the three-way cock may be forced to the separate exhaust valve, and by repeating the operation shortly afterward with cylinder oil the valve may generally be released.

Ques. 120: If the engine stands with high pressure side on dead center and will not move when given steam, where is the trouble and what may be done to start the engine? Why?

Ans.: A stuck intercepting or reducing valve preventing direct communication between the boiler and the low-pressure cylinder is most likely the cause of the trouble. Which valve is sticking may be known by the position of the intercepting valve stem, which would extend clear out if the intercepting valve were stuck. In that event a light tap on the end of the stem, after the throttle is opened, will send it ahead, unless some of the parts be broken. But if the reducing valve is stuck the stem will protrude only a few inches. In that case a few sharp blows on the intercepting valve back head, with the throttle opened, will usually start it and thus direct communication between the boiler and the low-pressure cylinder will be once more effected. Because 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 insufficient to move the locomotive in starting.

Ques. 121: What can be done to shut off steam pressure from the steam chest and low pressure cylinder, (a) with a Schenectady, (b) a Richmond, (c) a Pittsburg?

Ans.: (a) Place the separate exhaust valve and the intercepting valve in position for working engine as a simple locomotive. (b) By moving the three-way cock in the cab, which in turn opens the separate exhaust or "emergency" valve. (c) By placing the intercepting valve in the desired position.

Ques. 122: Is it important that air be pumped up on a Schenectady two-cylinder compound locomotive before the engine is started? Why?

Ans.: It is extremely important. It ensures a sufficient quantity of air pressure to operate the separate exhaust valve in order that the engine may be operated as a simple locomotive or single expansion engine.

Ques. 123: Generally speaking, what is the difference between disconnecting a simple and a compound engine?

Ans.: Generally speaking, there is no difference between disconnecting a simple and a compound engine. In both cases the separate valve should be opened, blocked and the ports covered.

Ques. 124: To what ports are the by-pass valves connected, and why are they used?

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

Ques. 125: Describe in a general way, the arrangement of steam pipes, receiver pipes, and cylinders in a two-cylinder or cross compound.

Ans.: The steam passes from the dry pipe through a steam pipe to the high-pressure cylinder steam chest. Exhausts from that cylinder through a large low-pressure steam pipe called the receiver and extends around the inside of the front end to the low-pressure steam chest and cylinder on the other side of the engine, exhausting from there through the exhaust pipe and nozzle.

Ques. 126: What would you do if a receiver pipe were to break in (a) a Schenectady compound, (b) a Richmond, (c) a Pittsburg?

Ans.: (a) If not serious enough to cause too great a fall in receiver pressure would run engine in that condition. If a bad break, the automatic intercepting valve would close and live steam from the boiler would be delivered to the large cylinder under reduced pressure. (b) The same as for a Schenectady compound. (c) Would open the emergency valve to permit the exhaust steam from the high pressure cylinder to pass directly to the atmosphere and would run the engine as a simple.

Ques. 127: Where would you locate the trouble if an engine would not go into compound in case of (a) a Pittsburg compound? (b) An improved Pittsburg? (c) A Richmond? (d) A Schnectady?

Ans.: (a) The intercepting valve. (b) The emergency valve sticking, or the intercepting valve. (c) The main valve of the intercepting valve might be broken. (b) The separate exhaust valve might be open, allowing the receiver pressure to escape at the stack. The primary cause being, lack of lubrication, or accumulation of gum. The three-way cock might be leaking. There might be a broken spring or leaky emergency valve, or leaks in the receiver. Speaking generally, the same causes for engine not going into compound would apply equally to all types of compounds named.

Ques. 128: Where would you locate trouble in case engine would not simple with (a) a Pittsburg? (b) An improved Pittsburg? (c) A Richmond? (d) A Schenectady?

Ans.: (a) The intercepting or reducing valve may have become stuck through defective lubrication. The valves may have become dry through "working water" on account of too much water in the boiler resulting in the oil having been washed off. (b) The same as the above, or the pipe leading to the separate exhaust valve might be stopped up or broken. (c) The separate exhaust valve stuck shut, preventing the removal of pressure from the chamber usually marked "U" in the diagram, thus preventing the intercepting valve from closing. (d) As above stated the usual place to look fc the trouble is in the intercepting valve or reducing valve, or the separate exhaust valve. With the Schenectady it is easy to see whether the interceptor is stuck by noting the position of the oil dash pot stem. In general, it may be said with regard to these answers, as in the case of the preceding question, that what applies to one type, will as a rule apply to all types of compounds.

Ques. 129: What would you do in case of (a) a broken high pressure valve? (b) A low pressure valve? (c) A high pressure piston? (d) A low pressure piston?

Ans.: (a) Would remove the broken parts, cover the ports, the starting valve opened, and run the engine on the low-pressure side. (b) Would remove the broken parts, cover the ports, open the starting valve so as to permit high pressure exhaust to escape to the atmosphere through the emergency exhaust ports. (c) Would disconnect the broken parts, set the high-pressure valve to block the ports, the starting valve opened, and run the engine on the low pressure side. (d) Would remove the broken parts, set the low pressure valve to cover the ports, the starting valve opened, and thus provide for the escape of the high pressure exhaust to the atmosphere through the emergency exhausted ports. In general it may be said that disconnecting a compound and blocking its ports is done practically in the same manner as with a simple engine.

Ques. 130: What would cause an intercepting, pressure reducing or separate exhaust valve to stick?

Ans.: Usually deficient lubrication, gum or too much water, also the small release port in the reducing valve chamber becoming clogged up. This applies especially to the intercepting and reducing valves, and also to the separate exhaust valve so far as sticking shut is concerned. In addition to this, however, a leaky emergency pipe or valve chamber head would have the same effect if the leak were large enough to prevent sufficient pressure to accumulate behind the separate exhaust valve to overcome the tension of the spring. A broken spring would cause it to stick open, and where the separate exhaust valve is operated with steam, if the water in the boiler was carried so high that the chamber and pipe would be filled with water instead of steam, and the emergency valve, or three-way cock, closed, the separate exhaust valve will stick open until the water has time to leak by the packing rings.

Ques. 131: Should a by-pass valve become broken or stuck what would you do?

Ans.: Would first ascertain which side it was on, and then in case it were stuck shut let it alone until a regular stop, offsetting the constant fanning effect it would have upon the fire by opening the furnace door. Usually a stuck by-pass valve can be jarred loose by a sharp rap with a block of wood, but failing to so loosen it, the cap should be taken off and the valve forced to its seat with the handle of the hammer. At the first opportunity the valve should be entirely removed and cleaned with kerosene. If a by-pass valve were broken would remove the by-pass valve casing from the side of the cylinder and cover both openings with a thin copper or sheet-iron gasket and then replace the casting.

Ques. 132: How can you tell when a by-pass valve is blowing on (a) a Schenectady? (b) A Richmond? (c) A Pittsburg?

Ans.: The same general rule respecting by-pass valve blows applies to all three of the compounds mentioned. Such a blow is readily distinguished from other blows since it is a very strong one and occurs only during one stroke of the piston. (a) To locate a blow on the low-pressure side would place engine on upper quarter on low-pressure side, reverse the lever in forward motion, close separate exhaust valve by placing three-way cock in compound position and admit steam to cylinder. If blow occurs from exhaust would know it to be forward by-pass valve; if it occurs with lever in back motion, engine in same position, would know it to be the back by-pass valve. Would follow the same course to locate by-pass valve blow on high-pressure side, except that in this case would open the separate exhaust valve by placing the three-way cock in simple position. Speaking generally, it may be said of all three types mentioned, that when one of the low-pressure by-pass valves sticks open it causes quite a bad blow which can be readily detected; whereas one stuck open on the high-pressure side does not cause a blow, instead it causes the engine to sound lame on that side.

Ques. 133: In blocking a disabled 10 wheel or consolidation engine, what is absolutely necessary to bear in mind regarding crossheads and forward crank pins?

Ans.: In blocking a disabled 10 wheel or consolidation engine it is necessary to know absolutely whether leading crank pin does or does not clear crosshead in all positions that crosshead might be left in.

Ques. 134: Say how you would block to avoid trouble.

Ans.: To avoid trouble, block crosshead in extreme travel ahead or swing leading drivers clear of rail and chain them with crank pins in position to clear crossheads. With reference to this question there are engines that the leading pin will not pass the crosshead except when the engine is coupled and in a working condition, i. e., the crosshead must be moving in unison with the pin and be in a certain position in relation to the pin twice at each revolution.

Ques. 135: If separate exhaust valve shut tight but interceping valve would not stop in compound position, what would the trouble be?

Ans.: Trouble would be caused by the drips from outer end of intercepting valve chamber being choked up and allowing live steam leaking by packing rings to create pressure at outer end of intercepting valve, thus causing it to move to simple position.

Ques. 136: If separate exhaust valve or valve chamber joint leaked how could it be located?

Ans.: By blow of steam at operating cylinder when engine is working compound.

Ques. 137: What is the disadvantage of working a compound engine simple for long distances or when unnecessary.

Ans.: Loss of fuel, excessive strains and wear, and it would make the engine logy.

Ques. 138: Is it a disadvantage to work a compound engine at short cut-off, and why?

Ans.: Yes; on account of excessive compression and because the work of the two cylinders is best equalized with the lever at about one-half cut-off.

Ques. 139: Why is it more important to have cylinder cocks open when starting a compound engine than when starting a simple engine?

Ans.: The cylinders are larger and there is greater liability of doing damage with water in them.

LUBRICATION.

Ques. 1: What produces friction and what is the result of excessive friction?

Ans.: The rubbing together of any two surfaces. The result is heat.

Ques. 2: What is lubrication and its object?

Ans.: The interposing of a thin layer of a lubricant so that the surfaces do not actually touch each other—the oily surface of one part slides with less heat against the oily surface of the other.

Ques. 3: What examination should be made by engineer to insure successful lubrication?

Ans.: He must examine so as to know that the oil-holes are open, packing clean and feel of all bearings to find if any foreign substance is affecting the lubrication. He must also give careful attention to the lubricator.

Ques. 4: How should feeders of all oil cups be adjusted?

Ans.: They should be adjusted according to the work and the temperature, closing them at terminals if they feed from the bottom of the cup.

Ques. 5. Why is it bad practice to keep engine oil close to boiler in warm weather?

Ans.: It gets too hot and will glow off of the bearings too readily. Besides, many times the oil needs thinning rather than heating in cold weather.

Ques. 6: In what manner would you care for hot bearings when discovered on the road?

Ans.: If due to pounding, tighten up. If too tight, let up on wedge bolt or rod key. See that they are kept well oiled, cool them down if too hot to stand the grade of oil used; repack cellars and remove journal bearings in engine or tender trucks if necessary.

Ques. 7: What kind of oil should be used on hot bearings?

Ans.: If too hot to stand engine oil and no time to cool down, use valve oil or grease.

Ques. 8: At completion of trip what is necessary?

Ans.: Shut off the lubricator and all bottom feed oil cups, feel of all bearings and pins and report any that are running hot.

Ques. 9: How would you determine what boxes to report? Why not report all boxes?

Ans.: Never report more than is necessary. Feeling of the bearings shows which are running too hot—report those examined or packed.

Ques. 10: Why is it bad practice to disturb the packing on top of driving and engine truck boxes with spout of oil can when oiling engine?

Ans.: It stirs up the dirt, cinders and sand and liable to get them down on the bearing.

Ques. 11: How do you adjust grease cups as applied to rods?

Ans.: By screwing down the compression plug until the grease appears at the bearing. After a little experience on a given engine a man can tell just how much of a turn to give each plug to insure safe running. Taking hold of the rod, it will bind a little if the grease has fed down solid.

Ques. 12: Is it usual for pins to run warm when using grease?

Ans.: Yes; for the grease must melt and become practically an oil in order to lubricate freely.

Ques. 13: What effect does too much pressure produce?

Ans.: It wastes the grease and increases the friction.

Ques. 14: Is it necessary to use oil with grease on crank pins?

Ans.: No.

Ques. 15: Why should engine oil not be used on valves and cylinders?

Ans.: Because it will vaporize and become like a gas which has no lubricating qualities at such a high temperature as that of the steam.

Ques. 16: At what temperature does engine oil lose its lubricating qualities? Valve oil?

Ans.: From 200 to 300 degrees F. At from 400 to 600 degrees F.—depending upon the quality of the oil.

Ques. 17: How and by what means are valves, cylinders and air pumps lubricated?

Ans.: By lubricators.

Ques. 18: Why is it bad practice to carry water too high in boiler?

Ans.: It washes most of the oil off the valves and the cylinder walls and is liable to cause cutting.

Ques. 19: When valves appear dry when using steam, and lubricator is working all right, what would you do to relieve conditions?

Ans.: Ease off on the throttle and drop the lever down a little for a few strokes. If too much water in the boiler, blow off some.

AIR BRAKE

THIRD YEAR QUESTIONS AND ANSWERS

AIR-BRAKE QUESTIONS.

Ques. 1: Can you tell by the length of the exhaust of air from train pipe, about how many air brake cars are coupled to the engine?

Ans.: Yes; the longer the train line the longer the exhaust for any given reduction.

Ques. 2: Does this give the number of brakes that set or the number of car lengths of train pipe coupled up?

Ans.: Only the approximate car lengths of piping coupled up.

Ques. 3: What is the difference between an application and a reduction?

Ans.: From the time the brakes are applied until they are released no matter how many reductions, is one application. When they are released and again set it is another application.

Ques. 4: (a) With two or more engines coupled to a train, which brake-valve should be used to make the test before starting? (b) Which engineer should operate the brakes thereafter? (c) What should the other engineer do?

Ans.: (a) The brake-valve on the leading engine. (b) The leading engineer. (c) When two or more engines are coupled in the same train, brakes must be operated from the leading engine. For this purpose the cut out cock in the brake pipe just below the brake valve on all but the head engine must be closed and the air pumps kept running with the brake valve handle in running position and the maximum pressure maintained.

Ques. 5: Give the meaning of the various signals made by the air signal whistle.

Ans.: This should be answered in accordance with the Code of Rules of the railway by which you are employed.

Ques. 6: How do you cut out a brake?

Ans.: With the old-style triple valve, by turning the handle on the valve to an oblique position, midway between horizontal and vertical; with all other types of triple valve, by closing the cut-out cock in the branch pipe of the particular car or locomotive brake to be cut out.

Ques. 7: Give some of the causes for a pump running hot.

Ans.: Air cylinder packing rings leaking; discharge valves stuck closed or the discharge passages so obstructed that the pump will be pumping against high pressure continually; poor lubrication; running pump at too high speed; discharge or receiving air valves leaking; air piston rod packing leaking or too tight; choked air passages or choked discharge pipe; too small a main reservoir for the number of cars in train.

Ques. 8: If a pump runs very hot on the road, how will you proceed to cool it?

Ans.: First, would reduce speed of pump and look for leaks in the train line. Second, would examine packing around the piston rod to make certain it is not too tight or in bad condition. Third, would see that main reservoir is properly drained. Fourth, would look to lubrication and would put a small quantity of good oil in the air chamber; would then run the pump slowly until it cooled down. If it continued to run hot would report it at end of trip.

Ques. 9: If the pump stops, how can you tell whether the trouble is in the pump or in the governor?

Ans.: If the red gauge pointer has fallen below the figure at which the pump governor is adjusted, and pressure is escaping from the small air vent port in the governor just below the diaphragm valve, it denotes that the governor is defective, permitting pressure to enter and hold the steam valve closed. If this port is open and no air escapes then it would denote that the trouble was in the pump.

Ques. 10: State the common causes for the pump stopping.

Ans.: Loose nuts on the piston rod in the air cylinder; a broken reversing valve rod; a rod disengaged from the reversing plate; a loose reversing valve plate; bad packing rings on the main valve piston (or, if an 8-inch pump, the reversing piston) or a dry pump.

Ques. 11: Under what circumstances will a pump compress air in but one direction?

Ans.: With either discharge valve broken and held off its seat.

Ques. 12: How will defective air valves affect the operation of the pump?

Ans.: Leaky air valves, like leaky air cylinder packing, cause a pump to heat badly and lose greatly in the amount of air compressed. A broken air valve causes the loss of all service of compression at that end of the pump, that is, makes it single instead of double acting.

Ques. 13: How do you locate these defects?

Ans.: By the way the pump acts. The main piston moves quickly toward a broken receiving valve and away from a broken discharge valve. The various defects all have their symptoms, which are noticed if the principle of the pump and its details are clearly understood.

Ques. 14: Should an engineman observe the working of a pump on the road so as to properly report defects or repairs needed, and do you consider yourself competent to locate defects?

Ans.: Yes; he should. The student must answer the latter portion for himself.

Ques. 15: If the pump stops on the road, what will you do to start it?

Ans.: Close the steam valve a moment and then open it quickly. If it then failed to start, it would indicate that the main valve was broken. Would also examine it in both air and steam end for defects. Be sure, first, that the governor is not defective or has not shut off the supply of steam to the pump.

Ques. 16: By what pressure is the Duplex Governor operated in high speed service? By what pressure in ordinary service?

Ans.: The governor tops are adjusted for 90 and 110 pounds and the two feed valves are set for 70 and 90 pounds. To operate the low or ordinary pressure feature, the handle of the reversing cock is turned to the left, this cuts out the 110 pound governor and 90 pound feed valve and renders operative the 90 pound governor and 70 pound feed valve. By reversing the position of the reversing cock handle the low-pressure parts are cut out and the high-pressure parts cut in; but the small stop cock in the governor pipe must also be closed.

Ques. 17: What is the object of the relief port in the governor? Why should it be kept open?

Ans.: 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.

Ques. 18: If the pin valve of governor leaks, what effect will it have on the pump?

Ans.: 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.

Ques. 19: How can you detect leaks in the governor?

Ans.: By disconnecting the upper from the lower section of the governor, then attaching the air pressure connection, turn the air pressure under the diaphragm. If it raises with the proper pressure and opens the port the escape of air will be readily noticed. Should it not be raised or the port be closed by dirt, it would be in that section, this will also show if the diaphragm leaks. Would then inspect the lower section.

Ques. 20. Where would you look for the cause if the governor allowed the pump to raise the pressure too high?

Ans.: 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.

Ques. 21: Where, if the pump stopped when the pressure was too low?

Ans.: If the pump was not getting steam it would probably be due to the pin valve gummed up or dirt under it; the detector hole or leakage port in the side of the governor would then blow. Once in a great while the piston and steam valve have been known to stick closed, but very rarely.

Ques. 22: What effect does it have on the pump if the drip pipe is stopped or frozen up?

Ans.: The governor cannot then act to shut off the pump and too high pressure will be pumped into the main drum.

Ques. 23: What is the main reservoir pressure used for?

Ans.: The main reservoir pressure is used for releasing the brakes and for recharging the auxiliary reservoirs.

Ques. 24: Why does water accumulate in the main reservoir and how often should it be drained?

Ans.: The atmosphere contains moisture which is precipitated by compression and settles in the main drum which should be drained daily and at a time when the reservoir is warm enough to be certain no ice would remain therein.

Ques. 25: What is excess pressure, and what is it for?

Ans.: Excess pressure means simply "additional" pressure or more pressure in the main reservoir than in the train line. For example, if the train line has 70 pounds and the main reservoir 95 pounds there would be 25 pounds of excess pressure. Again, if the train line has 90 pounds and the main reservoir 115 pounds there would still be 25 pounds of excess.

Ques. 26: Explain the effect of a cut rotary valve face or seat.

Ans.: A leaky rotary valve or seat usually causes a loss of excess pressure in running position and releases the brakes in lap position.

Ques. 27: What is the duty of the small reservoir con[illegible]ed to the brake valve?

Ans.: [illegible] for the purpose of enlarging Chamber "D" without making a great bulky brake valve in the cab.

Ques. 28: If the pipe leading to this reservoir were leaking badly or broken off what would you do?

Ans.: Would plug up this pipe or put in a blind gasket, also would plug the train line exhaust nipple and use emergency position carefully, as with the old three-way cock.

Ques. 29: When making a service reduction can an emergency action be detected by the train line exhaust, and if so how?

Ans.: Yes; by the train line exhaust stopping suddenly.

Ques. 30: Does air ever blow out of the train line exhaust when releasing the brake? Why?

Ans.: Yes, sometimes; it is caused by some defect in the triple valve.

Ques. 31: What will be the result of leaving the handle of the brake valve in release position too long and then moving to running position?

Ans.: The result would be that the brake pipe and main reservoir pressures would equalize at 90 pounds, if the brake valve handle is then placed in running position, the feed valve would be held closed until the brake pipe pressure reduced to 70 pounds, thus allowing brake pipe leaks to cause the brakes to creep on until the pressure in the brake pipe and auxiliaries was reduced to 70 pounds, then the feed valve would supply the leaks in the brake pipe.

Ques. 32: What evil results are liable to follow from moving brake valve handle to release position from time to time when train line is charged to maximum pressure?

Ans.: It would result in the main reservoir and train line pressures equalizing and in the train line becoming overcharged. In this connection, it is dangerous to repeatedly apply and release brakes on grades or at stations because unless the auxiliary reservoirs are given time to recharge between applications there will not be sufficient pressure with which to make a stop.

Ques. 33: How would you proceed to release a stuck brake when train was in motion (a) on a passenger train? (b) A freight train?

Ans.: (a) Would move handle to release, leave it there for a second or two and then put back to running position in order to force the triples to release position. (b) Would make a heavy service reduction and with the high excess pressure throw the brake valve into full release position. Usually this suffices to release stuck brakes.

Ques. 34: How do you handle the brake valve to apply the brakes in emergency?

Ans.: The brake valve handle should be moved directly to emergency position and left there until the train stops or the danger is passed.

Ques. 35: How do you handle the brake valve in the case of a bursted hose?

Ans.: Would shut off steam from the engine, put brake valve handle on lap and apply sand quickly and consecutively. When the train had stopped would aid trainmen in finding the rupture by placing brake valve handle bolt on the shoulder between lap and running positions and would then move it slightly to the left until enough pressure would feed to the train line to make a blow at the point of the ruptured hose.

Ques. 36: In case the train breaks in two?

Ans.: Place the brake valve on lap until the rear cock of the first section is closed; then release and as soon as these brakes are off, place the handle again on lap to get pressure to release the rear portion of train when coupled up. Do not recharge to full pressure until the whole train is coupled up.

Ques. 37: When the train is backing up and a tail hose is used on rear end to apply breaks?

Ans.: Always carry the valve in running position when the tail hose is being used. Never throw it to full release unless the train stops and some brakes fail to release.

Ques. 38· Do leaks in the brake valve affect the operation of the brakes? How?

Ans.: Yes. If air leaks to the atmosphere it will affect the reduction desired. If it leaks from the main reservoir to other ports it may release the brakes or make the service application position of no effect.

Ques. 39: Name the defects in the brake valve and explain how you would locate them.

Ans.: Leaky rotary valve (or body gasket) place the valve in service position, bleed the engine and tender auxiliaries and place the rear tank hose in a bucket of water. Air bubbles in the water will indicate this leak. If the rotary and body gasket are tight, loss of excess means dirty or cut feed-valve or broken feed-valve gasket. Leaky packing ring in piston 17 (the equalizing discharge piston) makes the gauge reduce slower and the black hand recoil after a considerable reduction. A leak in chamber "D" or its connections (the gauge and the equalizing reservoir) causes the train line exhaust to blow and the brakes to set on lap position. These are the main defects and "symptoms."

Ques. 40: In what manner can you remedy these defects?

Ans.: Carefully tighten the bolts or unions where gaskets are leaking and clean any dirty valves without scratching them; after that is done it is better to handle the valve carefully until the terminal is reached and report the repairs needed in detail.

Ques. 41: What is the duty of the double check valve and how does it operate?

Ans.: To prevent air escaping from the brake cylinder through the triple exhaust port while the straight air is applied, also to prevent the air escaping from the brake cylinder through the straight air brake valve exhaust port while the automatic brake is applied. It consists of a double piston with a leather face on each. When the automatic brake is applied the piston is forced to such a position as closes the straight air side and at the same time opens a set of ports that admits the air to the brake cylinder. When the straight air is applied, just the reverse occurs and air from the main reservoir, through the straight air brake valve is admitted to the brake cylinders.

Ques. 42: What pressure should the reducing or feed valve used with this brake be set at? The safety valve?

Ans.: Reducing valve set at 45 pounds. Safety valve set at 53 pounds.

Ques. 43: How do you operate the straight air brake?

Ans.: By placing the handle of the brake valve forward in application position the application valve is opened admitting air from the main reservoir to the brake cylinders; by placing the handle of the valve back in release position; the release valve is opened allowing the air in the brake cylinders to flow to the atmosphere. Lap position is intermediate and in this position both valves are closed.

Ques. 44: In what position should the automatic brake valve be when releasing the straight air brake?

Ans.: The automatic valve should be carried in running position with excess when using the straight air brake.

Ques. 45: How do you cut out a triple valve so its brake will not operate?

Ans.: If an old-style plain triple would turn the handle down obliquely to about forty-five degrees. With the later style and all quick-action triples, would close the stop-cock (or cut-out cock) in the "cross-over" or branch pipe which connects the main train line with the triple valve. Would then bleed the auxiliary reservoir.

Ques. 46: If a triple valve does not apply the brake at the proper time, where will you look for the trouble?

Ans.: If the auxiliary is charged, the triple valve is probably frozen or stuck or the packing ring worn badly, or the brake cylinder itself leaking badly. If the auxiliary has not charged the feed groove may be closed or the reservoir itself be leaking badly.

Ques. 47: If the brake will not release, where will you look for the trouble?

Ans.: Retainer turned up or its pipe stopped up; triple piston packing ring worn; triple strainer stopped up or triple frozen.

Ques. 48: Name the common defects of the triple valve and explain how you locate them.

Ans.: Defects in the triple are manifested by certain things such as, for instance, failure to charge auxiliary; to set the brake; or release the brake; or by a blow at the triple exhaust or retainer, or by quick-action or emergency when only service was intended. Failure to charge might result from the strainer or feed groove being clogged; a bad leak under the slide valve; bad gaskets or loose bolts; or the release valve on auxiliary may not properly seat. A bad leak by the emergency valve will cause the brake to set while the auxiliary is being charged, and the air will be heard blowing out of the retainer. Failure to set brakes might result from a worn piston packing ring; dirty strainer; leaky cylinder; and sometimes through the supply port in the triple valve seat becoming clogged and so preventing auxiliary pressure from getting into the brake cylinder. Failure to release might result from the pressure in the train pipe being below that in the auxiliary through not having been increased fast enough, hence the pressures equalize and fail to move the slide valve if the triple piston packing ring is badly worn or gummed up, or if the strainer is clogged so that it retards the flow of air, either of which would cause the brake to remain set. After an emergency application this often occurs because the auxiliary pressure is then very high, making it necessary for the train pipe pressure to be **suddenly** raised against the plain side of the triple piston, otherwise a leak by the packing ring would allow the auxiliary to charge without releasing the brake. If the retainer is turned up, or any dirt clogs in the retainer pipe, or should port h in the triple valve seat get clogged, the brake cannot be released except by being bled off by letting the air escape through the auxiliary release valve. The drain plug in the auxiliary should be taken out. A blow at the triple exhaust or retainer is caused by a leak from either the auxiliary or the train pipe side of the triple piston, or the slide valve might be off its seat, or the gaskets between triple and auxiliary might leak. Sometimes on freight cars only, the blow is caused by a leak in the supply pipe between the triple and brake cylinder, either of these would be a leak from the auxiliary side of the piston; while a blow from the train pipe side would be caused by a leak under the emergency valve or past the check gasket. To tell where blow came from would cut out the brake and if it set itself would know the leak was on train pipe side of the triple piston; if, however, it did not set itself, would know it to be an auxiliary leak; to tell whether it were the triple gasket or slide valve would cut brake in and make a reduction on train pipe, if the blow stopped while the brake was set, but started again when brakes were released, would know it to be the gasket; but if blow continued while brake was set or released, would know it to be the slide valve causing the trouble. Quick-action or emergency when only service was intended might be caused by either a sticky triple, weak or broken graduating spring or broken graduating valve pin. The latter and a sticky triple act alike, as at the first light reduction the slide valve does not move to open the port into the brake cylinder if it is a sticky triple, and a broken pin would prevent the graduating valve from unseating, and in either case when the second reduction is made the graduating spring could not prevent the triple from going to emergency position. The action would be the same no matter in what part of the train the defective triple was located; but, if the emergency was caused by a weak or broken graduating spring it would have to be within seven cars from the engine and would show itself on the first light reduction. To find which triple was defective would cut out part of the train and make a very light reduction, and if one brake did not set would watch it (or have some one watch it) while the second reduction was being made, it would then "fly on" so would cut it out. Would continue trying with different portions of the train in this way until the defective triple was located.

Ques. 49: Name the complete parts that are added to the ordinary brake to make the latter a high speed brake?

Ans.: Two feed-valve attachments with reversing cock, a Siamese fitting with two pump governor tops, and one high speed automatic reducing valve connected by piping to each brake cylinder on the engine and cars.

Ques. 50: How much pressure is carried in train pipe and auxiliaries with high speed brake?

Ans.: One hundred and ten pounds (110 pounds).

Ques. 51: How would you change from low to high or from high to low pressure with high speed equipment?

Ans.: Turn the reversing cock so the 70-pound feed-valve would regulate the train pipe pressure and cut in the cock to the low pressure governor top; change both these cocks and you are ready for the high speed brake.

Ques. 52: How many pounds train pipe reduction in a service application will give a fully applied brake?

Ans.: Twenty pounds to twenty-five pounds.

Ques. 53: At what pressure will the auxiliary reservoirs and brake cylinders equalize with an emergency application using the high speed brake?

Ans.: At about 85 pounds with a 7-inch piston travel.

Ques. 54: Explain in a general way the operation of the reducing valve in service and in emergency.

Ans.: 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 50 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.

Ques. 55: If a train with high speed brakes should pick up a car not equipped with same, what should engineman do?

Ans: Unless a safety valve is at hand to screw into the cylinder oil hole on the car, the only perfectly safe way against wheel sliding in case of emergency would be for the engineer to discontinue the use of the high speed brake on the whole train.

Ques. 56: When a car that is equipped with an ordinary brake is coupled to a train using the high speed brake, what must be done with this car to run it with the high pressure?

Ans.: The automatic reducing valve should be cut into operating if the car is equipped with one. If not so equipped, the oil-plug in the brake cylinder should be removed and the 60-pound safety valve screwed into place.

Ques. 57: How many full service applications can be made without recharging and have left as much pressure as is used with the ordinary quick-action brake?

Ans.: Two; the first 110 to 90 pounds; the second 90 to 70 pounds.

Ques. 58: How does the air signal equipment operate?

Ans.: Air pressure from the main reservoir is supplied at a reduced pressure through the reducing valve to the signal line. On each car a branch of the signal line leads through a cut-out cock to the signal discharge valve above the door; a branch on the locomotive leads to the whistle valve. Any sudden reduction in the signal line releases the whistle valve and blows the whistle.

Ques. 59: What pressure should be carried in the signal line? How do you know you have this pressure?

Ans.: Fifty pounds; to determine if this pressure is being carried would shut off the pump, and reduce the pressure in the main reservoir by opening the angle cock at the rear of the tender; would watch the fall of the red pointer of the duplex gauge and at the instant the air whistle blows, the red pointer will indicate just about three pounds less than the pressure being carried in the signal line.

Ques. 60: What causes the signal whistle to blow each time the brake is released?

Ans.: Dirty reducing valve which lets full main drum pressure accumulate in the signal pipe and when the brake is released, the flow of air from the signal pipe back to the main reservoir blows the whistle.

Ques. 61: If the whistle gives a weak blast where would you look for the trouble?

Ans.: First see that the whistle was clean and properly adjusted; next see if opening the rear signal cock on the engine a little would give good whistle; if not, the whistle valve or pipe may be stopped up.

If the apparatus on the engine is all right, the car discharge valve or strainer may be stopped up or a very bad leak exist in the signal line on the train.

Ques. 62: What makes it repeat the signal?

Ans: Too short and quick an opening of the discharge valve in the middle of a long train sometimes, or the whistle valve stem not fitting properly.

Ques. 63: Will a leak in the signal line affect the working of the signal valve? Explain.

Ans.: Yes. You can give signals from cars ahead of the leak better and in more quick succession than from cars back of the leak. A continuous leak keeps the reducing valve open all the time, hence to blow the whistle you have to reduce the signal line pressure faster than it is being supplied, which is difficult on a long train especially.

Ques. 64: Where would you look for the trouble if the signal pipe does not charge?

Ans.: In the reducing valve. It would probably be found to be dirty, or the adjusting spring may not be set, or the signal cut-out cock may be closed at the reducer connection.

Ques. 65: Should the engine equipment be tested before leaving the engine house?

Ans.: It certainly should, and be known to be in good working order.

Ques. 66: How should this test be made?

Ans.: Open the bleed cocks in main and auxiliary reservoirs, start the pump slowly, lubricate it properly, observe about the number of strokes required to compress from 40 to 50 pounds, open the rear and front signal and train line cocks to see that they are working and not frozen, see that the governor and the feed valve are properly regulating the pressures and that the pump stops working, indicating no leaks; then apply a service application and see that the brakes remain set at least three minutes and that the pistons have proper travel; release and see that they release all right.

Ques. 67: What is your first duty after coupling on to a train?

Ans.: Start the pump to charge the air brake system, running it according to weather conditions, charging the train reasonably fast without overheating. When charged should make sure that the train is reasonably free from leaks: then as soon as the signal is received would apply from 15 to 18 pounds in service and put valve handle on lap. When next signal is received would release. Should then learn from the head brakeman or other person the number of air cars in good working order and the tonnage and length of the train.

Ques. 68: Should the brakes be tested before leaving a terminal?

Ans.: Yes, they should.

Ques. 69: How should this terminal test be

made? Explain in detail, giving Inspectors' and Trainman's duties also.

Ans.: Beginning at the rear, the brakeman should couple all the hose, open all the angle cocks except the one at the rear, see that all the cars are cut in (except such as are marked defective), see that all the hand brakes are off, and the retainers open, with the handles pointing down. The engine should be cut in last. While the engine is charging the cars the brakeman should pass along the train and inspect it carefully to ascertain if there are any leaks. In charging a train the pump should be run according to the temperature of the weather, in order to charge the train reasonably fast without overheating it. Where there are average leaks, an eight-inch pump should charge the train in about one-half as many minutes as there are cars; a nine-and-one-half inch pump, twice as quickly. After the train is charged and the engineer is satisfied that it is reasonably free from leaks, the head brakeman (stationed at the head air brake car) should signal the rear brakeman (stationed at the rear air brake car) who should repeat the signal. After the engineer gets the signal from the rear man, he should apply fifteen to eighteen pounds in service application and place the engineer's valve handle on lap. The brakemen should walk toward each other, inspecting each car, to see that it sets and holds—noting the piston travel as well. After this has been done, they should signal the engineer to release. He having done so in release position, the brakemen should pass each to his respective end of the air brake cars to see that all the brakes have been released, and, in winter, see that no shoes are frozen to the wheels. The head brakeman should then advise the engineer as to the number of air cars that are in good working order, and the tonnage or length of the train.

Ques. 70: Why is a terminal test necessary? Or, is it only advisable?

Ans.: It is necessary to insure the safety and celerity of the train on the road.

Ques. 71: What test is necessary after coupling up when air brake cars have been separated for a crossing, or make-up of train changed?

Ans.: To know by trial that the engineer can set and release the rear cars in the train. If the make-up of the train has been changed and any cars added; besides noticing the rear cars, a regular terminal test should be given the cars just picked up.

Ques. 72: What is meant by a running test on passenger trains? How and where is this test made?

Ans.: A test of the air brakes while the train is moving. It is good practice to make a running test of the brakes at the summit of heavy grades, also two miles from important points, meeting points, railroad crossings, etc. On passenger trains a sufficient reduction (8 to 10 pounds) should be made to feel the brakes holding well, also noticing the length of the blow from the train line exhaust. On long freight trains, releasing brakes while moving is such poor practice that it is generally better to make only a three- or four-pound reduction for a running test, determining the length of the train from the train line exhaust.

Ques. 73: In making a service application, what should the first reduction be? Explain why.

Ans.: From 5 to 8 pounds, sufficient to get all pistons by the leakage grooves. With 10 to 15 cars, 5 pounds would do this, with 50 to 60 cars, 8 pounds would be necessary.

Ques. 74: Does a long train require a heavier reduction than a short train? Why?

Ans.: Yes; because the train line exhaust opening is the same size for all length trains, hence the longer the train, the slower the reduction in train pipe pressure and the slower the pistons move past their leakage grooves; unless the reduction is continued until each piston passes the leakage groove, that brake will not apply in making the stop, or if it does set later it will be with a less pressure.

Ques. 75: From a seventy-pound train pipe pressure, how much of a reduction will be required to apply the brakes in full?

Ans.: From 18 to 20 pounds with an eight-inch piston travel—the greater reduction on long trains on account of more loss at the leakage grooves.

Ques. 76: Has the piston travel anything to do with the pressure obtained in the brake cylinder?

Ans.: Yes, the shorter the travel (if beyond the leakage groove) the greater the pressure, as the space to fill is so much smaller.

Ques. 77: With proper pressure and proper piston travel what is the brake cylinder pressure with a full service application? With an emergency application?

Ans.: About 50 pounds in service; about 60 pounds in emergency with the quick-action triple.

Ques. 78: Is there any difference in the brake cylinder pressures with different forms of triples?

Ans.: Yes, with the plain triple there is no greater pressure in the cylinder from emergency than from service application.

Ques. 79: How should you apply and release the brakes on a part air-braked freight train? How on a very long all-air train?

Ans.: Shut off and let all the slack that will run in, then make the first application, as per answer No. 73. Increase the application as necessary. To release this part air train if necessary while moving, let off a few brakes at a time by placing the brake valve in running position a second and back to lap several times in slow succession; when you think they are all off, to full release, then running position, and let the slack run out before carefully working steam. With a very long all-air train it is practically impossible to jerk the train, no matter how you apply the brakes in service. First reduce eight or nine pounds, then ten to fifteen more, as is necessary to stop. If avoidable, do not release at all when moving or you will likely break the train in two, especially when moving very slowly. If necessary to release at the foot of a grade, do so while the rear part of train is still on the hill. If you have an independent or straight air brake on the engine, keep it set tight until the train brakes are all released.

Ques. 80: How would you make a two-application stop with a passenger train?

Ans.: If fast time is to be made, run fast near the station, apply 10 to 15 or even 20 pounds in service, when the train is down to about 15 or 20 miles per hour speed, release in full release and back to lap; then apply with two or three 5-pound reductions, as necessary to stop right.

Ques. 81: How and when would you release the brakes on a freight train?

Ans.: Not until the full stop is made on any length freight train, if it can be avoided. See answer to Question 79.

Ques. 82: How and when would you release the brakes on a short passenger train? On a long passenger train (over ten cars)?

Ans.: Release the brakes on a short passenger train just 5 or 6 feet before stopping; on a very long passenger train, release 10 or 12 feet before stopping. More depends upon how much pressure you have in the brake cylinders than on the length of train. Try to release just as early as you can and still not let the train run along.

Ques. 83: How should a stop at a water tank or coal chute be made with a freight train?

Ans.: Stop a few car lengths short; cut off the engine to take coal or water.

Ques. 84: In switching with an air brake train and picking up uncharged cars, how should you handle engineer's valve?

Ans.: A high main reservoir pressure will release a low auxiliary pressure; hence before coupling to the uncharged cars see that this condition exists, even if you have to set and release the brakes (without recharging) you have coupled to the engine. When coupled up, the handle on lap and a high excess pressure, you will be able to release and move at once. Leave the valve in full release until the gauge hands begin to rise.

Ques. 85: If one quick action triple goes into emergency, will the others follow? How will you locate this defective triple?

Ans.: Yes, if it is a quick-action triple, all the other triples of either kind will go into emergency. Rare exceptions to this rule may occur where a large number of plain triples or cars having brakes cut out are placed together in a train. One method is to set about five pounds in service application and then find out which cars having quick action triple valves have not set; have some one watch each car while increasing three to five pounds more in the service application. The car that sets in quick-action first is the defective one, but as emergency travels at the rate of about 23 cars per second, it is best to cut out one of the cars that did not set at the first reduction and have the application continued; if this proves not to have been the one thus defective, test the train again, cutting out another car that failed on the first application, until the defective car is located. Another and ordinarily shorter method is as follows: Cut the air cars in two equal sections and repeat the test for applying brakes. This will tell which part of the train is defective. Then take one-quarter or three-quarters, according to whether the defective car is in the front half or back half of the train, and continue in this way (never trying with less than three car lengths of piping) until the defective car is found and cut out. A broken graduating pin in the quick-action triple or a sticky triple piston will cause a brake to set quick-action, and although this rarely occurs, no train should be taken out of the station until the defective car is located and cut out. It should be done before damage occurs.

Ques. 86: Should the brakes be released before uncoupling from train? Why?

Ans.: Yes, in order that the cars can be switched and the car repairers can tap (test) the wheels or jack up a journal box; also to prevent shoes from freezing to the wheels, and especially because a brake that is applied leaks so rapidly that in changing engines it may be found that much of the air has escaped.

Ques. 87: In descending a grade how can you best keep a train under control?

Ans.: The best way is to apply the air lightly while the train is moving slowly; keep the train at a slow speed and the train-line pressure as high as possible all the time. To do this, if it is necessary to recharge, reduce the speed below the average just before recharging. To recharge, handle the train as though a flagman had been seen half a mile ahead, that is, go slowly and exercise caution.

Ques. 88: In what position would you carry the brake valve handle between applications of the brake while descending a grade? Why?

Ans.: Full release up to the standard train-line pressure, because you can thus charge up more quickly.

Ques. 89: How rapidly does an auxiliary charge from fifty to seventy pounds? When should you particularly bear this in mind?

Ans.: About half a pound a second. In making a second application soon after having released.

Ques. 90: Explain the operation of the pressure retaining valve. What is its use?

Ans.: It is a weighted valve which the triple exhaust from the cylinder has to raise in order to escape, when the handle is turned up, before the brake is released. It causes the release to be slower and finally holds from 15 to 20 pounds pressure in the brake cylinder while the auxiliary reservoir is being recharged.

Ques. 91: **How many pounds of air is it intended to close up on and hold in the brake cylinder?**

Ans.: About 15 pounds.

Ques. 92. **Does the brake release any slower until it gets down to this pressure?**

Ans.: Yes; it causes the release to be slower.

Ques. 93: **Name the defects which cause the retaining valve to be ineffective.**

Ans.: Dirt under valve, cock leaking, retainer pipe leaking.

Ques. 94: **How do you make a test of retaining valves?**

Ans.: Reduce 10 to 15 pounds train line and then release with the retainers turned up. The retainer should hold the brake set at least two minutes.

Ques. 95: **When brakes go on suddenly without the action of the engineer, what are the causes? And what should be done?**

Ans.: The train has parted, a hose has burst or a valve has been pulled open. Shut off at once under all circumstances and place the brake valve on lap as quickly as possible.

Ques. 96: If you found the train was broken in two, how would you proceed to get under way again promptly?

Ans.: When the train has been brought to a stop, would place the handle in running position to see if the train pipe is still open. If it appeared to be a burst hose, would keep the handle moving from lap to running position and back, so that the trainmen could hear the air escaping from the burst hose. If it was found that the black hand is gaining in running position would know that the trainmen had found the defect and had closed the angle cock ahead of it. Would then release the head brakes and lap the valve so as to pump up excess ready to release the rear cars when the hose had been replaced, or the train recoupled if it had parted.

Ques. 97: How would you proceed in case of bursted hose? How can you help trainmen to locate it?

Ans.: By occasionally throwing the brake valve to release and back to lap.

Ques. 98: Why is it dangerous to apply and release the brakes repeatedly on grades, and approaching stations, meeting points, railway crossings and draws?

Ans.: If the auxiliary reservoirs are not given time to recharge between applications, there will not be sufficient pressure left with which to make a stop.

Ques. 99: Why is it important to have driver brakes in good order?

Ans.: Because they are the most powerful brakes on the train, are used the most, keep the tires worn down and prevent the engine from pulling away from the tank or train.

Ques. 100: How would you test for leaks in driver brakes?

Ans.: Make four 5-pound reductions (and see that they apply with the first), and they should remain set at least three minutes. If not, set fully or in "straight air" and examine with a torch all joints and pipes from the triple valve to both cylinders and all parts of the latter.

Ques. 101: Would you reverse an engine with the driver brakes applied? Why?

Ans.: Not if the brakes were in good order; because it would slide the wheels and not stop as quickly.

Ques. 102: What is the proper piston travel for engine brakes? For tender brakes? For car brakes? Explain how each is adjusted.

Ans.: Generally speaking. the piston travel should be kept between one-half to three-fourths the length of all kinds of brake cylinders except drivers. It is advisable, however, that freight cars be taken up to five inches when empty and drivers are best kept between two and four inches. It occurs in the practice of some companies, that engine trucks and ore cars or other cars of special construction have cylinders but eight inches long. In passenger cars the slack is taken up by the turn-buckles or dead levers. In freight cars and tenders it is taken up by the dead levers or bottom rods for inside connected brakes. In cam driver brakes it is taken up by lengthening the arms, and in truck brakes by lengthening the outside arms.

Ques. 103: What is the percentage of braking power on an engine? A tender? A passenger car? A freight car?

Ans.: About 70%;—100% of its weight without coal or water;—90% passenger and about 79% for empty freight cars.

Ques. 104: Do you consider a good light on the air gauge as important as on the steam gauge? How often and at what places should you look at the air gauge?

Ans.: Yes, more so, as steam is indicated by the working of the engine while, until ready for its use, there is no certain indication of the amount of air pressure except by the gauge, which must be clearly seen. Clear vision of the air gauge at night is very important and should be given proper attention; the light from the fire box when the door is open is not sufficient. When whistling for road crossings, or other similar places, and about two miles from all dangerous places, or places where the train is to stop, the gauge should be examined particularly.

Ques. 105: Do you appreciate the fact that handling the air brakes is a task requiring skill and close attention, to insure the comfort of passengers and the safety of freight and cars?

Ans.: I do.

Ques. 106: Do you understand that a failure of air brakes to work is invariably due to the failure of some man to do the proper thing at the proper time?

Ans.: I do.

Ques. 107: Do you understand that all brakes must be kept in good order to give proper service, and that proper reports of their condition must be made by men operating them to insure their maintenance?

Ans.: I do.

ELECTRIC HEADLIGHT.

Ques. 1: What attention must be given an electric headlight each trip to keep it in good working order?

Ans.: The commutator should be cleaned, a new carbon inserted in the lamp, the point of the electrode cleaned, and the proper amount of oil put in the bearing each trip.

Ques. 2: Describe passage of current through lamp and tell how arc or light is formed.

Ans.: The current flowing from the dynamo is called the positive current and enters the lamp at the binding post and from there passes through a No. 8 insulated copper wire to the bracket, thence through connections to the carbon; then down through the copper electrode and holder to a No. 8 insulated copper wire, through the solenoid, then to the binding post and back to the dynamo. As soon as current passes through the solenoid, it attracts the solenoid armature, which in turn is connected with the levers which clutch the carbon and separates it from the point of the copper electrode. As soon as this separation begins, the current jumps from the carbon to the electrode, and as the distance is increased the current becomes stronger in its effort to jump from one point to the other, and at the same time the current going through the solenoid becomes weakened and releases the solenoid armature until the distance between the carbon and the electrode points is properly adjusted to form the arc. As the carbon gradually burns away and the distance from the carbon and electrode becomes greater, the current going through the solenoid becomes weaker and the carbons are again drawn together by the tension spring until the proper arc is re-established.

\Ques. 3: If light burns all right while engine is standing, but dies down while running where would you look for the trouble? How would you remedy it?

Ans.: If the light burns all right while the engine is standing, but dies down while running, it is an indication that the carbon is jarring through the clutch faster than it is consumed and the clutch spring should be strengthened so as to hold the back edge of the clutch from being jarred upward and thereby releasing carbon. This may also be caused by the tension spring being too tight, thereby forcing the carbons too close together to form the proper arc.

Ques. 4: If the light flashes and goes out, and repeating this several times then goes out entirely, what would be the cause?

Ans.: This is probably caused by the carbon being very nearly burned out and the holder is fed down so that it just touches the clutch and the jar of the locomotive causes it to flash. This possibly might also be caused by a broken wire under the insulation, or both wires being jarred together where there is no insulation—it means a short circuit somewhere.

Ques. 5: If the light burns all right when engine is standing but dies down when running, and the faster you run the more the light dies down, what is the cause?

Ans.: This condition is caused by the same trouble as in question No. 3 and should be handled the same, for the reason that the faster the locomotive runs the more jar there is and the more apt the carbon is to jar through the clutch.

Ques. 6: If light dies down when you pull out from station, what is the matter?

Ans.: This trouble is caused by having too much water in the boiler and working wet steam in the turbine engine.

Ques. 7: If your light flashes and goes out for a second, then burns brightly, for a second, and keeps this up, where would you look for the trouble?

Ans.: It is probably caused by a broken wire, a loose wire in the binding post, or insulation worn off both wires, allowing them to be jarred together. Examine your lamp thoroughly, and see that all screws are tight and insulation good.

Ques. 8: If your light burns very dim and engine is working hard, and cab lights are bright, where is your trouble?

Ans.: This condition is caused by a short circuit and is probably in the incandescent wiring. The first thing to do is to pull out one of the incandescent wires from the screw, which will determine if the short circuit is in the incandescent wiring. If this does not remedy the trouble, look for a "short" in the lead wires between the dynamo and lamp.

Ques. 9: What should you be sure of, when putting in carbons?

Ans.: In putting in a carbon would be sure that the carbon was smooth and straight and that it falls through the clutch freely.

Ques. 10: If copper electrode burns off during the trip, state probable cause. What effect does it have on the light? Can you prevent it burning more? If so, how?

Ans.: The probable cause of the electrode burning off during the trip is the speed of dynamo being too high. This is shown by a green light instead of a white light. The burning of the electrode can be stopped at once by throttling the steam on turbine, which reduces the speed for the time being, and then, when at the end of trip, would report the governor and have the speed readjusted.

Ques. 11: Why should copper electrode be clean both on point and where it passes through holder?

Ans.: The copper electrode should be clean on the point so that the top carbon will touch the copper, for if there is any scale on the end of the copper it will prevent the carbon from touching the copper, and therefore would not get the proper contact necessary to get a current. It should also be clean where it passes through holder, so that the current will pass from holder to the copper freely, as any foreign substance has a tendency to insulate the copper from the holder.

Ques. 12: Give different causes for light burning green. What must be done to stop it burning green?

Ans.: The cause for the light burning green is that the copper electrode is burning. This may be caused by the speed of the dynamo being too high, or by the wires from the dynamo to lamp being connected up wrongly, so that the positive current enters the copper electrode instead of the top carbon. In this case the binding posts should be changed on the dynamo.

Ques. 13: If commutator becomes rough and out of round, what should be done with it?

Ans.: It should be trued up, which can be done very nicely, if not too badly out of round, by holding a strip of sandpaper by the ends on the commutator when it is running. If pretty bad, it should be put in the lathe and trued up, using a very sharp tool for the work, after which the mica strips in the commutator should be filed out a trifle below the surface, to be sure that the copper strips do not lag over.

Ques. 14: How and when should commutator be cleaned?

Ans.: The commutator should be cleaned at the end of every trip. This should be done with a piece of damp waste endwise on the commutator, and then finished with a dry piece of waste. It is not necessary to use sandpaper unless the commutator is rough and sparks.

Ques. 15: What is the bad effect of holding sandpaper except by ends?

Ans.: The bad effect of sandpaper on the commutator, except when held by the ends is to increase the low spot, as the sandpaper would then reduce the copper at the low spots, as well as the high, where if the sandpaper is only held by the ends, it only reduces the high spots on the commutator and therefore trues up the surface.

Ques. 16: Why should mica strips in commutator be kept below copper?

Ans.: For the reason that the copper, being softer than the mica, wears away more rapidly, and therefore the copper becomes a trifle lower than the mica, and the brushes passing over this mica cause the sparking on the copper.

Ques. 17: Why should sand-paper be used on commutator and not emery cloth?

Ans.: Because there should be a piece of sandpaper left between the commutator bars, where the mica is filed out, the current would not pass through the sand, but the emery, being a conductor of current under these circumstances, would cause a short circuit by allowing the current to pass through the emery.

Ques. 18: Do you put any oil in turbine? What kind and how often?

Ans.: The turbine engine should be oiled at least once a week to prevent scale on the buckets. Black oil is recommended for this.

Ques. 19: How and when should you oil armature bearings?

Ans.: The middle bearing should have just oil enough in the cellar to allow the ring in revolving to pass through it and carry the oil up on the shaft. It is very easy to tell when more oil is required, by removing the oil cap and noticing whether the ring is carrying the oil. The outside bearing on the cap should be oiled about every trip.

Ques. 20: What is the purpose of tension spring No. 932?

Ans.: Its purpose is to overcome the pull of the solenoid on the solenoid armature, preventing the same from separating the points of the carbon too far, and breaking the arc.

Ques. 21: If too tight, does it affect light burning with low steam pressure? If too weak?

Ans.: If tension spring No. 932 is adjusted too tightly, it will prevent the engine from running with low steam pressure, as by forcing the carbon points together the current is not consumed, and is therefore backed up into the dynamo, which creates a heavy current. If adjusted too weak it will allow the solenoid to separate the carbon points too far, thereby breaking the arc.

Ques. 22: If commutator sparks badly, what would you do?

Ans.: If the commutator sparks badly, and the sparking cannot be stopped by the adjustment of springs on the brushes, it should be trued up with sandpaper, as stated above, and then if the sparking does not cease, the face of the brush should be refitted to the commutator.

Ques. 23: Why should commutator be cleaned endwise and not round?

Ans.: If the commutator is cleaned "round" there is a tendency for dirt to lodge in the creases between the copper strips, which allows the current to pass through the dirt; the commutator should therefore be cleaned lengthwise, so that these creases will be kept clean.

Ques. 24: If light does not start when turning on steam, what would you do?

Ans.: The point of copper should be examined to see that there is no foreign substance to prevent the carbon touching it, that the proper tension is on the brushes, and that the commutator is clean, and then if the light does not start, a carbon or piece of wire or something which will carry current should be placed across the binding posts and then removed suddenly. If there is a flash upon removing same, the dynamo is all right, and then if the light does not start the trouble is in the lamp.

THE VAUGHAN-HORSEY SUPERHEATER

THE VAUGHAN-HORSEY SUPERHEATER.

Ques. 1: Describe in a general way the principle of construction of this type of superheater.

Ans.: The ordinary form of Vaughan-Horsey superheater consists of a series of five-inch tubes, termed "smoke" tubes, the number depending upon the size of the boiler. These tubes extend from the front to the back flue sheet, the same as the ordinary boiler tubes (commonly called flues); each of these tubes contains two U-shaped tubes, termed the "superheater elements," one end of these superheater tubes connecting to one part of a steamer header, which takes the place of the ordinary nigger head, and the other end of the tubes connecting to a separate chamber in the same header; this header consists of two elongated chamber castings, each entirely independent of the other, and each cast with a series of fingers. One chamber casting (acting as a nigger head) is bolted centrally to the dry pipe in such a manner as to have the fingers extended vertically downward, while the other chamber casting fastens at either end to a short steam pipe and has its fingers extending upward; these fingers when in position interlace, but with sufficient space between to permit the introduction of circulating tubes. As the throttle is opened steam is admitted through the dry pipe to the header, which acts as a nigger head, and from thence goes back through the superheater tubes and is returned forward, flowing into the other part of the header, which is connected to the steam pipe, from whence it flows to the steam chests and is admitted to the cylinders by the movement of the valves; the steam in its passage through the superheater elements takes up an additional amount of heat from that passing through the smoke tubes, and is in this manner superheated.

Ques. 2: What advantages are obtained from superheating the steam?

Ans.: Superheating steam raises its temperature and overcomes the loss due to condensation in the cylinders. It also has the effect of practically converting the steam into a perfect gas, thereby making it what can be termed "more lively," so that its flow, and likewise its action, against the piston is more rapid. Another advantage in superheated steam is its great capacity for work. This is not because of greater initial pressure in the cylinders, but is due to a greater volume per pound of steam to what may be called "greater elasticity" in the steam on account of the fact that there is sufficient reserve heat in the steam to permit a portion of the heat to be absorbed by the cooler metal of the cylinders without condensation resulting, and because the expansion of the steam is greater and its pressure during the period of expansion is therefore greater than with saturated steam. In short, superheated steam has the advantage of making an engine more snappy, besides effecting quite an economy in both fuel and water.

Ques. 3: Apart from reasons given as to why

water should not be carried too high in the ordinary locomotive boiler, why is it particularly objectionable on a superheater engine?

Ans.: Because, in this case, the advantages of superheating are in a large measure destroyed. The water that is carried over into the superheater elements with the steam absorbs the heat that would otherwise be absorbed by the steam itself, and simply converts this water into steam without having time to superheat it. Thereby the steam entering the cylinders is not much better than ordinary saturated steam, as it has been noticed that when the water is carried too high in the boiler, so that some of it is carried over into the superheater elements, the temperature of the superheated steam is materially lowered.

Ques. 4: Where is the superheater damper located and how is it operated?

Ans.: The superheater damper consists of a sheet iron plate mounted on a shaft extending across the inside of the smoke box, and is so arranged that when the damper is closed it stops the flow of gas from the fire box through the large tubes in which the superheater elements are located. At the outer end of this shaft, on which the damper is hinged, is secured a bell crank, one end of this being connected to a piston contained in a small steam cylinder attached to the side of the smoke arch, so that when the throttle is opened steam is also admitted to this small cylinder, which forces the piston out and opens the damper, holding it open so long as the throttle is open. When the throttle is closed the steam supplied to this small cylinder is cut oft and a counter weight attached to the outer arm of the bell crank forces the piston back into the small cylinder, at the same time closing the damper.

Ques. 5: Why is the superheater damper necessary?

Ans.: Because if the flow of gas through the large smoke tubes containing the superheater elements were not cut off when there is no steam in the superheater elements, that is, when the throttle is closed, it would soon cause the superheater elements to become overheated and burn out.

Ques. 6: Do you consider it necessary to keep the superheater tubes clean? Why?

Ans.: Yes, as if these tubes are allowed to become clogged up with cinders it would stop the flow of gas through them and, consequently, the steam in the superheater elements in the stopped up tubes would not be superheated.

Ques. 7: Is there any difference in lubricating the valves and cylinders of a superheater and a non-superheater engine?

Ans.: Not necessarily, although when superheating was first introduced it was believed that forced lubrication would be necessary, that is, that it would be necessary to force the oil by means of pumps into the steam chests and cylinders. Experiment has proven, however, that where a moderate degree of superheat is used the ordinary hydrostatic sight-feed lubricator will supply the oil as needed. The opinion also prevailed that more oil would be necessary when using superheated steam than when using saturated steam, and that it would also be necessary to lubricate the cylinders direct in addition to the oil that is fed to the steam chests. This has also been proven erroneous, and tests have shown that where first-class valve oil is used no more is necessary when using superheated steam than in using saturated steam.

Ques. 8: Are there any noticeable differences regarding handling of an engine using superheated steam as compared with one using saturated steam?

Ans.: Yes, there is quite a difference, the engine using superheated steam being much quicker or more snappy than the engine using saturated steam. Again, the engine using superheated steam does not use near as much water as the engine using saturated steam, and, consequently, is that much lighter on fuel.

THE WALSCHAERT
VALVE GEAR

THE WALSCHAERT VALVE GEAR.

Ques. 1: Name the different parts of the Walschaert valve gear?

Ans.: Beginning at the crank pin first, the eccentric crank which imparts motion to the valve, the eccentric rod connecting the crank with the link, the radius rod connecting the link with the combination lever, the combination lever which is connected to the crosshead by means of the union link at the bottom and to the radius rod at the top, and the valve connecting the combination lever. Of course, this gear also has the tumbling shaft, lifting arm, reach rod and reverse lever common to the Stephenson gear.

Ques. 2: How would you disconnect in case of broken suspension link?

Ans.: Simply remove the broken parts, block the radius rod in the link at the point where it is desired to work the engine, and proceed on both sides.

Ques. 3: How would you disconnect in case of broken radius bar?

Ans.: With the radius bar broken the engine would be disabled on that side. In this case simply remove the broken parts, block the valve to cover the ports and make the usual provision for lubricating the cylinder, either by slacking off the front cylinder head or removing the indicator plugs.

Ques. 4: How would you disconnect in case of broken crosshead arm or union link?

Ans.: In case the union link was broken, the combination lever could be tied by means of a chain, either to the guide lugs or the guide yoke. If possible, it should be tied so as to hang straight up and down. In this case, the engine can be brought in on both sides and the valve on the disabled side will have a travel equal to its original travel less the lap and the lead. If the combination lever is tied either forward or back the engine can still be brought in on both sides, but will sound very lame.

Ques. 5: How would you disconnect in case of broken combination lever?

Ans.: If the combination lever were broken near the top so that there was not enough remaining to fasten it, as in case of a broken union link, if possible, connect the radius rod direct to the valve stem or the valve stem crosshead at the point where the combination lever was originally connected. Where this can be done the engine can be brought in on both sides, the valve on the disabled side having a travel equal to its original travel less the lap and the lead. If this cannot be done the engine is disabled on that side. In this case, however, all that would be necessary to disconnect or remove is the broken parts, blocking the valve to cover the ports and making the usual provisions for oiling the cylinder. If the combination lever is broken off at its lower end, proceed the same as for a broken union link.

Ques. 6: What should you do if valve stem was broken?

Ans.: Disconnect the front end of the radius rod, tieing it up to clear, block the valve to cover the ports, and make the usual provision for oiling the cylinder. Unless a good light chain is available with which to suspend the front end of the radius rod it is advisable to disconnect the lifting arm also and block the back end of the radius rod in the centre of the link.

Ques. 7: How would you block main valve for broken main rod or bent piston, or cylinder head knocked out?

Ans.: In case of a broken main rod or a bent piston, the main rod necessarily comes down. In this case, the valve can either be blocked forward so as to leave the back steam port open, which would have a tendency to block the piston in the forward end of the cylinder, or the valve can be blocked to cover the ports and the crosshead be secured in the guides by means of wooden blocks. In case of a front cylinder head knocked out, it is not necessary to take down the main rod, but simply disconnect the front end of the radius rod and block the valve to cover the ports.

Ques. 8: What motions are combined in this gear?

Ans.: Two motions, that imparted by the eccentric crank which gives the valve its travel, and that imparted by the combination lever, which overcomes the lap and gives the valve its lead.

Ques. 9: How is the eccentric crank secured to the main crank pin?

Ans.: Different types of fastenings are used, the eccentric crank being sometimes split and slipped over the end of the main crank pin and then clamped to the pin by means of a bolt drawing the crank together where it is split. In other cases, by the eccentric crank being forced into the end of the crank pin and a bolt or key passing through both.

Ques. 10: Where is the radius bar connected to the combination lever on an inside admission valve? Where on an outside admission valve?

Ans.: In case of an inside admission valve the radius bar is connected to the combination lever above its point of connection to the valve stem, and with an outside admission valve below the valve stem connection.

Ques. 11: What is the position of the eccentric crank relative to the main crank, if forward motion is taken from the bottom of the link with inside admission valve? With outside admission valve?

Ans.: With inside admission valves it follows the crank pin at an angle of about 90 degrees, and with an outside admission valve it leads the crank pin the same amount.

OIL BURNER LOCOMOTIVES.

General Rules for Firing and Operating.

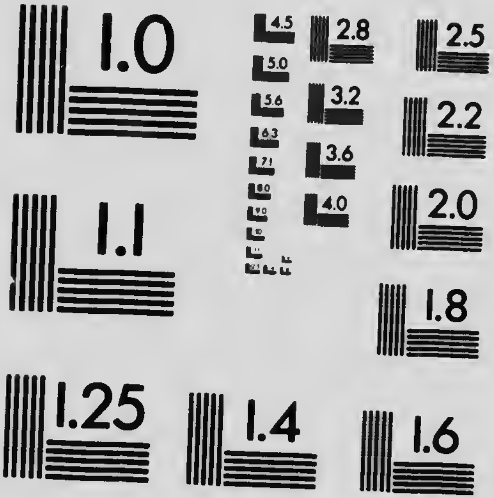
Note:—The following rules are divided into paragraphs. Each paragraph is numbered from No. 1 to No. 14. Following the paragraphs is a set of questions numbered 1 to 14. Read a question, then turn to the paragraph bearing the same number and the correct answer will be found. Following this section will be found a set of examination questions and answers upon Oil-Burning Locomotives.

1. Certain rules must be adhered to in firing an oil-burning locomotive, and these may be summed up briefly as follows: (1)—Before departure, oil-tanks must be full, and oil-heated to proper temperature without loss of time; (2) the fire must be burning and no oil dropping or lying in the outer pan; (3) there must be no brick or other obstruction to interfere with the free passage of the oil from the burner to the front wall; (4) sand buckets must be filled.

2. In starting the fire, the fireman must be sure that the fire-box is heated to the igniting point. If it is a dull red, the dampers must be opened, the blower started, the atomizer operated, and a piece of oily waste lighted and thrown on the bottom of the inner pan. If it does not ignite at once, the oil should be turned off, and the fireman should note if the waste is burning. When the oil ignites, the

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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blower and atomizer should be reduced to a very light speed, and the oil flow should be reduced until the stack becomes nearly clear. If the fire is started by the hot fire-box, no waste is needed.

3. The temperature of the heavy oil of the Kern River fields should be heated from 150 to 170 degrees, the McKittrick (thin) oil from 100 to 120 degrees, the temperature being taken from the measuring-rod that is suspended in the forward tank. The vents on the top of the oil-tanks should be kept open all the time, with the exception of when the tanks are so full that the oil is liable to splash out. The vents may be closed until the oil has been reduced about 6 inches in the tanks, but no lights should be near when the tanks are opened after being closed for any length of time, as the volatile products evaporate and fill the upper space with gas.

4. In heating oil by the direct application of steam, the heater should be put on strong until the proper temperature in the oil has been reached, then the heater should be closed before giving another application. Too strenuous application of the heater is apt to inject too much water into the oil. When there is a coil in the tank, the cock should be opened on the boiler-head sufficiently to produce steam at the drain-cock under the tank. If the weather is chilly at all, the superheater should be used constantly. The drain-cock of the superheater should be kept open enough to keep the cylinder dry.

5. In starting the train or engine, no move should be made until the fireman is at the valve. The care of the fire-box is important in keeping up steam and making time. The engine should be started care-

fully, and the firing valve should be opened sufficiently so that the exhaust will not extinguish the fire. The fireman should be careful not to feed in enough oil to make black smoke. The atomizer and oil should be gradually increased until full speed has been attained, and the supply should always be just below the quantity that would cause heavy smoke. When the engine is hooked up, the oil supply must be governed accordingly. When starting, the blower should be used about half a turn, because this assists in consuming smoke between exhausts, and keeps the engine hot.

6. The danger of black smoke is in filling the flues with soot, and as soot is a non-conductor of heat and produces none itself, the steaming immediately falls off. With the exception of starting, the stack should be kept clear all the time. Sanding the flues should be resorted to as often as necessary, and if the locomotive has to be worked hard, the sand should be employed every ten or twelve miles, but if the stack is clear, every 30 to 50 miles will be sufficient. Should switching be done at a station, the sand should be used at once upon leaving. With a good rate of speed, about a quart of sand should be used. All dampers should be closed, the reverse lever placed near full-stroke, the throttle opened wide, and the sand should be drawn from the funnel in a thin stream. When entering stations where stops are to be made, the oil supply should not be cut too low before the throttle is closed.

7. In firing with oil, it is well to remember that any draft through the fire-box is apt to extinguish the fire. With the throttle closed and the oil supply

cut down, the atomizer must also be reduced without delay—with just enough force to keep oil from falling on the ash-pan, because there is danger that the intensely hot fire will blow down through the air inlet and burn the bottoms of the pans. The fire should never be entirely extinguished unless at the end of the run, or when the entire crew is leaving the engine. To extinguish the fire, close the stop-cock under the tank, permitting all the oil to be drawn from the pipe and burner. Then the firing-valve, atomizer and dampers should be closed. In order to blow any obstruction from the oil line, the firing-valve should be closed, the cock between the heater line and the oil line opened, the heater line closed, and the cock on the boiler-head to the heater line be turned on full. This blows the obstructions back into the tank.

8. This same arrangement may be employed to heat the oil in the tank in event the coil heater fails. Should bricks fall from the arches or walls into fire-box in front in the burner, they should be removed without delay—or should be pushed to the front of the fire-box. When blue-gas comes from the stack, it indicates that the fire is either out or nearly so. This should be avoided—and particularly on passenger engines.

9. Care should be taken to see that the burners are so adjusted that the oil will strike about the middle of the front wall, because if the oil drags on the bottom of the pan, the result will be black smoke. This smoke, passing through the flues, has no cinders to cut it away, as in the case of coal, and interferes with the steaming of the engine. The sand in

the oil and pieces of waste sucked up by the air-inlet, are apt to clog the burner, but ordinarily the steam-jet case can be removed without disturbing the burner and the obstruction taken out. When water is being taken at water-tanks and the injector is on, the oil supply must be a little heavy and the blower be kept on lightly. Then, when the start is made, a full head of steam will be on. Careful attention should be given to the fire-box at all times, and particularly to the brick where it is used, as the oil penetrates it, and causes it to crumble. It is well to bear in mind also that an increase in steam-pressure in the boiler causes the atomizer and blower to work harder and they must be cut down.

10. In firing up an oil-burning locomotive in the round-house, steam connection is made to the three-way cocks in the smoke-arch, acting both as a blower and an atomizer. A piece of grease waste should be thrown in front of the burner in the fire-box, the atomizer-valve opened slightly so that the oil can ignite, and the fire should be watched until the engine is generating its own steam, when the round-house supply can be dispensed with. Too much oil permitted to run into the fire-box would cause an explosion that would not only extinguish the flame, but might also injure those near-by. Great care should be taken to see that the fire does not go out when started in a cold engine, as the flow would accumulate and might explode violently when ignited. The smoke from the stack is a good index to the condition of the fire. If it is white the fire has gone out, but oil is still running into the pan. The heat of the bricks causes this smoke.

11. When steam is not available in starting the engine, wood may be used until ten or fifteen pounds of steam have been generated, but care should be taken in placing the wood in the fire-box, as it might damage the brick. Care should also be exercised, where wood is burned, for fire might be caused along the road.

12. Absolute harmony should exist between the fireman and the engineer, and the latter should inform the fireman in plenty of time before closing the throttle, so that the oil supply can be diminished and waste avoided. The same care should be taken before opening the throttle, so the oil supply can be started. The increase and the work of the engine and the supply of oil should be similar. It is too easy to bring up steam on an oil-burner, and if more time is taken (about the same as a coal-burner would require) damage to the plates and bolts will not result. In drifting, or coasting, a little fire should be maintained. The dampers should be adjusted to suit the fire, and the injector can be worked now and then to prevent popping. The blower should be used sparingly, as leaks are apt to occur from over-indulgence in its functions. Waste should not be used around the oil-tank, as it is apt to get in with the oil and interfere with the feed.

13. The fire-door should not be left unfastened when starting the fire, as the flames are liable to be driven out of the door through the natural explosions of combustion. In measuring the oil in the tank, no light should be carried, but the measuring-rod should be used, which can be taken to the light afterward. Whenever a fire does go out, oily waste,

lighted, should be used to rekindle it. This will avoid explosions. In inspecting even an empty oil-tank, no light should be used unless the tank has been thoroughly steamed and cleaned out. Slipping or working the engine hard with the fires out, or starting before the fire has been lighted, will cause the flues to leak.

14. In doing work inside of the oil tanks, after they are empty, the tank should be filled with water, and a few pounds of caustic soda put in. The steam should then be turned on through the heater until the water boils through the man-hole.

15. While progress will be made with the burning of oil on locomotives, the principles are not complicated. Constant care on the part of the fireman takes the place of heavy work—and perfect combustion of oil means freedom from smoke. Economy is just as important as in the use of coal, and a little care and study will assist the fireman to become as proficient as his fellow-workers who still use the shovel. Oil will, perhaps never be used for locomotives in some parts of the country, but in other sections, it is the most available, and the cheapest supply. Some railway companies own their wells and secure oil far below the market value, but the price has never climbed very high without a recession, so that all companies are protected by contracts extending over long periods—but if oil were costing only a tenth of what it does, that would be no excuse for wasting it.

QUESTIONS.

Note:—The questions which follow are numbered from 1 to 14. They relate to the preceding paragraphs numbered in the same way. To find the answer to any question refer to the paragraph bearing the same number.

1. In firing with oil, what must the fireman do? How must he regulate the drafts and oil supply?

2. What should be the temperature of the different oils? How is the supply measured? What should be done about the vents on the oil-tanks? What precaution should be observed?

3. How should the heater be used? What should be avoided in using steam? In case of chilly weather, what should be done about heating the oil?

4. What should be done in starting the engine? When the train is under way, what should the fireman do? When should the blower be used, and how much?

5. Why should soot be avoided, and how often should sand be used on different classes of engines? How is the sand utilized? When entering stations, what should be done about feeding the oil?

6. What attention must be given to drafts? Should the fire ever be entirely extinguished? How is the fire put out? How is an obstruction cleared from the oil line?

7. If the coil heater fails, what is done? What should be done with bricks that fall into the fire box? What does blue gas coming from the stack indicate?

8. What should be done before adjusting the burners? Why? How does black oil smoke interfere with the steaming of the engine? How can obstructions be removed from the burner? When water is being taken, how should the oil supply be fed into the fire-box? What other attentions are needed?

9. How is an oil-burning locomotive fired up in the round-house? How long should the round-house steam be depended upon? What precaution must be taken about letting oil run into the fire-box when firing up? If the fire goes out in a cold engine, what danger threatens? What is a good index to the condition of the fire? What does white smoke denote? What causes this smoke?

10. If round-house steam is not available, how can the fire be started? What must be avoided in this case?

11. Why should there be harmony between the fireman and the engineer? What relationship is there between the throttle and the oil supply? How can damage from over-heating be avoided? How about the condition of the fire when drifting? How can popping be avoided? Can too great use of the blower cause damage? Should waste be used around the oil-tank—and why?

12. When starting a fire, what should be done about the fire-door? What care should be taken when measuring the oil in the tank? If a fire does go out, how should it be rekindled? In inspecting an empty oil-tank, when can a light be used? What may cause leaking flues?

13. What should be done with the oil-tanks before working in them?

14. What takes the place of hard physical work of the fireman who fires on an oil-burner? What may be said about economy? Are the far western roads fairly sure of an abundant supply of oil for some time to come? Should cheap oil be an incentive to careless methods?

EXAMINATION QUESTIONS AND ANSWERS ON OIL-BURNING LOCOMOTIVES.

Ques.: What are the fireman's duties on arrival at engine house previous to going out with an oil-burning engine?

Ans.: See that the heater is adjusted and the oil is heated sufficiently and that the oil is in condition to flow freely to the burner.

Ques.: How warm should oil be at all times in tank?

Ans.: When the oil is heated to a temperature that the hand can be held on the tank, (about 110 degrees Fahrenheit) the best results are obtained.

Ques.: What happens if the oil is too warm?

Ans.: By constant boiling some of the qualities of the oil are lost, the burner does not work well and it is more difficult to operate.

Ques.: What tools are necessary for firing purposes on an oil-burning engine?

Ans.: The tools prescribed by the railroad.

Ques.: If the heater valve is open too much what is liable to happen?

Ans.: A hose is liable to burst.

Ques.: When approaching oil supply stations, where additional supply of fuel oil is to be taken, what should be done?

Ans.: Care should be taken to see that there are no lamps or lights on the tender when the engine stops.

Ques.: In the use of lamps, torches or lanterns about oil-tanks, whether hot or cold, what care must be exercised?

Ans.: Care should be taken not to carry, nor permit any-one else to carry oil-lamps or oil-torches within a distance of ten feet of the tank opening.

Ques.: By what should the depth of oil in the tank be measured without taking a light to manhole?

Ans.: By the gauge.

Ques.: Before entering tanks that have been used for oil, to clean or make repairs, what precaution must be taken?

Ans.: Tanks should not be entered before they have been thoroughly cleansed.

Ques.: How should the fire be lighted in oil-burning engines?

Ans.: The boiler should be properly filled by trying the gauge cocks when the fire is lighted in the round-house. Steam connection can be made to the three-way cock on the smoke arch which will act as blower and atomizer. If there is 20 or 30 pounds of steam in the boiler it can be operated with its own blower. The front of the fire-box should be free from carbon or anything that would obstruct it from burning. It must have free passage to allow the oil to get to the burner. The front damper should then be opened, the blower put on strong enough to make the necessary draft, the atomizer valve opened long enough to blow out any water there might be in steam-pipe or burner; next the valve should be closed and a bunch of lighted old waste thrown in front of the burner, then open the atomizer sufficiently to carry oil to the waste and open the regulator slowly until the oil is known to be ignited—this can be seen through the fire-box door.

Ques.: If the fire goes out and it becomes necessary to re-light it while bricks are hot, is it safe to ignite the oil on the hot bricks without the use of lighted waste?

Ans.: It is not safe. Waste should always be used to re-light the fire as the hot bricks are likely to do damage from explosive gases formed.

Ques.: What is an Atomizer, and what duties does it perform?

Ans.: Atomizers are made of brass, about twelve inches long, by four and a half inches wide and two inches thick from top to bottom. They are divided into two parts by a partition in the middle. Their purpose is to separate the oil into a fine spray and blow it into the fire-box. The atomizer is located just under the mud-ring, and it is pointed a little upward, so that the stream of oil and spray of steam will strike the opposite wall a few inches above the bottom if it were to pass clear across the box. Deep fire-boxes have the atomizer at the back end of the box. Shallow and long fire-boxes have it located at the front end, pointed backward.

Ques.: When starting up or shutting off throttle of an engine, how should the fireman regulate the fire, in advance or after the action of the engineer?

Ans.: In advance of the engineer's action.

Ques.: Is it necessary that the fireman and engineer on an oil-burning engine work in perfect harmony, and advise each other of intended action at every change of conditions?

Ans.: Yes, they should work in harmony, and the fireman should watch every move the engineer makes. The engineer should also inform the fireman of every change of the throttle so that he can operate his valves accordingly, and so save oil.

Ques.: What is the effect on a fire-box of forcing the fire on an oil-burning locomotive?

Ans.: It causes the flues to leak. An even temperature in the fire-box should always be kept.

Ques.: Is a careful regulation of steam and oil valves and dampers necessary to obtain the most economical results?

Ans.: Yes, the firing valve should be opened sufficiently to make it certain that enough oil is being fed to produce a good fire, but not enough to cause a great volume of black smoke.

Ques.: How can you judge whether the combustion is good or bad, so that the valve may be regulated accordingly?

Ans.: By watching the smoke which comes from the stack.

Ques.: How should flues be cleaned of soot when running, and about how often is it necessary to clean them?

Ans.: The flues should be cleaned out after leaving terminals, or after an engine has been standing for some time. The use of the sand, frequently and in small quantities, is advisable.

Ques.: Is the injudicious use of the blower particularly injurious to an oil-burning engine?

Ans.: Yes, the frequent use of the blower is injurious to a fire-box and the cold air drawn in through the flues is likely to cause them to leak.

Ques.: Is the blower more injurious when a light smoke comes from the stack, or when a black smoke is emitted?

Ans.: It is more injurious when a light smoke comes from the stack.

Ques.: In drifting down long grades should the fire be shut off entirely or burned lightly? Why?

Ans.: The fire should be burning lightly, but not allowed to get too low. If the fire-box loses its temperature the flues may start to leak.

Ques.: How should the fire be handled when switching?

Ans.: The same as when running.

Ques.: Would some fuel be wasted in this manner?

Ans.: Very little; if a close watch is kept.

Ques.: How should fire be handled when leaving stations?

Ans.: It should be burning brightly and strong enough to keep from going out.

Ques.: Which is desirable—to use as much or as little steam-jet atomizer as possible?

Ans.: As little atomizer as possible at all times.

Ques.: What is the result of too little steam atomizer, when standing at stations, or engine working light?

Ans.: The fire is very likely to go out.

Ques.: If too much steam atomizer is used with little fire?

Ans.: Too much steam will be used and the temperature of the fire-box be reduced.

Ques.: When the fire kicks and smokes what should be done?

Ans.: The blower put on and the dampers closed.

Ques.: How should the dampers be used on an oil-burning engine?

Ans.: They should be closed when drifting to prevent cold air being drawn in, causing flues and staybolts to leak.

Ques.: About how much smoke do you consider an oil-burning engine should make under adverse conditions, when engine is steaming well, but is being crowded by engineer to make up time?

Ans.: No more than when an engine is working ordinarily.

Ques.: What color is most desirable at peep holes in fire-door?

Ans.: A bright, ruddy color.

Ques.: What will produce a ruddy color?

Ans.: By feeding only the amount of oil that is properly burned and watching the regulating valves closely.

Ques.: How does water in oil affect the fire?

Ans.: It affects the flame and requires more oil than otherwise.

ADDITIONAL QUESTIONS

ON THE

AIR BRAKE

Supplementary to the Examination

SUPPLEMENTARY AIR BRAKE QUESTIONS AND ANSWERS.

Ques. 1: How can you distinguish between the different kinds of triples?

Ans.: By their appearance and construction; there are three kinds: the plain, the quick-action, and the "K" triple. The "K" triple has a lug or fin cast upon the top of the body, which enables it to be readily distinguished from the other triples. The quick-action triple has a series of supplementary valves, which the plain triple has not, and which when thrown into action admit a portion of the train-pipe pressure to the brake cylinder, and at the same time the slide valve permits a large volume of air to flow to the cylinder, thus materially increasing the brake cylinder pressure.

Ques. 2: What are the features of the class "K" triple valve?

Ans.: It has additional features not possessed by the other triples, known as quick service, uniform release, and uniform re-charge.

Ques. 3: How does the E. T. Distributing valve operate?

Ans.: The principles governing the operation of the air-brake system with the E. T. Equipment are the same as those of preceding Westinghouse equipments. The difference consists in the means for supplying air pressure to the brake cylinders. Instead of a triple valve and auxiliary reservoir for each of the engine and tender equipments, the distributing valve is made to supply all the brake cylinders. The distributing valve consists of two portions called the "equalizing portion" and "application portion." It is connected to a "double chamber" reservoir, the two chambers of which are called, respectively, "pressure chamber" and "application chamber." The distributing valve permits air to flow from the main reservoirs to the brake cylinders when applying the brakes, from the cylinders to the atmosphere when releasing the brakes, and automatically maintains the pressure against leakage, keeping it constant, when holding the brake applied. The distributing valve also acts as a reducing valve in supplying air from the main reservoirs to the locomotive brake cylinders. Facing the distributing valve the two pipes on the right-hand side of the reservoir are: the upper pipe, the brake cylinder pipe, which connects the distributing valve to all the brake cylinders on the engine and tender. The lower pipe is the brake pipe branch pipe, which connects the distributing valve to the brake pipe. The three pipes on the left-hand side of the reservoir are: the upper, which is the supply pipe connecting the distributing valve to the main reservoir pipe; the intermediate, which is the application cylinder pipe connecting the distributing valve to both the automatic and independent brake valves; the lower, which is the release pipe connecting the distributing valve to the independent brake valve, and through it to the automatic brake valve. The distributing valve has two pistons; the application and the equalizing; and four slide-valves, being the application, exhaust, equalizing and graduating. The application and exhaust valves are operated by the application piston. The equalizing and graduating valves are operated by the equalizing piston. When the brakes are released the pressures in the distributing valve are: main reservoir pressure, brake-pipe pressure and atmospheric pressure. The main reservoir pressure is contained in the chamber above the application valve; while brake-pipe pressure is contained in the pressure chamber and in the chamber above the equalizing valve and graduating valve; and atmospheric pressure is contained in the chamber above the exhaust valve on the right-hand side of the application piston and in the chamber on the left-hand side of the application piston (called the application cylinder) and in the application chamber and the ports and cavities connecting to them.

Ques. 4: (a) How fast should a pump be run? (b) How should an air pump be oiled? (c) Under what conditions will a pump compress air in one direction only?

Ans.: (a) It should not be run at a speed greater than 140 strokes per minute, nor slower than 40 strokes per minute. It should be run just fast enough to keep up the pressure. For pumps in service quite a time 120 single strokes a minute is a fair average speed. (b) The steam end of the pump should be oiled through the air pump lubricator, feeding a sufficient amount of good valve oil, to keep the parts well lubricated and prevent groaning. Good valve oil is considered best for this purpose, but should be used sparingly, only sufficient being needed to keep the packing rings free and to prevent the cylinder walls from cutting. The air pump should always have a swab on the piston rod between the packing nuts, and this swab should be oiled regularly with good valve oil. Oil can also be fed into the oil cylinder, when necessary, through the air cylinder oil cups, but it should never be fed through the air inlets, as it will gum up the valves, close up the air passages, and cause overheating. (c) A receiving valve stuck open or shut, or a discharge valve stuck open or shut, or if the air cylinder piston rod packing should blow out, the pump will compress air in but one direction.

Ques. 5: On passenger trains at a high rate of speed, where should a train be steadied by brakes, on the curve or approaching it?

Ans.: Opinions differ as to this. The difference of opinion probably arises by confusing the two different effects that may be obtained from the brakes in accomplishing the desired result. One way is to materially reduce the speed before reaching the curve, by making an application as it is approached and following this by release as the engine enters the curve, using just sufficient steam in passing it to keep the train well stretched, the more so the better. The other method needs no material reduction in speed and requires a moderate brake application just as the engine is entering the curve, which should be held at least until all the train is on the curve, followed by a heavy use of steam as with the other method. The tendency of a curve is to press the wheels of a rapidly moving train heavily against the outer rail, and as there is always considerable lateral or side motion between the car wheels and the car bodies, as well as the same motion between the cars, there is always more or less tendency for the cars to jerk from side to side, producing shocks that it is sought to avoid in a train when it is passing over a curve at high speed with brakes off and but little draw-bar pull. As passenger car brake-beams are hung from that portion of the truck that is above the springs the application of the brakes reduces the spring action and much of the possible lateral or side motion in the trucks, rendering the car body and trucks more nearly a solid part, yet leaving the trucks free to curve. In like manner the greater the power exerted by the locomotive the more solid will be the train, as it tends to not only prevent the end-swing of cars, but also to ease the thrust of those toward the middle of the train against the outside rail. As a general thing, it may be assumed that a train will pass a curve more smoothly with the brakes held applied on the curve, provided the resultant speed will not be greater than safety justifies.

Ques. 6: (a) Where else, except at starting points, should you insist on a brake-test being made? (b) Of what should this test consist?

Ans.: (a) Wherever and whenever the number and condition of train brakes is not known, and at any other time when there seems to be a reasonable probability of an angle cock being closed that ought to be open; and safety demands that a test should be made at any points when the train is approaching a place where the failure of brakes to hold as expected would be attended with much greater danger than elsewhere. (b) The terminal test should be made of all the brakes on all cars picked up en route; and the conductor and engineer should, after such a test, know what percentage of the entire train this gives of operative brakes; it should be remembered that the law requires a minimum of 75 per cent and that the air brakes on all other equipped cars in the train shall also be used if they are so that the hose can be coupled, even though this might mean 100%. In no other way can safety be insured and the legal requirements complied with. On some roads it is required that a running brake test shall be made with passenger trains on leaving terminals and when approaching points where extra hazard would result if the brakes did not hold as they should. This running test consists of a moderate, but sufficient application, to enable the engineer to determine by the retardation and slack action experienced whether or not all is well. On leaving the terminal it should be made at about the same speed, and with practically the same reduction, as with either materially varied it is easy to be deceived. When the test must be made at higher and varying speeds, both speed and reduction should be taken into consideration in judging whether the results denote a satisfactory condition.

When an angle cock has been closed for any purpose and is supposed to have been again opened, as, for instance, after setting out cars, etc., and also when a train has been standing for some time where an angle cock may have been closed accidentally or maliciously, particularly if failure at the next expected use of the brake would prove extra hazardous, a standing test should be made by a reduction of 10 pounds, observing whether the rear brakes apply, and then release and observe whether they respond. Until it is positively known that the brake pipe is open as far back as it was supposed to be, the train should not proceed. No freight train should ever be started down a steep grade without a terminal test having been made at the summit, at which time the engineer should be informed as to the number of cars in the train, its tonnage and the number of good-order brakes. On some roads it is required that the engineer shall at such times be informed of the number of tons per good brake; this is arrived at by dividing the train tonnage by the number of good brakes. On one road an engineer is not permitted to start down a mountain grade with a train if the tons per good brake exceed the limits which have been predetermined for its various grades. If the caboose were equipped with air and it could be provided with a gauge connected with the brake pipe, the good order condition of this gauge could be deemed as importa[illegible] are the markers, and a rule could be made [illegible]ring that the "proceed signal" be not acted upon by the engineer after any stop unless it comes from a man at the caboose, and not to be given until the brake pipe gauge in the caboose showed at least 60 pounds and full pressure if descending a steep grade. Could this be positively insured it would be safe to employ it instead of the application and release tests with observation of rear brakes, made to insure against unintentionally closed angle cock.

Ques. 7: How do you test for leaks in air brake equipment, especially driver and tender brakes?

Ans.: To test the air gauge with the G-6 brake valve, would start the pump with the brake valve in full release position, both hands of the gauge should move up together, as in this position there is a direct connection between the main reservoir and the brake pipe; if the hands do not move up together and register the same pressure when the pump stops, the gauge is incorrect. To tell whether the pump governor is correct would note the pressure registered by the red hand when the governor stops the pump; if it is more or less than the proper main reservoir pressure and the gauge is correct, the governor needs regulating. To tell whether the feed valve is correct, would place the brake valve in running position, and if the black hand indicated more or less than 70 pounds and the pressure in the main reservoir is above this amount, the feed valve needs adjusting. To test for a leaky rotary valve of the brake valve, would close the cut-out cock under the brake valve and start the pump with the brake valve on lap position. If there is a leak past the rotary into the brake pipe it would be indicated by a blow at the brake pipe exhaust port, or the black hand will start. Another way to test the rotary would be to place the valve on lap, drain everything but the main reservoir, and then open the angle cock at back of the tender, and place the end of the hose in a pail of water. If there is any leak from the main reservoir into the brake pipe it will be indicated by bubbles arising to the surface of the water. When full pressure is pumped up, would shut off the pump and lap the brake valve; if the red hand started to fall back and the black hand remained in position, would know there was a leak in the main reservoir air. To test for a leak in the brake pipe, would make a seven-pound reduction and lap the valve, and the leak would be indicated by the black hand slowly falling; would then release the brake and close the cut-out cock under the brake valve, when, if there is any leak in the brake pipe of engine or tender, the brake will set. To test for a leak in the signal line, would close the cut-out cock next to the reducing valve, and if there is a leak it would cause the whistle to sound. Leaks in the joints and connections may be located by putting soap suds on them or by the use of a torch.

Ques. 8: (a) If, when making a stop with a heavy freight train, the drivers should begin to slide, and you did not dare to release the brake for fear of breaking in two, what would you do? (b) What would you do if equipped with combined automatic and straight air brake? (c) With E. T. Equipment?

Ans.: (a) In making a stop with a heavy freight train, would (provided the driver brake had any independent means of releasing) promptly operate the same and use steam. If not so provided, would "kick" the driver and other head brakes that would respond to a movement to release long enough to operate the driver brake triple valve, requiring but a second or two, so long as the reduction had not exceeded that necessary to fully apply any brakes, and would use steam. This would increase the liability of breaking in two, but as between two evils would prefer to accept the lesser, and slid-flat drivers are far more expensive, dangerous to rails and detrimental to train movement than is a break-in-two. Since prevention is better than cure, would always take precautions necessary to lessen the liability of sliding drivers, particularly where there is no means of independent release, such as keeping piston travel right—not too short—avoiding very heavy reductions and using sand in ample time when the rail is bad. (b) Would open the cut-out cock leading from the triple and double check valve and release the brake. (c) Would move the independent brake valve to release position until the drivers started turning again.

Ques. 9: Explain the operation of the pump governor.

Ans.: All the steam from the boiler to the air pump passes through the bottom of the governor containing the steam valve; this valve is closed by a piston operated upon by air pressure above it; when there is no air pressure above the piston it is held open by the combined action of the spring below it and by boiler pressure below the steam valve. As the boiler pressure and spring act constantly, it is only necessary to see how the air pressure is admitted to and taken from the top of the piston to understand the working of the governor. The top of the governor contains a thin, flexible diaphragm, holding a small pin-valve, which regulates the port leading to the top of the piston. The diaphragm is held firmly at outside edge by spring casing; the diaphragm has an additional spring above it and air pressure underneath it. The center of it is free to move up and down as conditions may require. In order to stop the pump air pressure must be admitted past the valve in the diaphragm body to the chamber on top of the piston, so it may force it and the steam valve downward. This air valve is held to its seat by the tension of the adjusting spring on top of the diaphragm body. In order to open it the air pressure under the diaphragm must be slightly stronger than the tension of the spring, so it may raise the diaphragm and valve. When this amount of air pressure is obtained, the diaphragm raises, opening the valve and allowing the air pressure to pass into the chamber on top of the piston, forcing it downward and closing the steam valve. To start the pump again, as soon as the pressure reduced below the required amount, through leakage or other cause, the spring overcomes the weaker air pressure and, forcing the diaphragm down, seats the diaphragm valve and so cuts off the supply of air from the chamber above the piston to escape. The piston is raised by a spring under it, with the assistance of the steam pressure under the steam valve, and as it raises it opens the steam valve and so admits steam to the pump.

Ques. 10: Explain how excess pressure head of E. T. governor operates.

Ans.: The excess pressure side of the governor controls the pump in release, running and holding positions, and when the brake valve is in either of the above positions main reservoir air from the H-6 brake valve will pass through a pipe leading to the chamber below the diaphragm of the excess pressure side of the governor; air from the feed valve pipe will enter the chamber around the regulating spring on top of the diaphragm. This spring is adjusted to a compression of about 20 pounds, therefore, there is the combined pressures of the feed valve pipe and the tension of the regulating spring acting on top of the diaphragm. As long as the pressure in the main reservoir and the chamber below the diaphragm is below the combined pressure above it the pin-valve will remain seated and the pump will continue to work. When the pressure in the chamber below the diaphragm and in the main reservoir exceeds the pressures acting on top of the diaphragm, the diaphragm will be raised and unseat the pin-valve and allow air to flow through the chamber on top of the governor piston, force it downward and seat the steam valve, thereby cutting off the flow of steam to the pump. When main reservoir pressure below the diaphragm becomes reduced, the combined pressures above the diaphragm will force it down and seat the pin-valve. This will allow the air pressure on top of the governor piston to escape through the vent port and the piston spring, and steam pressure under the steam valve will raise it and the governor piston, thereby allowing steam to flow to the pump. When the automatic brake valve is in lap, service or emergency position, the flow of air from the main reservoir to the excess pressure side of the governor is cut off, and the maximum pressure head of the governor will control the pump.

Ques. 1: (a) What might prevent governor from shutting off the steam when the maximum pressure is obtained? (b) What should be done with the broken air pipes on the governors?

Ans.: (a) There may be too much tension in the regulating spring; the steam valve may be held off its seat by dirt; the drip pipe may be frozen or stopped up; the pin-valve may be held on its seat by the spring box or if the pin-valve spring is missing the pin-valve will not be raised with the diaphragm, or the diaphragm may be cracked. (b) If the feed valve pipe branch to the excess pressure cock of the governor is broken off, would plug the broken pipe toward the feed valve pipe and put a blind gasket in a union in the pipe from the automatic valve to the excess pressure of the governor and allow the high-pressure top of the governor to control the pump. If the main reservoir pipe on the automatic brake valve to the excess pressure governor top were broken, would plug the broken pipe toward the brake valve and allow the high pressure governor top to control the pump. If the main reservoir air pipe to the high pressure governor top were broken off, would plug the broken pipe toward the main reservoir. The excess pressure governor top would still control the pump with the brake valve in release, running or holding positions, but when the brakes are applied with the automatic brake valve, would watch the main reservoir pressure gauge hand, and if the pressure were raising too high, would throttle the system supply to the pump at the pump throttle.

Ques. 12: What would you do if the governor would allow you but thirty pounds of air in spite of all you could do to fix it?

Ans.: Would cut the governor out of service by placing a blind gasket in the air pipe to the governor, or by plugging the pipe and controlling the pump by means of the pump throttle.

Ques. 13: To what part of the brake equipment is the distributing valve and its reservoir similar in operation?

Ans.: The connections between the two portions of the distributing valve and the double reservoir to which it is connected may be compared with a miniature brake set, the equalizing portion of the distributing valve representing the triple valve, the pressure chamber representing the auxiliary reservoir, and the application portion of the distributing valve representing the brake cylinder, due to its having practically the same pressure in its cylinder as that in the brake cylinders. The principle embodied in the quick action triple valve by which it gives a higher braking power in emergency applications is also embodied in the Number 6 distributing valve.

Ques. 14: What is the purpose of the independent brake valve?

Ans.: The independent brake valve serves the purpose of allowing the locomotive brakes to be operated independently of the train brakes. It also allows the release of the locomotive brakes under any and all conditions.

Ques. 15: How does the K and L type of triple compare with standard valves as to rate of charging?

Ans.: The K triple has a retarded release position as well as the usual release position of the ordinary triple. With the K triple valve in the normal release position, the rate of charging is practically the same as with the standard triples; but, in the retarded release position. the rate of charging is much slower than in normal release. This feature is used so that the brakes at the head end of the train will not recharge any faster than those at the rear end, and so that they will release more slowly, thus keeping the slack "bunched" and reducing the liability of break-in-twos. These K triples can be used with ordinary equipment and placed in any part of the train, although to get the benefit of their desirable features the K triples should be switched to the head end of the train. The L triples are for use in passenger service only, and, in addition to the ordinary charging action, they have a quick recharging feature, which operates by means of a supplementary reservoir on each car.

Ques. 16: **Can an entire train be charged as quickly as one car under ordinary circumstances? Why?**

Ans.: Theoretically, yes, because the feed grooves are designed to be of such a size that uniform recharging will take place throughout the entire train. In practice, however, this does not hold true, for, when the brakes are released on a long train, they commence to release on the head end first, and the recharge at the head end of the train is much more rapid than at the rear, due to the friction acting on the air in the brake pipe, and so causing the pressure to build up more rapidly at the triples at the head end of the train than at those in the rear. The fact that the auxiliary reservoirs at the head end begin to recharge before the rear brakes are released also tends to reduce the "pressure head" in the brake pipe by absorbing a quantity of the air and thus holding back the flow from the front to the rear of the train. The K triple has been designed to overcome these objectionable features.

Ques. 17: What additional features are embodied in the K triple valve that are not in the standard?

Ans.: The K triple valve, in addition to the regular features of the standard triple, has three new features, known as the quick service, uniform release and uniform recharge features. An entirely new part is added to the triple, known as the retarding device, and the arrangement of ports and passages in the slide valve and triple-valve body is also very different from that of the standard triple.

Ques. 18: What advantages are to be derived from these new features?

Ans.: The advantages derived from these new features of the K triple valve are as follows: First, more uniform charging of the entire train, consequently more uniform auxiliary reservoir pressures and a more uniform application of the brakes. Second, ability to leave the brake valve handle in release position longer without the resultant overcharging of the auxiliary reservoirs at the forward end of the train. Third, greater volume and pressure of air flowing toward the rear end of the train. Fourth, a saving of air, and much better control of the brakes and train by the engineer.

Ques. 19: Would it be necessary to brake as heavy to obtain the same result on a 75-car train equipped with K valves as it would if they were equipped with standard valves? Why?

Ans.: No, for the reason that a small amount of brake pipe pressure flows into the brake cylinders during service applications with the K triple valve. This increases the pressure produced in the brake cylinders by any certain flow of auxiliary reservoir pressure into this space.

Ques. 20: Name the different parts that are required to make up the L. N. schedule for passenger trains.

Ans.: The L. N. passenger brake equipment has the usual auxiliary reservoir and brake cylinder of the ordinary passenger equipment, an "L" triple valve being supplied in place of the standard triple. In the branch pipe from the brake pipe to the triple valve there is a centrifugal dirt collector and beyond that an air strainer. In addition to the auxiliary reservoir there is a supplementary reservoir, which is connected with the triple valve head and which is provided with a cut-out cock located in the pipe between the triple valve head and the supplementary reservoir. The "L" triple may, or may not, be provided with a safety valve, according to whether 110 pounds brake-pipe pressure is to be used, or whether 90 pounds will be the maximum. The "I." triple, in addition to the usual triple-valve features, has a by-pass piston and a by-pass valve, and a connection for a safety valve. In addition to these features, the arrangement of ports and passages in the slide valve and in the triple-valve body is different from that of former valves.

Ques. 21: Explain how you would handle a passenger train in making a service stop with complete L. N. schedule on the train and E. T. Equipped engine.

Ans.: In handling a passenger train equipped with L. N. passenger equipment and E. T. engine equipment, the brakes will respond much more quickly to service reductions. The auxiliary reservoirs will recharge very quickly so that full braking power will be available for a second, third or fourth application. There will not be the absolute necessity of returning promptly the handle of the brake valve to the lap position between applications, as the action of the supplementary reservoirs keeps the auxiliary reservoir pressure about equal to the brake pipe pressure during the re-charge, and there is thus less liability of the brake not responding promptly on the second and succeeding applications. By returning the brake-valve handle to lap, and moving it from lap to running position and back to lap, it is possible to graduate off the brakes on the train as well as the brakes on the engine. The other features are about the same as with ordinary equipment. From this explanation it can be easily ascertained how to handle the brake valve in making a stop under various conditions with a train thus equipped.

USEFUL POINTERS

NUMBER OF REVOLUTIONS AT DIFFERENT SPEEDS.

The number of revolutions made by the driving wheels of different sizes (from 4 feet to 7 feet in diameter), per minute, at different speeds, from 5 to 60 miles per hour:

Diameter of Driving Wheels		Speed per Hour in Miles.											
		5	10	15	20	25	30	35	40	45	50	55	60
		Revolutions per Minute.											
Feet.	Inches												
4	0	35	70	105	140	175	210	245	280	315	350	365	420
4	3	33	66	99	182	165	194	231	264	297	330	362	395
4	6	31	62	93	124	156	186	217	249	280	311	342	373
4	9	29½	59	88	118	147	177	203	236	265	295	324	354
5	0	28	56	84	112	140	168	196	224	252	280	308	336
5	3	26⅝	53	80	107	133	160	187	213	240	267	293	320
5	6	25½	51	76	102	127	153	178	204	229	255	280	306
5	9	24½	48	73	97	122	146	170	195	219	243	267	292
6	0	23⅓	46	70	93	117	140	163	186	210	233	255	280
6	3	22½	45	67	89	112	134	156	178	201	223	244	268
6	6	21½	43	64	86	108	129	151	172	194	216	237	259
6	9	20¾	40	61	81	111	121	142	164	182	222	223	243
7	0	20	40	60	80	100	120	140	160	180	200	220	240

TO FIND THE LOAD WHICH AN ENGINE WILL TAKE ON A GIVEN INCLINE.

Let G = Resistance due to gravity on the steepest gradient in lbs. per ton.

Let R = Resistance due to assumed velocity of train in lbs. per ton.

Let T = Tractive power of engine in lbs., as found above.

Let W = Weight of engine and tender in tons.

The load the engine can take in tons, including the weight of the cars, but not that of engine and tender

$$\text{will equal} \frac{T}{G + R} = W.$$

ADHESION PER TON OF LOAD ON THE DRIVING WHEELS.

When the rails are very dry........600 lbs. per ton
When the rails are very wet........550 lbs. per ton
In misty weather if the rails are greasy ....300 lbs. per ton
In frosty or snowy weather.........200 lbs. per ton

In coupling engines the adhesive force is due to the load on all wheels coupled to the driving wheels.

The adhesive power must exceed the tractive force of an engine on the rails, otherwise the wheels will slip.

SHORTCUTS IN ARITHMETIC.

To find the circumference of a circle multiply its diameter by 3.1416.

To find the diameter of a circle multiply its circumference by .31831.

To find the area of a circle multiply the square of its diameter by .7854.

To find the cubic inches in a ball multiply its cube of diameter by .5236.

To find the revolutions of drivers per mile divide 1680 by the diameter of the wheel in feet.

To find revolutions per minute multiply the speed in miles per hour by 28 and divide the product by the diameter of the driving wheel in feet.

To find piston speed in feet per minute multiply revolutions per minute by twice the stroke of piston in feet.

To find speed of train per second multiply speed in miles per hour by 22 and divide by 15.

To find time when rate of speed and distance is given multiply distance by 60 and divide by rate of speed.

To find rate of speed when distance and time are given, multiply distance by 60 and divide by time in minutes.

To find the distance when the time and rate of speed are given, multiply the time by the rate of speed and divide by 60.

To find the number of tons of coal in a bin: Length, height and width of pile in feet multiplied together, divide by 30 for hard coal, by 35 for soft coal, by 128 for cords of long wood, and by 135 for cords of sawed wood.

To find pounds of coal used per 100-ton mile multiply pounds of coal by 100 and divide by tons multiplied by the miles hauled.

To find the pressure in pounds per square inch of a column of water multiply the height of the column in feet by .434.

HOW AN ENGINE IS REVERSED.

When the reverse lever is in the extreme forward motion, the go-ahead or forward motion eccentric governs the movement of the valve entirely. When the lever is in the extreme back motion the backing eccentric controls the valve. As the lever is moved from the forward motion toward the center of the quadrant, the link to which both eccentrics are connected by means of the blades is likewise raised, the link block being brought toward the center of the link. In this position both eccentrics act on the valve, reducing its motion, or, in other words, shortening the cut-off. The motion of the engine is reversed, as the movement of the lever reverses the position of the valve, except in case where one side of the engine is on the dead center, in which case the port opening is not changed on that side. For illustration, if the engine is standing with right side on the forward dead center, the left side would be on the upper quarter. Now, if the reverse lever be put in the extreme forward motion the front port on the right side would be open the amount of the lead, while the back port on the left side would be fully opened, admitting steam behind the left piston and moving the engine forward. Now, if the lever be moved to the extreme back corner the front port on the right side would still remain open the amount of the lead, but the left valve would be drawn back, covering the back port and opening the front port, thus admitting steam against the front end of the piston and moving the engine backward.

THE LOCOMOTIVE BOILER IN SERVICE.

The frames of the locomotive are regarded as two girders, and are supposed to be strong enough to bear the weight of the boiler and all that is on it without yielding, but this is not entirely correct.

The boiler and frames are secured to each other by the expansion braces at the fire box end, the cylinders at the front end and by belly braces at intermediate points [illegible] the barrel of the boiler. The boiler and fram[illegible]ng bound to each other in the manner they a[illegible], it is the supposition that this combination is self-sustaining, but such is not the fact, as the boiler itself indicates. Keen observers, who are responsible for the care of boilers, know that the boiler yields by its own weight when it receives heavy shocks. Where the belly braces are riveted to the barrel of the boiler, which has run any length of time, it will be found that around the edge of the rivets, inside the boiler, the sheets are grooved. Grooving is nearly always a result of sheet movement. If these braces are not riveted, but are brought up to the boiler so as to fit around the under side, the working of the engine will show the chafing of the braces on the boiler, indicating the resistance it must offer.

Other signs of destruction are the small cracks that take place in the upper side of the throat sheet. These are generally supposed to be effects caused by some obstruction to the expansion of the boiler.

When the upper corner stay bolts and others next to the flange of the throat sheet are found leaking, it is evidence of the strain put upon them when the boiler bends up or down. There is some spring between the flange and these stay bolts, but little or none in the upper sides, where the cracks take place. This spot may be looked upon as the fulcrum of the lever, as it receives the direct crushing effect, alternating as the boiler bends. The weight of the barrel and its contents, with the cylinder bolted to the smoke box, acts like a weight on the end of the lever, keeping that end of the boiler down and binding it to the frames.

These destructive strains mentioned may be regarded as mechanical, while at the same time there are still some serious strains caused by the unequal expansion and contraction, due to heating and cooling. We have heard it said that certain boiler explosions were due to the act of God, but as a rule the neglect of inspection and proper reports by the men in charge are the real origin of the disaster.

WATER IN BOILERS.

Water contains two classes of mineral salts, the incrusting and the alkali salts, the amount of which determine its fitness or unfitness for use in locomotive boilers. The sum of these would represent the total solids dissolved in the water, and would be the residue left on evaporation. Total dissolved solids:

1. Incrusting matter or total hardness.
   a. Temporary hardness or carbonates of lime and magnesium.

b. Permanent hardness or sulphate of lime.

2. Alkali salts.
   a. Sodium sulphate.
   b. Sodium chloride.
   c. Sodium carbonate.

INCRUSTING SALTS.

The incrusting salts, or total hardness consist of the carbonates and sulphates of lime and magnesia, and may be divided into temporary hardness and permanent hardness. Temporary hardness represents the carbonates of lime and magnesia. These salts, when the water is boiled at atmospheric pressure, are precipitated in the form of a soft scale or as a mud, which, if allowed to accumulate, results in a dirty boiler and a tendency to foam. Permanent hardness is sulphate of lime.

When the water is boiled at pressures below sixty pounds this remains in solution, and for this reason has been called "permanent" hardness. At pressures above this it separates as a hard scale on the flues, the result of which is continual trouble from leaky flues, due to overheating of the metal.

ALKALI SALTS.

The difference between the total dissolved solids and the total hardness would represent the "alkali" salts or the sulphates, chlorides and carbonates of sodium. These salts remain in solution after the water has been boiled, their total amount increasing up to a certain concentration when foaming results. Waters high in alkali salts are, on account of the tendency to foam, unfit for boiler purpose.

TREATMENT.

There are, then, two evils that must be counteracted in a boiler water, the tendency to form scale, and the tendency to foam. The scale forming evil is remedied by the use of sodium carbonate, or as it is commonly called "soda ash." This is one of the alkali salts that exists in some waters, but it cannot exist in the same water with sulphate of lime, as the two would react to form sodium sulphate and carbonate of lime. Now, if a water containing permanent hardness, or sulphate of lime, be treated with soda ash, this same reaction takes place within the boiler, the carbonate of lime being precipitated as a mud and the sodium sulphate going into solution. The result is no scale on the flues, but the extra mud and increase in total dissolved solids aggravate the foaming trouble. A systematic and liberal use of the blow-off cock will keep down the foaming trouble in two ways; first, by removing the mud; second, by reducing the concentration of the water or total dissolved solids. It has been determined that when boiler waters contain over 200 parts per 100,000 total dissolved solids they are pretty liable to foam.

The usual practice has been to wash an engine out when it began to get dirty or show signs of foaming, but now we find that a sufficient use of the blow-off cock, especially the back water leg blow-off cock, makes it possible to avoid serious foaming troubles and to increase the engine mileage between washings very materially.

All laboratory analyses are expressed as so many parts per 100,000. This divided by 1.73 would show the same in grains per U. S. gallon.

STEAM.

Saturated Steam. When steam is taken directly from the boiler to the engine without being superheated, it is termed saturated steam. This does not necessarily imply that it is wet and mixed with spray and moisture.

Point of Saturation of Steam. When the vapor has attained the limit of density and pressure, corresponding to the temperature, the steam is said to be saturated, and it is always in the state of saturation when in contact with water. For one pressure there is one density and one temperature, and the higher the pressure the greater is the density and the higher is the temperature.

Dry Steam. When steam contains no moisture it is said to be dry. Dry steam may be either saturated or superheated.

Wet Steam. When steam contains mist or spray intermingled, it is termed wet steam, although it may have the same temperature as dry saturated steam of the same pressure.

Superheated Steam. Superheated steam is amenable to the laws of permanent gases, and behaves as one of them, expanding and contracting in the inverse ratio of the pressure, when the temperature is constant, without the condensation of any portion of it.

When steam is conducted into or through a vessel or coils of pipe separate from the boiler in which it was generated and is there heated to a higher temperature than that due to its pressure, it is said to be superheated.

Specific Heat.

The ratio of the amount of heat required to raise the temperature of a substance one degree to the amount of heat required to raise an equal weight of water one degree is called the specific heat of the substance.

The specific heat of bodies varies very considerably, as will be seen from the following table:

Water=1.000	Wrought Iron=0.113	Lead=0.031
Cast Iron=0.130	Copper=0.100	Mercury=0.333
Steel=0.118	Bismuth=0.031	Coal=0.241

Water has the highest specific heat of any substance except hydrogen, and the metals have the lowest. In other words, it takes more heat to raise the temperature of a given weight of water than any other substance.

Volume and Pressure of Steam. If the volume be forcibly reduced, and the vapor compressed, without any change of temperature, the compression has not the effect of augmenting the pressure, as would happen if the air was similarly treated; it only results in liquefying a portion of the steam, according as the volume is reduced, so that the volume, however reduced, will only contain so much proportionally the less of steam of the original pressure. In order to increase the pressure, the temperature must be raised.

Expansion of Steam. When a quantity of steam is placed out of contact with water, as in the cylinder of a steam engine, it may be expanded, and again compressed up to the limit of saturation, and it will follow approximately, though not precisely, the law of Boyle or Mariotte; that is to say, the pressure is nearly in the inverse ratio of the volume, insomuch that when the volume is doubled the pressure is reduced to about one-half, and when the volume is trebled the pressure is reduced to about a third.

VELOCITY OF STEAM.

The utility of high-pressure steam as a means of transforming heat into mechanical work results in a great measure from its expansive force and the velocity and freedom with which steam passes from one vessel to another or out into the atmosphere. The velocity of the flow of steam depends directly upon its pressure and is as the velocity of a body falling freely by gravity from a height equal to a column of steam represented by the steam pressure, or to the difference of level between the height of the column of steam and the height represented by the pressure of air or other vapor into which the steam is passing. One exception to this is that the velocity of steam flowing into a vacuum is constant at all pressures.

To calculate the velocity with which steam of any given pressure passes into a medium having a pressure equal to the atmosphere, the following process may be followed. The required height of the column of steam is estimated by its proportion to a column of water, due to a certain pressure. The square root of the height multiplied by 8, that well-known rule regarding falling bodies, gives the velocity of steam due to the pressure. Suppose we wish to find out the velocity of steam of 10 pounds pressure above the atmosphere. It is well known that one pound of pressure represents a column of water 2.3 feet high, and 10 pounds pressure will represent a column of water 23 feet high. At that pressure above the atmosphere one pound of steam occupies 1,0008 times the volume of a pound of water. So $23 \times 1{,}008 = 23{,}184$, the height of the column of steam. Then $\sqrt{23{,}184} \times 8 = 1{,}218$, the velocity in feet per second of steam of the pressure given. A small fraction is omitted, but the result is correct enough for practical purposes.

The quantity of steam of any pressure that will pass out of a safety valve, a whistle slot or other opening can be calculated by this rule; but it is found that when the opening is made in a thin slot the escaping jet of steam suffers a contraction, so that its area is reduced from 30 to 50 per cent.

To calculate the velocity with which steam will pass into a cylinder or other vessel that is already filled with vapor above atmospheric pressure, the difference between the two pressures has to be taken. Suppose we have a steam chest pressure of 100 pounds above atmospheric pressure, and at the beginning of the stroke there is a back pressure against the piston of 35 pounds, due to compression. The question is at what velocity will the steam begin to pass from the steam chest to the cylinder. Deducting the lower pressure from the higher one will give a basis for a column to generate the velocity. The velocity of steam passing from any higher to a lower level may be found at any point by this process.

THE END.