POCKET EDITION
OF
LOCOMOTIVE ENGINEERING

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Locomotive Engineering

A NEW COMPLETE SERIES OF QUESTIONS
AND ANSWERS TREATING ON THE

First, Second and Third Years' Progressive Examination Questions; Air Brake and Mechanical, Locomotive Construction and Mechanical Appliances.

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In Detail, Common to all Types and Classes of Locomotives and the Proper Method of Treatment.

Written Expressly for the

LOCOMOTIVE ENGINEER AND FIREMAN

By

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Chicago, Illinois

INTRODUCTION

The object of placing this little book in the hands of the employees of the various rail-roads is not to create the impression that the authors are supplied with all the knowledge there is pertaining to the subject, but is rather a treatise on the subject from our own point of observation. While rail-road employees and rail-road companies have come to realize that knowledge is power let us take into consideration some of the things which ought to be done, rather than be willing to criticize the things they have done, and if their efforts to direct some of the many employees of the rail-roads upon the right path in the manner of discharging their duties, our efforts to write this little book will not have been in vain.

Willingness to learn, as well as to be properly adapted to a certain class of work or profession is one of the essential factors that spell SUCCESS. The demands of the rail-roads of to-day, like all other large business enterprises, require that its employes be thoroughly familiar with the characteristics of their occupation, and to the man who excels in his chosen field of labor, promotion is always his reward.

While to the individual it may sometimes seem as though his particular efforts were not attracting the attention of the officials, nevertheless the man who goes along day after day, successfully doing his work, is the man who is always under the eyes of his employer.

This man needs not the suggestion and advice to keep him in line with his fellow men, but is held up to them as a fit example after which to pattern. Surely this reward is sufficient, for the employee is entitled to such praise but he should not think it necessary for his officials to be loudly heralding his praises. To this man and also to his brother fellow man (the one who is always the subject of comment by his fellows and his employers) is this little book dedicated.

Let us then in a brotherly spirit think of some of the things we should and should not do that we may better perform our duties with credit to ourselves and our employers. Do not think that because a man is new in this particular line of work, that it will be impossible for him to learn or that it will be impossible to teach him. Just have a little patience, try him out, he may be a very apt scholar, perhaps you may be able to learn a lesson while trying to teach him one. He may some day become a very valuable man to the company, and he will surely remember you in case you tried and did give him a successful start.

Always bear in mind that we ourselves were once new men, and in all probabilities as green as any one. Stop and think how hard it was for you to learn some of the things you did not know. Don't think because you are now an engineer that you never was a fireman. In a few short years this fireman may also be an engineer, and you may then have to compete with him then, even if he was at one time only a fireman.

Men of to-day are not only following in the footsteps of others before them but are going a little beyond those footsteps. While rail-roads require a great deal of their men, still they do not require more than the men can do (whatever man has done man may do). So that when you have reached your capacity as an individual you have done all they require of you, providing you have not fallen below the average. Prepare yourself for all emergencies. You can master what others have done. Stand on your own ability and little, if any, fault will be found with you.

Be interested in your work, be always on time, do things intelligently and you will have the key to success.

We will now quote a little book of don't, complied by Mr. Rob't. Quale, Sup't. of Motive Power and Machinery of the C. & N. W. R. R. While this book has been supplied to the employees of the C. & N. W. R. R. no doubt it will fall into the hands of the employees of other roads, and as the information contained in Mr. Quale's book is so valuable we insert, and quote it, in hopes that it will be the means of starting some of the many employees of rail-roads on the right path.

I am now to call your attention to a chapter of don'ts. I put it this way in order to make it stand out more boldly than if it were surrounded by too many words. You will please understand that the writer knows that it WOULD be unnecessary for this circular letter to be placed in the hands of many men, while on the other hand he knows it will do good to a great many, and we trust will result in an economical operation.

FIRST. Don't think because you are only one engineer or fireman that what you do does not amount to much. It is the little drops of water that make the mighty ocean, and the little grains of sand that make up this old earth of ours, so after all it is the little things that count, and just so each individual in the aggregate, can do a great deal. If each engine crew saves one quarter ton of coal, this on a thousand locomotives, would result in a daily saving of two hundred tons, or in round figures $157,000 a year.

SECOND. Don't neglect being at the roundhouse in ample time to examine the firing tools on the engine before leaving the roundhouse. See that your ash-pan, grates, and flue sheets are in good condition to make the run.

THIRD. Don't fill the boiler full of cold water as soon as you get out of the house. Leave a space so the injector can be worked to prevent popping, while the air-pipe exhaust is fanning the fire, pumping air to make the terminal air-brake test. If you do this your fire will be in better condition to pull out with. The noise of open pop prevents trainmen from locating the leaks.

Don't forget to start the lubricator a few minutes before leaving a terminal. Set it to feed regularly.

The proper lubrication of valves and cylinders saves coal.

FOURTH. Don't forget, when starting trains, to do so carefully, thus preventing damage to draw bars and draft-rigging. By so doing you will save serious delays to your own as well as to other trains. All delays mean extra fuel consumption to make up time lost.

Don't neglect using the blow-off cock, as it keeps the boiler clean and the water in good condition, and insures better circulation in the boiler. RESULT: Better steaming engine and a saving in coal.

FIFTH. Don't allow the engine to slip. This is an unnecessary waste of coal, wears out tires and rails, causes great damage to pins, axles and running gear, and generally results in spoiling a fire.

SIXTH. Don't pull out of a station with a train (after engine has stood for a while, and fire was allowed to get low) without first giving the fireman a chance to build up the fire. The time lost waiting to do this will save coal and can better be made up before reaching the next station. Remember this when you get a time order.

SEVENTH. Don't leave the reverse lever down in corner longer than is necessary when pulling out of stations. No rule can be made to govern how the throttle and reverse lever should be used. This must be acquired by practice and observing the performance of the engine. Bring the lever up as speed is acquired. The lever hooked well towards the center of quadrant, with throttle well open, usually gives better results than using the throttle to govern the speed. Up to five years ago we considered it good practice with our smaller power, to run with wide open throttle, and as short a point of cut-off as was possible consistent with weight of train, but in our heavier and larger engines we find that it is better at all times to throttle the engine. Particular attention is called to all wide fire-box type of engines. The engineer can permit the reverse lever in these engines to remain low in the quadrant when starting from a station, for a greater length of time than with the other type of locomotives, without pulling the fire or loosing steam. When you are running on short time, it would be good judgment for the engineer to take advantage of this when pulling out of a station. In this engineers will use their best judgment.

EIGHTH. Don't put four, five or more shovelfuls of coal into the fire at once. One or two shovelfuls will give better results, and these two should not be thrown in the same spot. It is good practice to fire on one side of the fire-box at one time, and the next time on the other side of the box, in order that the bright fire on one side may take up the gases from the fresh coal on the other side. This will reduce the smoke and give more steam.

Always fire as light as possible consistent with your work. Very heavy firing will make your flues and staybolts leak, and in time will crack your fire-box sheets. The reason for this is that when you have a very heavy fire the air will not pass up through it readily, and the gases pass off, because there is not sufficient oxygen to unite with them to produce combustion, and as gases must get air from somewhere, the air is pulled through the fire-door, causing the chilling of flues and sheets as referred to above.

NINTH. Don't allow steam to escape at pops unnecessary. Frequent blowing off at pops shows improper judgment, and implies that the engine crew is not practising economy. Tests have demonstrated that one-fourth of a pound per second or fifteen pounds per minute is wasted. This amounts to about one ordinary scoopful, and in most cases may as well have been thrown on the ground as into the firebox. There are only 133 scoopfuls in a ton of coal, so you can see that you would only have to have your pops open 133 times a day in order to throw a ton of coal away.

TENTH. Don't open the fire-box door to prevent steam blowing off at pops when engine is working; dropping the dampers is a better practice. The supply of air is cut off, and combustion is partially suspended. When engine stops blowing off open the dampers again, before putting in coal. This method keeps fire in better condition and saves coal. You have, no doubt, noticed that on class R. Locomotives, when working hard on a hill you have to shut your dampers to keep your fire from turning over. This is because the exhaust pulls too much air up through the grates, and causes your coal to be too active, and to prevent this activity of coal, as well as increased combustion which follows, we consider it a good thing to drop your dampers as per above.

ELEVENTH. Don't insist on having the maximum steam pressure with pops opening occasionally when handling light trains, when less pressure will handle the train on time, avoiding the opening of the pops.

TWELFTH. Don't forget, when engine is shut off for stations to drop your dampers, opening the firebox door slightly if necessary, and using the blower to carry off the black smoke.

THIRTEENTH. Don't blame the engine or coal if engine is not steaming properly, before you have ascertained whether or not both of you are doing your duty. Talk it over; see if the injector is not supplying more water than is being used, or that fireman is not firing too light or too heavy. Heavy firing is responsible for more poor steaming engines than the lighter method. You all know some engine crews have better success than others with same engines and conditions. Think a little, there must be some cause for this.

Don't wait until you get a signal to pull out before building up the fire. This should be done gradually until the proper thickness has been reached. A good fire to start is essential to maintain the proper steam pressure, while engine is working hard getting train under way. Afterwards distribute the coal on sides, ends, and in corners. Do this systematically, keeping in mind where you placed the last scoopful, thus avoiding getting holes in fire, and preventing the piling up of the coal all in one place. Endeavor to keep the steam pressure uniform, with as little black smoke as possible. Experience has taught that engines with draft appliances properly adjusted require very little coal in center of fire-box.

FOURTEENTH. Don't permit the water to get so high in the boiler that it is carried over into the valves and cylinders. This usually occurs when pulling out of stations, and the water carries off the oil, which not only results in cut valves and cylinders, but the extra friction damages the entire valve motion, to the detriment of the power of the engine and the coal record.

Don't gauge the amount of water an engine will carry by water coming out of the stack. Keep it low enough to insure dry steam being used, because moist steam has the same effect as water. Usually one-half glass or two gauges give best results. Be careful, however, that when ascending a grade, and you are about to pitch over the other side, that you have sufficient water to keep your crown sheet thoroughly covered. If your custom has been to carry high water try less and note change in better handling of tonnage, also saving in coal and oil.

FIFTEENTH. Don't neglect to take advantage of your excess steam before your engine is about to pop off, by making a heater of your injector, blowing steam back into the tank to warm the cold water, but avoid getting it so hot that the injector will not lift the water. By doing this you will keep your engine from blowing off at pops when standing at stations after boiler is filled up. You have all tried warming the water in the tank to help a poor steaming engine, with good results. What is good for a poor steaming engine will surely help a good engine to do better. Try it and you will find that it will not only save work for the fireman, but will make a better coal record for the engine crew, besides keeping the tank from sweating, which you are aware spoils paint.

SIXTEENTH. Don't think the fireman alone to blame for your coal record. The best and most economical fireman cannot make a showing with an engineer who supplies more water to boiler than is being used, and who shuts injector off only when the boiler is pumped full. The proper handling of the injector is one of the most important matters in saving coal. Feed water to boiler according to demands. If on through trains, keep water level as possible. If on way freight or switch trains, loose a little water between stations. Fill up again while drifting into, standing or switching at stations. The advantages of supplying less water than is being used between stations are: It requires less coal to keep up steam pressure when running; also leaves a space so injector can be worked to avoid pops opening, and heavier fire can also be maintained to do switching, without the possibility of the fire being pulled.

Don't pull out after making a stop with injectors working. The water introduced during the period throttle was shut off is put in circulation throughout the boiler, and pointer on gauge drops back from five to twenty-five pounds. The fireman must then fire heavier to regain the lost steam, and naturally will use more coal. This condition exists also when engine has gone down grade with throttle shut or only slightly open. Shut the injector off before opening the throttle. If it is not your practice, try it and note the difference.

SEVENTEENTH. Don't wait for the pops to open, and use this for a signal to put on the injector. Keep your eye on the air-gauge, steam-gauge and waterglass. You all know this can be done without distracting your attention from the track ahead. A look for an instant every mile or two will keep you informed and is a good habit. Doing this will also keep you posted on air pressure, and may avoid difficulties should the air pump stop. The fireman should also keep an eye on the water glass, and the engineer is sometimes compelled to keep the injector at work to keep the engine from blowing off. When glass is full, the fireman should fire lighter to give the engineer a chance to shut off the injector, and not have engine blow off. However, this condition should only exist when injector cannot be worked fine enough to just supply amount used. This sometimes occurs when card time is slow, or on down grade, or when running with light train.

EIGHTEENTH. Don't put too much coal under the arch of engines having sloping fire boxes, because these engines naturally pull the coal ahead, which results in forward section of grates becoming stuck and clinkered over, and fire is pulled in back end of fire box. Experience and observation will teach you to put most of the coal in the back end of the firebox.

NINETEENTH. Don't think an engine having two firebox doors requires twice the quantity of coal it would if engine had but one. The extra door is for the purpose of distributing the coal more evenly over the grate surface, with less effort on the part of the fireman.

TWENTIETH. Don't shovel large chunks of coal into the firebox, because you find them on the tank. The coal house men have instructions to break it in the size of an apple. If not properly broken, report it to road foreman of engines or to Master Mechanic, instead of fellow engineers or firemen, but don't think it a hardship to break some occasionally. Better break it than to throw in, in large chunks. They are foundations for clinkers.

TWENTY-FIRST. Don't expect the fireman to fire the engine with one or two scoops to each fire, and also ring the bell for highway crossings and stations. Some engineers expect this. If engine is equipped with air bell-ringer, get into the habit of starting the bell ringer when blowing the whistle. By so doing, the habit will become as fixed as whistling for crossings and stations. Besides it is just as important. Remember the engineer is responsible.

TWENTY-SECOND. Don't put in a heavy fire about the time the engine is shut off for a station or down grade. The heavy cloud of black smoke is evidence the engine crew is not working in harmony. If on train that stops at all stations, the fireman should guard against it and learn when to stop firing. He will be governed by grade, service and weather conditions. If train does not make all station stops, the engineer should keep the fireman informed of intended stops.

TWENTY-THIRD. Don't forget that different qualities of coal and different make of grate used, govern the shaking of grates. Coal that fills up and clinkers requires more attention than the better grade. The object is to keep the grates free, so the proper amount of air can be admitted.

TWENTY-FOURTH. Don't neglect cleaning your fire on trains that are long hours on the roads. Make use of the first opportunity. You will get better results with less labor and coal, and avoid leaky flues. Better clean out a small amount two or three times than not to clean it at all.

Don't take coal or water oftener than necessary, as it requires an extra amount of coal to get a heavy train again in motion, especially on a grade. Good judgment is required, in order not to run short before getting to next coal chute or water tank. Where possible take water only from tank containing good water, and as little as you can from tanks containing poor water.

TWENTY-FIFTH. Don't forget that leaks in the air pressure are being kept up by an equal amount of steam pressure. As it takes coal to make steam, air leakage means a waste of coal. Keep apparatus on your engine tight and insist on trainmen doing their part.

TWENTY-SIXTH. Don't try to put more coal on tank than will lay on it securely. All coal dropped off by overloading is wasted. Also keep coal from falling out of gangway when running. This may be only a little each day but it all counts against your coal records, besides it looks badly when strewn along the tracks. You cannot save coal by the ton; it must be in pounds which in time makes tons.

TWENTY-SEVENTH. Don't forget to make an intelligent report on your work slip on arrival at the Round House. Consult your fireman in regard to any defect that has come to his notice, especially with grates, dampers or firing tools.

TWENTY-EIGHTH. Don't neglect reporting the pop-valves ground in when they are leaking or when they blow back eight or ten pounds before seating. Also report leaky piston rod and valve stem packings, or if cylinder packing or valves are blowing. All these leaks draw on the coal pile unnecessarily; as it takes coal to generate the wasted steam. This also applies to leaky steam heat appliances, cylinder cocks, etc.

TWENTY-NINTH. Don't neglect looking at coal report each month to see how you stand in relation to others in same service with whom you are comparable. The other crews get the same pay you do, and it should be your aim to be as economical with both fuel and supplies as they are, other things being equal. Keep posted and be with the average. It will be to your credit and interest some time; therefore aim to be at the top.

THIRTIETH. Don't think when coal report shows you using only two pounds more per 100 ton mile than other crews in same service, it is close enough. This means two pounds more used for every mile you hauled 100 tons,—or another way, two pounds for every 100 tons hauled one mile. Figure this up and you will find in hauling 1,000 tons 100 miles, a difference of 2,000 pounds or one ton. This method of showing up the individual record is more equitable to all than on basis of mile run per ton of coal.

THIRTY-FIRST. Don't think, after reading over this chapter of Don'ts that you should save coal to the detriment of the service. The actual amount required to make up time, keep on time, or handle tonage, is not what we are trying to save; it is the waste. You will notice the proper method of handling the engine to the extent of the economical use of fuel only has been considered.

There is much more that might be said on this subject, but no doubt you will think by this time that enough has been said; at least the writer will think so if the results obtained will show they have thoroughly digested this chapter of "Don'ts" and put the same into practice, and get the returns we are looking for.

You of course understand that this is not written in any but the most cheerful spirits, and this department urges upon you an intelligent, thoughtful earnest compliance with the same.

Yours truly,

R. QUAYLE, Supt. M. P. & M.

Chicago, March 28, 1901.

FIRST YEAR'S MECHANICAL QUESTIONS AND ANSWERS.

1. What are the fireman's duties on his arrival at the Round House, previous to going out?

Ans. In regards to the duties of Locomotive Fireman on his arrival at the Round House, he should first consult the bulletin board, ascertain the correct time, what Engineer, and engine he is to have, compare his time with a standard clock, or get same from train dispatcher, and register in or out, according to the custom of the road by which he is employed. He should assist the Engineer in getting the engine ready in whatever way he can, such as seeing that the firing tools are all on the engine, also signal appliances, and devices, note the water level, and condition of the fire, getting same in condition to make the trip. He should assist the engineer in whatever way he can to get the engine out on time, according to the rule Master Mechanic regards to getting out before leaving time of train.

He should also examine grates, to see that they are in working condition, note condition of fire-box, see that it is free from leaks. After getting out of the house he should take water, examine the ash-pan, see that the man provided for that purpose cleans the same.

He should have fire in good condition and sufficient water in the boiler to enable engineer to use blow-off cock at place provided for that purpose. After such performance he should build up the fire according to train and conditions of the trip, and at all times bearing in mind the use of the injector to keep the engine from blowing off and avoid making any black smoke.

He should at all times be under the instructions of his engineer, and try to supply the water to the boiler and build up the fire so as to have both in proper condition to pull out of the terminal without putting any more water into the boiler until train is well in motion and engine hooked up.

After train is in motion he should fire as light as possible, consistent with the work the engine has to do, trying at all times to prevent the making of black smoke and having the engine blowing off.

2. **Have you acquired the habit of comparing time with the engineer? And do you insist on seeing the train orders?**

Ans. Yes.

3. **What causes the tank to sweat? And what effect has it on paint? What would you do to prevent it?**

Ans. The tank sweats on account of the water in the tank being colder than the atmosphere. This causes the paint to crack and peel off leaving the bare metal to rust. In order to prevent this the water in the tank should be raised to the same temperature as the atmosphere by making a heater out of the injector.

4. Describe the ash-pan, its use, and what would be the effect if allowed to fill up?

Ans. The ash-pan is a rectangular box, provided with dampers at each end, and its uses are, to be a receptacle for ashes, also to regulate the draught of the fire. There are also ash-pans with sliding bottoms but their uses are the same. If the pans were allowed to fill up the air would be excluded, thus destroying the draught and there would be danger of burning out the grates and grate shaker bars. The pan would also be warped out of shape and in all probabilities burned badly. This would cause fire to be strewn along the track setting fire to any burnable substance along the right of way. When the air necessary for furnace combustion is excluded by a badly filled up ash pan a poor steaming engine is the result.

5. What advantage is it to the fireman to know the grades of the track, and the location of the stations?

Ans. With this information he can more intelligently and economically fire the engine, thus avoiding the engine blowing off and the making of black smoke.

6. What is the source of power?

Ans. Heat is the source of power.

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

Ans. Steam is an invisible gas. It is generated by the heat coming in contact with the water, raising the same above the boiling temperature. This causes the water to assume the form of a bubble, which on reaching the surface of the water it bursts into the gas called steam.

8. What is the composition of bituminous coal?

Ans. The composition of bituminous coal is Hydrogen, Nitrogen, Oxygen, Carbon, Sulphur and Ash.

9. What is carbon and where do we obtain oxygen?

Ans. Carbon is non-metallic substance, one of the elements of which the diamond represents it in its purest state. We obtain Oxygen from the atmosphere.

10. What per cent. of oxygen is there in the atmosphere?

Ans. The atmosphere is about 20 per cent. or 1-5 oxygen.

11. What per cent. of carbon is there in bituminous coal?

Ans. There is from 60 to 90 per cent. carbon in bitumenous coal.

12. What is the igniting temperature of carbon and oxygen?

Ans. The igniting temperature of these two substances is about 1,800 degrees Fahrn.

13. What other heat giving properties are there in bituminous coal?

Ans. The hydro-carbons, and other gases, which when liberated and ignited, form one of the most heat-giving properties of coal.

14. In what condition should a fire be to consume these gases?

Ans. It should be at a very high temperature, or a white heat. This condition can be maintained by a systematic method of firing, such as firing light and often. Firing heavy, such as putting four or more scoops of coal on a bright fire at one time, has the effect of cooling the gases below the igniting point. The gases which are then liberated pass off un-consumed, and black smoke is the result. Black smoke is not combustible after it is once formed and the best heat-giving properties of the coal are wasted. It should be the fireman's effort to adopt the method of firing light and often, as the results obtained are not only more satisfactory, but much more economical. While building up the fire at the stations this method will be found satisfactory,—open the blower slightly, fire one side of the box at a time, regulate the draught of the fire by raising and lowering dampers (if engine is so equipped), bearing in mind that a sufficient amount of oxygen must be admitted to the fire through the grates to form perfect furnace combustion. These results cannot be obtained by heavy firing and a waste of fuel and black smoke is the result.

The arch in a locomotive fire box consists of a composition of fire clay in the form of a brick. These bricks are supported in the fire box on an arch flue or circulation flue, and are placed a sufficient distance from the flue sheet to allow a circulation of the gases underneath them and through the flues.

There are several forms of these bricks, but the most common are the solid brick. The solid arch consists of the solid brick, while the hollow arch consists of the hollow brick, or the double combustible surface by reason of having a cavity through the brick. This double surface retains the gases longer before liberating them, thus forming a more perfect combustion in the firebox.

These different forms of arches have another advantage namely: the protection of the flues by preventing the cold air from striking them while the firebox door is open. These results, such as flue protection, and a more perfect combustion cannot be obtained on an engine not so equipped.

15. **When and why should we wet the coal down?**

Ans. Some authorities differ as to the wetting of the coal as an aid to combustion, but it should be wet for cleanliness sake. The proper time is before the engine is started and as often thereafter as necessary to keep down the dust.

16. **Why are grates made to shake and why should they be shaken?**

Ans. Grates are made to shake in order to rid the fire of ash and to prevent clinkers from forming. If the fire is not rid of the ash that forms the air will be excluded from the fire and a poor steaming engine is the result. Ashes and clinkers also tend to cause black smoke. Different make of grates and different grades of coal govern the shaking of grates, the best results being obtained while the engine is standing still or if necessary it is in some cases permissible to shake them while the engine is working light or drifting. It is very bad policy to shake the grates while the engine is working as the exhaust will tear holes in the fire and then a large amount of cold air is admitted and the gases are cooled below the igniting point. This causes the formation of black smoke, uneven expansion and contraction takes place in the firebox and leaky flues and sheets are the results.

17. **What do you consider abuse to a boiler?**

Ans. Improper firing, such as allowing the pressure to rise and fall by firing too heavy or too light, not keeping an even steam pressure causing uneven expansion and contraction, the improper use of the blower or the injector, not supplying the water to the boiler according to evaporation, firing with the door open, these things all tend to bring about boiler abuse.

18. **Describe the blower, its use and abuse.**

Ans. A blower consists of a tap of live steam at some convenient place on the boiler head (usually on the fountain) conveyed to the smoke box through a pipe, controlled by a valve. This steam is emptied or emitted in the smoke box causing a partial vacuum, the air from the atmosphere rushing through the grates to fill this vacuum, causes a draught on the fire. The blower should be used to create a draught on the fire when the engine is not working, when cleaning or dumping a fire, and to help in the prevention of black smoke. The abuses of the blower are using it too strong at any time, or to use same when the engine is working steam.

19. How does the exhaust steam create a draught through the fire?

Ans. The exhaust steam expanding as it passes through the nozzle, petticoat sleeve and stack causes a suction that in turn creates a vacuum in the smoke box while the air rushing in through the grates and flues to fill up vacuum causes a draught on the fire.

20. Why is it necessary for a supply of air through grates in furnace combustion?

Ans. It is absolutely necessary to have air in the firebox for furnace combustion as there must be a certain amount of oxygen in order to bring about this mixing in order to produce the burning of any burnable substance. This theory can be proven by turning the scoop on the firebox door while the engine is working and noticing the mixing of the gases.

21. What is the effect if too little, or too much, air is admitted to the fire in furnace combustion?

Ans. If too little air is supplied it is impossible to obtain combustion. If too much, the gases are cooled below igniting point, and they will pass off as black smoke.

22. How should you take care of a boiler with leaky flues?

Ans. When an engine has leaky flues you should keep the temperature in the firebox as high and as uniform as possible, keeping the heat against the flue sheet, and if necessary use the blower while standing to accomplish this result. When the leaks are in the side sheets low enough would bank the fire against them, causing the coal to cake, and thus not allowing the leak to spread over the fire, thereby reducing the temperature of the firebox by deadening the fire.

23. **What amount of water ought to be evaporated in a locomotive boiler to a pound of coal?**

Ans. About 8 or 9 pints to the pound of coal.

24. **What is the advantage of a large grate area?**

Ans. The advantages are that a lighter fire can be carried, a more perfect combustion with a poorer grade of coal, also a greater heating surface, thereby preventing the necessity of forcing the fire.

25. **Can you fire an engine more intelligently by watching the water level?**

Ans. An engine can be fired more successfully by watching the water level as by so doing the fire can be maintained in a more perfect condition, a more uniform pressure of steam kept, expansion and contraction remain the same, and the work of the engine will be much more economical from both the running and the firing standpoint.

26. **What are the fireman's duties on his arrival at the terminal in regards to dampers and signals?**

Ans. On the arrival at the terminal the boiler should be left full of water, a good fire in the box, dampers closed, and all signals that have been displayed removed and placed in their proper places in the cab.

SECOND YEAR'S MECHANICAL EXAMINATION.

Has there been any thing to hinder you, or to prevent you from taking this examination?

Ans. This question can be answered in the negative, as by a few minutes of study each day the whole list of questions can be mastered in a very short time. The information necessary to successfully answer these questions, can be obtained from the different officials of the different railroads, and books are now so cheap, that any man who cares to make a success of the business he has chosen will not fail to provide himself with some of the many kinds of books, pertaining to the subject.

1. How many cubic feet of air are necessary for the combustion of one pound of coal in a locomotive firebox.

Ans. It requires from 250 to 300 cubic feet of air to the pound of coal, to produce perfect combustion.

2. What, in your opinion, is the best way to fire a locomotive?

Ans. In order to successfully fire a locomotive the fireman must have good judgment, must be well acquainted with the conditions under which the engine is being operated, as follows: Always bearing in mind that successful and economical discharge of his duties depend upon attention to such things as, being familiar with the road upon which he is working, close watch upon the method of handling the engine by his engineer, taking into consideration that the train, time to be made, weather conditions, and physical characteristics of the road have much, and in fact all to do with the method to be used in firing. He should always bear in mind that a close watch on the water, or proper pumping is the largest factor in the successful operation of the engine from both the running and firing standpoint. He should always try to maintain his fire in as good a condition as possible making allowances for poor coal and hard steaming engine. Keep his fire as light as possible, consistent with the work the engine has to do, bearing in mind that if the engine does not steam with a light clean fire, providing it is not too light that no better results can be obtained after it has become heavy and clinkered due to heavy firing (commonly called slugging). He should take advantage of stops to notice the condition of the fire, and if necessary, while standing is the proper time to shake the grates. See to it that the ash pan is not so full that the draught is effected by the air being shut off from the fire, for without this oxygen it is impossible to get that form of combustion which produces economical results. Try to get the method that will suit the engine, rather than make your method suit the engine. Railroads have come to realize that brains, rather than muscular prowess, produce the best results.

3. **What is the cause of the drumming noise when engine is shut off? Can it and should it be avoided? Why?**

Ans. The drumming noise heard when the engine is shut off is caused by the rapid explosion of the hydro-carbon gases. This can and should be avoided as it is very annoying to passengers. This drumming or vibrating noise will often shake the last car in a 15-car passenger train, which is very annoying to the occupants of the car. This can be stopped by slightly opening the firebox door or by closing the dampers, if engine is so equipped. This drumming noise while very annoying to passengers also has certain injurious results on the machinery of the engine, but is no cause for fear as it shows the fire to be in good condition.

4. **Describe the general form of a locomotive boiler?**

Ans. The general form of a locomotive boiler is cylindrical in shape, but the firebox end is generally larger than the barrel of the boiler. The boiler consists of a firebox end, and the cylindrical portion containing the flues which run from the firebox to the smoke box end. The firebox consists of a back sheet, side sheet, flue sheets and a crown sheet. The space between the inside and outside sheets is called the leg of the boiler.

5. **How does the wide firebox differ from other**

types of boilers, and what advantages has it over other boilers?

Ans. The wide firebox differs not only in construction but has other advantages. The box extends out over the wheels which gives it a much larger grate area than is possible with the older types. This larger grate area permits of a greater heating surface, a more uniform and slower rate of combustion.

6. To what strain is the firebox subjected?

Ans. The firebox is subjected to a crushing strain. The weight of water and pressure within have a tendency to rend the box apart, also the atmospheric pressure from the outside has a tendency to force the sheets in.

7. Describe a locomotive firebox.

Ans. The general form of a locomotive firebox is rectangular in shape, consisting of back sheet, side sheet, flue sheet and crown sheet. The crown sheet forms the top or roof of the box, and the space between the inside and outside sheets is known as the leg of the boiler.

8. How are the sheets of a firebox supported? In what manner is a crown sheet supported?

Ans. The sheets of the firebox are supported by a threaded bolt known as a stay bolt. This bolt is screwed through the two sheets and riveted over. These bolts are usually about four inches apart. The crown sheet is supported, either by crown bars or by radial stays.

9. What is the bad feature about crown bars?

What are the advantages of radial stayed crown sheets?

Ans. The bad feature about crown bars is, that they are hard to keep clean, very expensive to repair, and by some authorities it is claimed that they permit of a very poor circulation of water in the boiler.

The advantage of a radial stayed crown sheet are, that the crown sheet is much easier to keep clean, cheaper to repair, and permits of a better circulation of water in the boiler. So far as safety is concerned there is not considered any particular difference.

10. **What is known as the leg of the boiler?**

Ans. The part of a firebox between the inside and outside sheets of a boiler is known as the leg of the boiler.

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

Ans. The inside and outside sheets are secured at the bottom by what is known as the foundation, or mug ring. This ring consists of a solid piece of metal usually about four inches square, and is the foundation on which the firebox end of the boiler is built.

12. **Is it objectionable to run tanks over or spill water at stand pipes? Why?**

Ans. It is objectionable to run tanks over for following reasons: In freezing weather this causes ice to be formed around pen stocks and water tanks, and on the backs of tenders, which is very dangerous in winter. It is also very wasteful. In summer it washes away the gravel from the track destroying the road bed. This waste is very expensive, and in some localities, where the pumping facilities are limited, is very much felt. There is no real good excuse why water should be wasted, any more than any thing else belonging to the company.

13. **What is a wagon top boiler?**

Ans. A wagon top boiler is one in which the fire-box end is much larger, than its cylindrical portion.

14. **Why are boilers provided with steam domes?**

Ans. The boiler is provided with a steam dome to furnish a receptable, or place for the collection of dry steam, also a place for the boiler fittings, such as the whistle, safety valves, throttle valve, and etc.

15. **What must be the condition of a boiler to give the best results?**

Ans. The boiler must be clean, free from corrosion and incrustation, such as limey deposits, and have a good circulation.

16. **What causes the water to circulate in the boiler?**

Ans. By circulation of the water in the boiler is meant, the movement of the water caused by the coldest water settling nearest the highly heated sheet. The hot water rising up through the other water in the form of a bubble, causes a movement known as circulation. Or the fact that the cold water moving to the heated sheets and displacing the hotter water-may be called the circulation of the water in the boiler.

17. (a) What would be the effect if the leg of the firebox became filled with mud?

(b) What would be the results if firebox sheets became overheated?

Ans. If the leg of the firebox became filled with mud, the water would be excluded from the sheets and they would become what is known as mud burned and would in all probabilities be forced from their stays.

If the firebox sheets became overheated the metal would become soft and the pressure of steam would force the sheets off their stays and an explosion would be the result.

18. Would it be advisable to put water onto a sheet that had become bare and redhot?

Ans. While this question has been answered by actual tests and under certain conditions, the introduction of water on heated sheets only served to cool the metal, the writers think that it would not be advisable as the sheets being red hot would in all probabilities warp and pull off their stays. If not the formation of steam so suddenly might bring about disastrous results, such as an explosion.

19. In the event of losing the water in the boiler from any cause, how would you be governed?

Ans. In the event of losing the water in the boiler from any cause, or being uncertain as to its true level, the throttle should be eased off and the gauge cocks opened to ascertain the true level. In case the water level is below the bottom gauge cock the throttle should be opened and the reverse lever hooked well up in the quadrant. If the water could not be raised to the bottom gauge cock the fire should be dumped to protect the boiler. If the water shows at the gauge cocks, or water glass the injectors should be put to work and the boiler filled to a safe working level.

20. What effect has the stoppage of a large number of flues?

Ans. If a large number of flues became stopped up the boiler is robbed of that amount of heating surface, and also cause the engine to tear holes in the fire. This also causes the fire to burn unevenly, a poor steaming engine and in many instances leaky flues and sheets is the result.

21. Why is water delivered so far away from the firebox?

Ans. Water is admitted to the front end of the boiler so that it will attain a certain degree of heat before it reaches the highly heated sheets or the firebox. If the water was admitted at or near the firebox (the water being practically cold), would be liable to bring about very uneven expansion and contraction. Leaky flues and sheets, a poor steaming engine due to the fact that the greatest degree of heat would be absorbed before it could reach the flues, where the greatest amount of water is stored. The manner and place of admitting water to the boiler has much to do with its proper circulation.

22. What part of a locomotive boiler has the greatest pressure? Why?

Ans. The crown sheet and legs of the boiler are subject to the greatest strain as they have the weight of water as well as the pressure of steam to stand. The belly of the boiler has practically the same strain.

23. What is the object of the hole drilled in the end of the stay bolt?

Ans. The hole drilled in the end of the stay bolt is known as a tell tale hole, and its purpose is to detect a broken bolt. The hole is usually about 3-16 of an inch in size and extends just through the outs sheet, this being where the bolt usually breaks.

24. What will cause the engine to tear holes in the fire?

Ans. Holes are usually torn in a fire when an engine slips, with a light or badly clinkered fire. Also when an engine has a very small nozzle, or is very sharp on the fire due to the adjustment of the draught appliances. By some authorities it is claimed that a large nozzle will likewise cause the engine to tear holes in the fire, as the exhaust being so free, causes the fire to be lifted in a body and holes are the result.

25. Name the various adjustable appliances in the front end by which the fire is regulated.

Ans. The adjustable appliances in the front end are, the diaphram, the petticoat, pipe and sleeve, and the nozzle tip.

26. Explain what adjustment can be made and the effect of each adjustment?

Ans. The diaphram is used to regulate the burning of the fire evenly over the box. Lowering the diaphram increases the draught through the bottom flues, or increases the burning of the fire in the front end of the firebox. Raising the diaphram increases the draught through the top flues, or increases the burning of the fire in the back end of the firebox. Raising the petticoat and lowering the sleeve increases the draught all over the fire. Lowering the petticoat pipe and raising the sleeve, decreases the draught all over the fire. Raising the petticoat pipe increases the draught through the bottom flues, or in the front end of the box. Lowering the sleeve increases the draught through the top flues, or in the back end of the box. Increasing the size of the nozzle, decreases the draught all over the fire. Decreasing the size of the nozzle increases the draught all over the fire.

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

Ans. When the exhaust issues strongest from one side of the stack, it is an indication that either the petticoat pipe and sleeve are out of line with the stack, or that the nozzle is not in line with the stack.

28. What is the effect of leaky steam joints inside the front end?

Ans. Leaky steam pipes inside the front end cause a poor steaming engine due to the fact that they destroy the vacuum created by the exhaust steam. A good indication of leaky steam pipes is when the engine is shut off the steam and water quickly pick up. Another indication is that the engine burns a very red dirty fire.

29. **What causes the pull on the firebox door?**

Ans. The pull on the firebox door may be caused by a badly clinkered or heavy fire, dampers being closed, or the ash pan full of ashes and no chance for the fire to get the air through the grates, consequently in order to get air to supply the vacuum being created in the front end it must be supplied from some other source, hence the pull on the door. A large number of flues stopped up will also bring about this result.

30. **If upon opening the firebox door you discovered what is commonly called a red fire, what might be the cause?**

Ans. This red fire might be caused by a heavy clinkered fire, leaky steam-pipe or a badly filled up ash pan, or a leaky firebox will in some instances cause the fire to burn red.

31. **Is it not a waste of fuel to open firebox door to prevent pops from opening? How can this be prevented more economically?**

Ans. It is a waste of fuel to open the firebox door to prevent the engine from blowing off, and shows that the fireman is not practicing very rigid rule of economy. This can and should be prevented by a more systematic method, fire lighter, drop dampers (if engine is so equipped), increase the boiler feed if it is permissible, if not it is better practice to put on the heater and blow the surplus steam back into the tank, raising the temperature of the feed water a few degrees, thereby materially aiding in coal economy, as well as preventing the tank from sweating in warm weather which spoils the paint.

32. After steam heat throttle was opened how would you regulate the reducing valve to control the pressure?

Ans. In order to regulate the steam heat pressure after throttle was opened would increase or decrease the tension on the regulating spring until the steam heat gauge showed the desired pressure.

33. In winter when steam heat is not in use what should be done?

Ans. In cold or freezing weather on an engine equipped with a steam heat line, a slight tension should be placed on the reducing valve, so as to open the supply valve, the steam heat throttle should then be opened slightly so as to allow a circulation of steam through the pipes to prevent them from freezing up.

34. Describe the principal upon which the injector works.

Ans. The principal upon which the injector works embodies several different theories. Steam under a given pressure escapes with a much greater velocity through a hole or an orifice, than water will under the same conditions. Steam has 22 times as much momentum or force as water under the same pressure and conditions. Under 180 pounds pressure steam would expand while issuing, reaching at the end of the nozzle a velocity of 3,600 feet per second, while water having no expansion would reach a velocity of 164 feet per second.

Steam 3,600 feet per second. Jet at 180 pounds per square inch.

Water 164 feet per second.

Therefore for water to enter the boiler with its own pressure, against its own pressure we must have at least 164 feet per second as the momentum of the combined jet.

A good formula to figure out the action of the injector is: If the steam nozzle discharges one pound of steam per second, at 3,600 feet per second velocity, the momentum of the steam is 1.3600 or 3,600. If the vacuum caused by the action of the steam, lifts and draws 10 pounds of water per second, into the combining tube, at a velocity of 40 feet per second, its momentum is 10 times its lift or 400 feet per second, and that of the combined jet is 3,600+400 or 4,000 feet per second.

The weight of the combined jet is 11 pounds at the time of entering the delivery tube. Its velocity ought to be equal to 4,000 divided by 11 or 366 feet per second. But as the water and the steam do not unite in precisely the line of discharge, there is a loss of momentum and the velocity in the delivery tube is only 198 feet per second. But the jet only needs a velocity of 164 feet per second to enter the boiler at 180 pounds pressure, or a pressure of 180 pounds on the check. Therefore the active jet in the delivery tube is able to overcome a pressure of 206 pounds per square inch on the check. This overcomes the friction of the branch pipe and the check.

There are several other theories advanced by leading authorities, one of which is that the injector operates on the piston principals. The water from the steam nozzle to the check is compared to a piston, the pressure of steam on the larger end of the volume of water acts the same as a piston, and the water is pushed into the boiler as it were. The most usually accepted theory is that any moving body will overcome a still body, or motion overcomes force. Then the working principal of an injector will be described as, first the syphonetic, or the act of lifting the water from the tank to the injector, second the theory of induced currents, or the velocity of combined steam and water jet when forced through the expanding rings and tapers of the injector nozzles, causes it to gain in velocity to the extent that the water is able to enter the boiler with a greater pressure holding the check to its seat, than the pressure by which it is driven.

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

Ans. The difference between a lifting and non-lifting injector is that, with the lifting injector the body of the injector is above the water level of the tank and gets its water by what is known as the priming jet, while with the non-lifting injector the water gets to the injector by gravity or what is known as the force jet, the injector being placed on or below the water level. There are now some non-lifting injectors which have independent priming valves.

36. Will the injector work with a leak between injector and tank? Why? Will it prime?

Ans. An injector will work with a leak in the feed pipe, providing it is not too great, that is if the leak is below the water level of the tank. If the leak be a heavy one, and above the water level of the tank it will not work as the syphonetic principal of its operation is destroyed by the leak furnishing air.

The injector will work providing the leak is below the water level. If it primes it will usually work.

37. If it primes good, but breaks when steam is turned on wide, where would you expect to find the trouble?

Ans. If it primes good, but breaks when steam is turned on the trouble is ahead of the combining nozzle, it being understood that the injector is getting a sufficient volume of steam. There might be some obstruction in the combining nozzle or delivery nozzle, the delivery nozzle might be lose or worn out of round, the lime check might be badly limed up, or stuck shut, the intermediate check might be stuck shut, or full of fine coal, the injector check might be stuck shut or the lift destroyed by scale, or the globe valve attachment to the check might be closed.

38. If it will not prime where would you look for the trouble?

Ans. If the injector would not prime I would first look to see if the tank contained water. It may be that the throttle valve at the fountain is not open wide and the injector is not getting sufficient steam, or that the injector check or throttle is leaking, destroying the possibility of creating a vacuum. There might be leaks about the body of the injector, the sprinkler hose might be open, there may be a leak in the feed pipe, the water ramb may be disconnected, the strainer may be stopped up, there may be a piece of waste in the water ramb, preventing the injector from priming, the heater cock may be screwed down, the tank valve may be disconnected, the vent plug may be out of the syphon tank valve connection, or the man-hole cover might be frozen down preventing a supply of air to force the water up to the injector, or the primer nozzle might be turned up side down blowing the steam back into the body of the injector, or the overflow pipe might be frozen up. The things that prevent the injector from priming are usually found back of the delivery nozzle toward the tank, with the exception of leaks in throttle and check valve.

39. **Will the injector prime if check valve leaks bad or is stuck up? If injector or throtttle leaks bad?**

Ans. The injector will not prime if the check is leaking bad or stuck up as the steam blowing back in the body of the injector destroys the possibility of the primer creating a vacuum. If the check has a globe valve attachment it can be shut off, and the injector will then prime, after the injector primes the globe valve must be opened and the injector will resume work. A leaky throttle has the same effect on the priming of the injector as a leaky check. Some times by opening the throttle quickly the hot water and steam will be momentarily blown out of the body of the injector and feed pipe, and the injector will some times prime, due to the rush of heavier cold water.

40. If steam appeared at the overflow when priming valve was closed, how would you tell if leak was from throttle or priming valve? How would you know if check was leaking?

Ans. If steam appeared at the overflow when the primer was closed, in order to tell whether the primer or throttle was leaking it would be necessary to put the injector to work. If the steam still showed at the overflow it would indicate that the primer was leaking. If steam does not appear after the injector is working, it is either the check or the throttle valve that was leaking. The indication of a leaky throttle valve are usually dry steam, while a leaky check shows both steam and water. In order to test for a certainty which of the two is leaking, the branch pipe valve or fountain valve leading to the injector should be closed off, if the leak continues (providing the fountain valve does not leak) it is the boiler check that is leaking.

If the leak stops it is a good indication that the throttle valve is leaking.

41. Will injector prime if primer valve leaks? Will it prevent its working?

Ans. An injector will prime with a leaky priming valve, and will continue to prime when the injector is shut off, if leaking bad. This leak will not effect the operation of the injector, as the water can be stopped by closing the tank valve, or by opening the pet cock on the syphon pipe when the injector is not in use, or by closing heater valve.

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

Ans. An injector will not work if the air cannot get into the tank as fast as the water is taken out, as the water in the tank must have the weight of the atmosphere on it in order to force it up to the vacuum created in the injector.

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

Ans. An injector will not work to its full capacity if all the steam is not condensed by the water.

44. If you had to take down tank hose, how would you stop the water from flowing out of the tank, that has the syphon tank connection, instead of the old style tank valve?

Ans. To stop the water from running after the hose is disconnected, with the syphon tank connection, the vent plug should be removed, or the pet cock should be opened.

If the water should not stop, as has been the case the hose should be coupled up again and the heater put on for a few seconds, then remove the plug and take down the hose. This will serve to stop the water in case all other methods fail.

45. Is the water glass safe to run by, if the water line in the glass is not moving up and down, with the motion of the engine? Explain.

Ans. It is not safe to depend on the water glass, unless the water is in motion or has a good circulation when the engine is in motion. The water glass should never be entirely depended upon, even though there is a good circulation. The gauge cocks are the only safe and sure way by which the water level can be told. When there is no circulation in the glass, it should be either knocked out and another one placed in, or the cause of the sluggish movement of the water ascertained, and reminded.

46. Is any more water used when the water foams in the boiler, than when it is solid? Explain.

Ans. A great deal more water is used when the water in the boiler foams than when it is solid, as the water assumes the from of suds and becomes so light that it is carried over with the steam into the cylinders, and is thrown out of the stack.

47. How would you prevent the injector and attachments from freezing when not in use?

Ans. To prevent the injector and attachments from freezing, when not in use, the heater cock should be screwed down and the injector throttle opened slightly to allow of a slight circulation of steam, care should be taken to prevent blowing the hose off, the frost cock at the boiler check should be opened so a circulation of steam will prevent the delivery pipe from freezing up.

48. Describe the manner in which a sight feed lubricator operates?

Ans. The sight feed lubricator operates on the Hydrostatics of fluids, or liquids, specific gravity of oil, as compared to water, and heat and motion. The feeding of the modern lubricator is brought about by obtaining as near a perfect balance of pressures at the oil outlet, and the inlet as is possible. After this balance takes place the weight of water in the condensing chamber, along with the specific gravity of oil, cause it to a level of the choke plug where it is met with a jet of steam from the equalizing tube and forced through the choke plug. It then continues its way to the valves by its own gravitation.

The operation is as follows: after all connections have been closed of such as steam and water, and regulating feed valves, the drain plug should be opened and the water in the reservoir drained off. The filling plug should then be removed and the oil reservoir filled with clean strained valve oil, care being taken not to fill the reservoir too full of cold oil as there is danger of bursting the reservoir when the oil becomes heated.

After replacing the filling plug, the steam valve should be opened and a few minutes after the water valve should be opened. After waiting a few seconds more the lubricator will be ready to feed. Its operation is as follows: when the water valve is opened the water in the condensing chamber flows down underneath the oil and raises it up in the body of the oil reservoir, where it flows down through a pipe (called a stand pipe), to the bottom of the oil reservoir, or to the oil channels leading to the regulating feed valves. The sight feed glasses have also filled with water from the equalizing tubes up to a level with the choke plug. Now upon opening of the regulating feed valves the drop of oil will pass up through the water in the sight feed glass, and upon reaching the choke plug will be met by a jet of steam from the equalizing tube and after being forced through the choke will be carried to the valves by its own gravity.

49. Does the draught from an open cab window effect the working of the lubricator? Why?

Ans. The draught from an open cab window will effect the working of the lubricator as it causes the oil in the oil reservoir to become heavy and the drop feeds much slower than is intended.

50. What else causes irregularity in the working of lubricators?

Ans. The choke plug worn large will cause irregular feeding, an imperfect balance at the oil outlet, either caused by high back pressure or by stopped up equalizing tubes. Dirt or sediment of any kind will also bring about irregular feeding.

51. If the lubricator feeds faster when throttle is closed than open, where is the trouble?

Ans. When the choke plugs are worn large the lubricator will feed faster with the throttle closed, than when open, due to the fact that the balance at the oil outlet is destroyed by a high back pressure from the steam chest. The oil will be held in the glass and tallow pipe until the throttle is closed off, causing a very irregular feed. Most all of the troubles in irregular feeding have been overcome in the modern lubricator, the balance feature being more perfect by reason of placing the choke plug at the steam chest, instead of in the tallow pipe at the lubricator.

52. Will any bad results ensue from filling the lubricator full, with cold oil?

Ans. This is very dangerous on the older styles of lubricators as the oil expands about 1-5 in volume, (when heated) and there being no provision made for this expansion is liable to burst the cup. On the newer types of lubricators there is a dead air space that takes care of this expansion. It is better policy not to fill the cup full of oil and even then the safest thing to do is to open the steam and water valves, this will relieve the cup of expansion that takes place when the oil becomes heated.

53. If the sight feeds get stopped up how would you clean them out?

Ans. With the bulls eye type would open the sight feed glass cleaning plugs, open the steam and water valve on the condenser, allowing the steam to blow through these vents will clean out the sight feed glasses, then close the cleaning plugs, and open the regulating feed valves, any substance in the feed nipple will then blow back into the body of the lubricator.

With the older styles of lubricators the drain plug should be opened, and a small amount of water drained out, the regulating feed valves should then be opened and any sediment in the feed nipple will then be blown back into the body of the lubricator. At the first opportunity the lubricator should be thoroughly blown out to prevent the repetition of this trouble. Care should be exercised with the old styles of lubricators as the sight feed glasses are very liable to break.

54. **How would you clean out chokes?**

Ans. The chokes can be cleaned by partially draining the water out of the reservoir, and sight feed glasses, the brakes should then be set and the engine throttle opened, the back pressure from the steam chest will usually blow the obstruction into the sight feed glass. If they cannot be cleaned in this manner the lubricator will have to be closed off all around, and the tallow pipe disconnected and a fine wire run through the choke.

55. **Which is the better practice, to close the feed valves or water valves while waiting on sidings, and etc.?**

Ans. It is advisable, and better practice to close the regulating feed valves while waiting on sidings, as the water valve might leak, and there would be a loss of oil. Closing the water valve would prevent the air pump from receiving any oil (providing it did not leak) and it is as necessary that it receive oil at all times, so closing the regulating feed valves is better practice.

56. How can you tell if the equalizing tube becomes stopped up?

Ans. When the equalizing tube becomes stopped up, the drop of oil takes a spiral motion up through the water, the glass does not always fill with water, there is sometimes a very poor, irregular feed if any at all, the balance being destroyed, again the glass has a tendency to fill up with oil, in case it feeds at all. When this takes place, the oil quickly disappears when the throttle is closed off, showing that it is not the choke that is stopped up.

SECOND SERIES OF AIR BRAKE QUESTIONS.

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

Ans. The present brake is called an automatic brake, due to the fact that the brake is applied automatically (by the triple valve) through the medium of a brake pipe reduction, from any cause, such as a burst hose, breaking in two, or the air having been pulled on the rear end.

2. What are the essential parts of the air brake, as applied to the locomotive?

Ans. The essential parts of the air brake as applied to the locomotive, are, the air pump, or compresser, the main reservoir, and its pipe connections, the engineer's brake valve, equalizing reservoir and its pipe connections, air gauge, pump governor, auxiliary reservoir, and the triple valve. The brake cylinder, and its pipe connections, a suitable set of levers and rods which in turn are fastened to brake beams, which hold metal shoes against the wheels when the brake is applied. With the E. T. equipment the distributing valve takes the place of the auxiliary, and triple valve of the D8 and G6 equipments.

3. **Name the positions of the engineer's brake valve.**

Ans. The positions of the engineer's brake valve are, full release, running lap, service, and emergency. With the E. T. equipment 5 or 6 there is a new position known as (holding position) between running and lap positions, as with the D8 or G6 equipments.

4. **How is the automatic brake applied and released?**

Ans. The automatic brake is applied by reducing brake pipe pressure below auxiliary reservoir pressure, the triple valve is forced by the auxiliary pressure to set position, which position causes auxiliary pressure to be vented to the brake cylinders applying the brakes. This action is entirely automatic, after the brake pipe reduction has been made, and the air will continue to flow to the brake cylinders until equalization takes place.

5. **Where are the different pressures stored?**

Ans. The different pressures are stored in the main reservoir, equalizing reservoir, or chamber D, brake pipe, auxiliary reservoir, straight air piping, and application chamber of the straight air brake valve, also the signal line pressure which is stored in the signal line piping.

6. Where do these pressures begin and end?

Ans. Main reservoir pressure begins at the discharge valve of all styles of pumps, and ends at the further walls of the main reservoir, and its pipe connections, the top of the rotary in the engineer's brake valve, the red hand of the air gauge, the pump governor, and the face of all valves operating main reservoir pressure, such as the straight air reducing valve, the signal line reducing valve, the bell ringer, air sanders, head light extinguisher, traction increaser, pin lifter, and all such devices that are operated by compressed air. In full release of the engineer's brake valve it ends at bridge W of the rotary and the preliminary port of the rotary seat. In running position it ends at the main reservoir side of the excess pressure valve of the D8, and the main reservoir side of the feed valve attachment in the G6 brake valves. In lap, service, and emergency it ends at the rotary seat.

Equalizing reservoir, or chamber D pressure begins at the preliminary and equalizing ports, and ends at the further walls of the equalizing reservoir, and its pipe connections, the top of the equalizing piston in the engineer's brake valve, the pump governor, and the air gauge.

Brake pipe pressure begins at bridge W in full release with all styles of brake valves, at the brake pipe side of the excess pressure valve of the D8, and the brake pipe side of the feed valve attachment of the G6, in running position, and ends on the underneath side of the equalizing piston, the walls of the brake pipe, the brake pipe side of the triple piston, and the first closed angle-cock in the train. It also ends in cavity Y of the quick action triple, cavity C of the engineer's brak evalve, and the pump governor with the D8 brake valve, the conductor's valve in coach or way car, also the air gauge when one is in use.

Auxiliary reservoir pressure begins on the auxiliary side of the triple piston and ends at the further walls of the auxiliary and its pipe connections, and the auxiliary side of the water pressure valve in the pullman and tourist cars. Straight air begins on the straight air side of the straight air reducing valve and ends on top of the application valve, in the straight air brake valve and its pipe connections.

Signal line pressure begins on the signal line side of the signal line reducing valve, and ends in the signal line piping, the first closed angle-cock in the signal line pipe, chambers A and B in the signal valve and at the face of the car discharge valve in the coach.

7. **What is excess pressure and where carried?**

Ans. Excess pressure is pressure carried in the main reservoir over and above the brake pipe pressure.

8. **What is excess pressure for?**

Ans. Excess pressure is to insure a prompt release of the brakes, a rapid recharge of brakepipe and auxiliaries, and to operate all the appliances on the engine (that are operated with compressed air) without interfering with the brake pipe pressure.

9. **What are the functions of the triple valve?**

Ans. The functions of the triple valve are, to automatically charge, the auxiliary, apply and release the brake.

10. **What are the functions of the pump governor?**

Ans. The function of the pump governor is to automatically control the working of the pump.

ENGINEER'S MECHANICAL EXAMINATION.

1. **What are necessary duties of the engineer before attaching the engine to the train?**

Ans. The duties of the engineer before attaching the engine to the train are as follows: He should arrive at the engine house in sufficient time to prepare his engine for the trip. This rule varies on the different divisions, and roads, but is usually one hour before leaving time of train. His first duty on arriving at the engine house is to examine the bulletin boards, for special instructions, relative to old and new bulletins issued since last trip. He should then examine the train board, see the number of the train, engine, time ordered to leave, and what fireman he is to have on the trip. He should then examine the work report book, to see what work has been reported on the engine. Compare time with a standard clock, or get the same from the train dispatcher. He should then proceed to the engine, open the channel drain cocks on the air pump as he passed by the engine, and after getting up on the engine he should notice the water level in the boiler, compare the gauge cocks with the water glass, see that there is a good circulation in the glass, examine the firebox, for leaks in the side, back, flue and crown sheet, notice the condition of the fire, the amount of steam on the boiler. He should then fill the lubricator, and start the air pump feed working, after oiling the air end of the pump he should start the same slowly allowing the condensation to be worked out, and a cushion of from 30 to 40 pounds of air to be formed before timing the pump down to a regular stroke. While the air pump is getting the pressure he should try both injectors, see that they are in working order. He should then note that the air pump has the pressure pumped up, that the governor and feed valve are properly adjusted, maintaining and separating their pressures. He should then with a lighted torch and hammer make a careful inspection of the engine in regards to the condition of the machinery, and air brake equipment (the subject of engine inspection will be taken up later). After satisfying himself that the engine is in condition to make a trip, he should fill and adjust grease cups on rods, oil all parts of the engine that require lubrication, giving special attention to all new work, see that it is properly connected up, the work done in a workman like manner and that all tools have been removed by the machinists. He should then make his round house tests of air sanders, bell ringer, and air brake on engine and tender. He should know that the sand box contains sand and that the sanders work, sand from both pipes should strike the rail at the same time. The bell ringer should be tried to ascertain that it will operate with the air. A full reduction of 25 pounds should then be made with the engineer's brake valve and the following things noticed, whether there is a cut rotary valve or seat, leaky gasket 32 or any one of the several defects that will destroy excess and cause the brakes to release, or defects of the feed valve that will destroy excess he should notice the piston travel on engine and tender, see that it is properly adjusted, also know that the brakes remain applied the required length of time. He should then blow out the air signal and brake pipe hose, noticing that the air signal whistle responds to the reduction. If the engine is equiped with steam heat and dynamo lines he should know that their respective reducing valves are in working order and (if in cold or freezing weather) he should have a good circulation of steam through them.

He should then satisfy himself that the fireman has done his work in regards to tools and supplies (classification, flagging and markers to come under the heading of tools). That he has all the necessary firing tools, scoop, broom, coal pick, clinker hook, slash bar, and plugging bar. That the engine is supplied with at least two extra water glasses and headlight chimneys. Also a set of suitable blocks to cope with a possible breakdown.

He is then ready to get out of the house, and should ring the bell as a signal for the table. After receiving a signal to back out and satisfying himself that the table is properly lined up, the doors opened, and the jack raised, he should place the reverse lever in the full back motion and open the cylinder cocks, giving the engine steam very gradually, allowing the condension to be worked out, he should be very careful that no one is about the engine in a position where they could be hurt. After backing off the table he should proceed to the water tank or pen stock, and take a full tank of water, he should also take coal if necessary, have the ash pan cleaned by the man employed for that purpose, being certain that he does the work as it should be done. He should then back up to the place where the blow off cock is used and try the blow off cock according to the condition of the water in the boiler. When blowing off the boiler the best results are obtained by opening and closing the valve at intervals of from 5 to 10 seconds. This method removes more mud than by simply opening the valve and allowing it to remain open. This is considered the best method, by most all the leading authority. The injector should not be used while blowing off the boiler. He is now ready to proceed to the terminal and get his train.

2. **Trace the steam from boiler to atmosphere, and explain how it transmits power to the locomotive.**

Ans. The steam, which is generated in the boiler, transmits its power to the locomotive in the following manner. The steam is generated somewhere nearest the highly heated surface of the boiler and rises through the water in the form of a bubble, on reaching the surface of the water the bubble bursts, or explodes into the gas, called steam. The steam now collects in the highest point of the boiler (the dome), surrounding the throttle valve.

It now upon opening the throttle valve, passes into the throttle box, the stand pipe, the dry pipe, and then to the steam pipes in the smoke box, to the steam supply ports or induction ports to the steam chest and surrounds the valve, regardless of the position in which the engine is standing (when properly connected up, with the reverse lever in full gear), it finds one of the admission ports open to the cylinder, it then passes through the open port to the cylinder and exerts its expansive force on the piston. This causes the piston to move away from the head at which the steam was admitted. This action of power is then transmitted to the engine in the following manner: From the piston to the piston rod, piston rod to cross-head, cross-head to main rod, main rod to main pin, main pin to the main wheel or driver, wheel to the rail, the wheel is caused to move the power of the steam in the cylinder having transmitted itself to the machine, or engine, causing it to do work. The work done will be equal to the expansive force of the confined steam in the cylinders. The movement of the wheel in turn causes the eccentric to transmit motion to the blade, blade to link, from link to link block, from link block to rocker arm, from rocker arm to valve stem, from valve stem to valve, and this action of the valve causes the steam to be cut off from the cylinder at whichever port it was admitted, and as the valve continues its travel ahead, or back, the exhaust arch of the valve registers with the edge of the admission port, and the steam from the cylinder is released, or exhausted, in the following manner: it passes out through the same port at which it entered the cylinder, out through the exhaust arch of the valve, through the exhaust cavity in the cylinder saddle, nozzle stand and tip, petticoat pipe and sleeve, and stack to the atmosphere. At the same time the valve was opening the steam port to release it was also opening the steam port on the opposite end of the cylinder to admission.

The fact that a locomotive consists of two engines whose valve events are the same, with the exception that they are placed at different quarters, or angles, and consequently take place at different intervals accounts for the fact that the engine is kept in motion so long as steam from the boiler is supplied to the cylinders.

3. **What precaution should be taken if any work or repairs have been made such as valves faced, brasses filed, etc.?**

Ans. When such work as valves faced, or brasses filed, and etc., the engineer, should see that all work has been done in an intelligent and workmanlike manner, see that all parts are properly connected up, that all tools have been removed by the machinist, see that the parts are in a proper condition to receive a lubricant and that they are properly lubricated. These parts should receive his special attention at every opportunity until satisfied that they are running all right, and that the work done is producing the desired results wanted when reported.

4. **When train is ready, how should engine be started, and what should be observed? If necessary to take the slack of train, how should it be done?**

Ans. After the engine has been attached to the train, the air having been pumped up and a terminal test of brakes made, and you have been informed by the conductor, and train men the condition and operation of the same, also being supplied with the proper information relative to the make up of the train, and having been provided with the orders and after reading the same, being certain that you fully understand the same, would then compare time with the men in the crew. Upon signal from the conductor, proceed, providing that conditions relative to the movement did not interfere with any superior train. Would first hearing the bell ringing, open the cylinder cocks, place the reverse lever in the direction wished to go, would then on a signal from the conductor, and switch tender, open the throttle gradually, starting one car at a time, in the train until the engine and train is in motion. As soon as the full train is in motion the throttle opening should be increased, and the engine hooked up to a point where it can do its work most economically, all the while keeping a close watch for signals from the train crew. The engine should be hooked up to a point (as the train gains in speed), where it can do its work, bearing in mind that the weather, train, time to be made, and physical characteristics of the road must be taken into consideration from the economical standpoint, as there is no economy in doing work to a disadvantage to the company.

In case it becomes necessary to take the slack of the train it should be done very carefully, as in taking the slack great damage is very often done to drawbars, and draft rigging, bunch the slack of the entire train and wait until satisfied that the slack is all run out before reversing the engine? In case it becomes necessary to take the slack the second time it should be done in like manner.

5. How should the water be supplied to the boiler?

Ans. The successful handling of the water (or proper pumping), is one of the largest factors in the successful handling of the engine from any standpoint, especially an economical one. Proper pumping has a great bearing on the lubrication of an engine, proper lubrication has a great bearing on coal consumption, improper pumping destroyes the lubrication, causes valves and seats to become cut, causes unnecessary wear on all parts of the valve gear, is very liable to knock out cylinder heads, spring pistons, rupture cylinder and piston rod packing. Bad blows and steam leaks are the results, a generel decrease in the efficiency of the engine, all due to an improper manner of supplying the water to the boiler.

The water to the boiler should not be supplied to exceed evaporation. When starting from the terminal the boiler should contain as much water as it will safely carry, in order to enable the train to be gotten under way and the engine well hooked up before the injector is put to work. On through passenger or freight runs the water should be carried as near as possible the same level all the time. Usually two gauges, or one-half a glass is considered the proper amount. On local passenger or way freight runs a little water should be lost between stations so as to pump the boiler while standing at the station, or while doing switching if on a way freight job. The method will be found to help in preventing the engine from blowing off, as well as enabling the fireman to carry a heavier fire while switching is being done. On switch engines the water should be supplied to the boiler, when the strain on the same is the least, being certain to have a safe amount in the boiler when going into cinder pits or up into coal chutes to protect the crown sheet.

6. After engine has been started, how can it be run most economically?

Ans. After engine has been started it can be run most economically by hooking up the reverse lever to as short a point of cut off as possible where the engine can do its work bearing in mind that the train, time to be made, and weather conditions must be taken into consideration. Proper pumping and proper firing, and according to the engineer the proper amount of oil supplied to the valves and cylinders will produce the most economical results. On some of the large power of today the better results are obtained by working the lever a notch or two lower in the quadrant, and throttle the engine, this is of course left to the good judgment of the engineer, as there is no set rule as to how the lever and throttle should be handled.

7. In case you broke down between stations, what would you do?

Ans. In case of a breakdown between stations the engineer should see that his train is protected by flag (in both directions if necessary), and after making an inspection of the engine, should arrange to notify the train dispatcher as to the nature of the break down and the length of time necessary to make temporary repairs, so as to get the train on a side track where the necessary repairs to bring the train to the terminal can be made.

8. Name the different draft appliances in the front end, and explain how you would adjust them to regulate the burning of the fire?

Ans. The different draft appliances, are the diaphram, petticoat pipe, sleeve, and nozzle. The diaphram regulates the burning of the fire from front to back end of the box. Raising the diaphram causes the fire to burn more in the back end of the box. By reason of increasing the draft through the top flues, lowering the diaphram increases the burning of the fire in the front end of the box. By reason of the increased draft through the bottom flues, raising the petticoat pipe, and lowering the sleeve sharpens the draft all over the fire. Lowering the petticoat pipe and raising the sleeve softens the draft all over the fire. Decreasing the diameter of the nozzle sharpens the draft, increasing the size of the nozzle (or diameter), softens the draft. Lowering the sleeve helps to increase top flue draft. Raising the petticoat pipe helps to increase bottom flue draft. The adjustment of the diaphram is made by means of holes in the plate, while the petticoat pipe and sleeve are moved up and down in a slotted stand. The diameter of the nozzle is changed, either by bushing, or some times by putting a bridge, or split in it. To increase the diameter the nozzle is usually changed, or bored to the desired size.

9. (a) What is the difference between priming, and foaming of water in the boiler? (b) What would you do in case of foaming?

Ans. Priming of water in the boiler is caused by contracted steam space there being not enough room for the steam due to over pumping, or filling the boiler too full of water. They sometimes prime when the throttle is opened suddenly, the water being raised in a body, and carried over into the valves and cylinders. Foaming is caused by some foreign substance in the water, such as vegetable, or animal oil, soap, alkali, or certain kinds of boiler compound. The water assumes the form of a suds, when an engine foams, and is far more dangerous than priming as the water level becomes deceptive. Priming or foaming have practically the same effect on the lubrication, it being washed away in either case. The engine not only loses its power, but the greatest damage is done to valves and seats, cylinders and piston rod packing. They become dry and cut (blows are the result).

There is also great danger of blowing out cylinder heads, springing the piston, buckling the rods and the heavy strain placed on the valve gear parts to move the dry valve is very liable to break the eccentric straps, blades, or in many cases has caused the eccentric to slip on the journal.

The greatest danger of foaming is the liability of burning the crown sheet as the water level is very deceiving, the water glass should not be depended on in cases of foaming but the water level should be ascertained by the gauge cocks.

When an engine is foaming the cylinder cocks should be opened, the throttle eased off, and the reverse lever dropped lower in the quadrant, the blow off cock should then be opened if the water level will permit, and some of the water blowed out. If the engine is equipped with a surface blow off cock it should be used in cases of foaming, as the substance that is causing the trouble is usually on top of the water. This method should be continued until the foaming stops. When an engine is priming the water is clean and all that is necessary to stop it is to reduce the water level with the blow off cock. The engine should of course be handled the same so far as the throttle and reverse lever is concerned.

In extreme cases it may be necessary to fill the boiler full of water and after getting a full head of steam the blow off on the dome opened, this will skim the substance off the water that is causing the trouble.

In case the engine is not equipped with a blow off cock and it becomes absolutel ynecessary to blow off the boiler, it can be done in the following manner: Take off the front cylinder head, and shift the valve so the front admission port is opened, block the wheels, and set the brake, open the throttle valve and the impurities can then be blowed out. If the engine is equipped with a relief valve in the front of the steam chest, the relief valve can be taken out instead of taking off the head. This method will not be resorted to only in extreme cases. A dirty boiler is not sufficient cause for an engine setting out a train.

Good judgment should be exercised in cases of either foaming or priming as aside from the danger of burning the engine. Great damage to all parts of the engine can be done if not properly handled. The engineer should be certain as to the water level before attempting to rid the boiler of the impurities, that are causing the trouble. He should if possible get his train in the clear, and the engine to a pen stock or water tank, before blowing off the boiler. If the trouble was caused by oil in the tank, the oil can be gotten out by putting on the heaters, and running the tank over the heaters will raise the oil and the water will carry it away.

10. **What is the danger when water in the boiler foams badly?**

Ans. The greatest danger lies in the fact that the boiler is liable to become burned, as the water level is very deceptive. There is really no danger of burning the engine while it is foaming, but in case the water settles, it is very liable to fall below the crown sheet. The sheets becoming bare, and exposed to the firebox heat will soon become over heated and an explosion would be the result. The water glass should never be depended upon when an engine is foaming. Both injectors should be put to work and if the water level should fall below the bottom gauge cock the fire should be dumped to protect the firebox sheets.

11. **(a) Supposing a washout plug blew out or a blow off cock broke, off or would not close, what would you do?**

Ans. If a washout plug blew out or a blow off cock broke off, the fire should be dumped at once to protect the firebox sheets. In case it was necessary to refill the boiler the hole could be plugged with another plug or a piece of soft pine, in case it was the blow off cock it might be repaired and replaced, if not it too could be plugged with a piece of soft pine. There are several ways of making the plug, some of which are as follows: Make a plug that will just fit the hole, split the end and insert a hard wood wedge, drive the plug in the hole wedge end first. When the wedge strikes the inside sheets it will spread the plug and wedge it solidly in the hole. The steam will cause it to swell, and there is very little danger of blowing out. Another way is to make a sectional plug and insert the sections. When the pressure is on the plug it becomes very tight due to the way it is made and the wood swelling causes it to become very tight, with little danger of it blowing out. After the hole has been plugged the boiler can be refilled either by a hand pump or pressure, or if necessary while the engine is being towed (this subject will be taken up later).

If the blow off cock would not close it can some times be made to by first screwing in the pig tail. This action forces the boiler valve from its seat and the scale or whatever was keeping it open will in some cases be blown out. In case it will not close by this method the pig tail should be screwed out and the intermediate valve will be forced to its seat, thus preventing the loss of the water. In case it cannot be closed by these methods the fire should be dumped and after the boiler was empty, the blow off cock can be taken off and the cause for its failure removed. The blow off cock can then be replaced and preparation made to refill the boiler.

(b) Can a boiler be refilled while an engine is being towed? If so, how?

Ans. A boiler can be refilled while being towed in the following manner: Close all inward opening valves on the boiler such as, cylinder cocks, relief valves, plug or block by pass valves, blow off cock whistle, shut off the lubricator, air pump, blower, and screw down the heater plugs on both injectors, open injector throttles, put the reverse lever in the motion engine is being towed, and open the main throttle. The engine should be towed sufficiently fast to create a vacuum in the boiler (this depends on how well the air is excluded at all openings). As soon as this is accomplished, the atmospheric pressure on the water in the tank will force the water up through the injectors into the boiler. The boiler can be filled in this manner while being towed about two miles. When sufficient water is obtained to re-fire up, all that is necessary to do is to close the main throttle, and the action of the syphon is destroyed, the engine can then be towed to a place where it will be out of the way until steam is raised. Care should be exercised, and be certain that the boiler contains enough water to generate steam to work the injectors.

12. **Name the different parts of the engine that operate, and control, the valve motion.**

Ans. The parts of the valve motion that operate the valve are the eccentric, the eccentric strap, eccentric blade, link, link block, top and bottom rocker arm, valve stem, valve rod and valve. The parts that control are the reverse lever, quadrant, reach rod, reversing arm, tumbling shaft and its arms, link hanger, link lifter, and link.

13. **What attention should be given to boiler attachments, such as gauge cocks, water glass cocks, etc.?**

Ans. The engineer should give boiler attachments such as gauge cocks, and water glass cocks, the following attention: They should be well packed, free from corrosion, and at all times have a good circulation. When found in any other condition than this they should be reported, or the work done by the engineer (if the custom).

14. What work should you do about the engine?

Ans. Different roads have different rules, but usually the engineer is supposed to do such work as follows: Pack all cocks in the cab, put in water glasses lubricator glasses, key up rods, set up wedges, tighten all bolts and nuts that he can reach, keep all boxes, and cellars well packed, keep all oil holes open, take care of the headlight, see that the engine receives the proper lubrication in all parts, adjust piston travel on engine and tender brakes, clean feed valve, governors, make a careful and thorough inspection of the engine and report all necessary work in an intelligent manner.

15. How would you proceed to set up wedges; and how would you know if one was stuck; and in what manner would you proceed to pull it down?

Ans. When necessary to set up wedges, it should be done in the following manner: Place the engine on a straight, and level piece of track, place the right engine on the top forward eight (the left engine will then be on the top back eight), the reverse lever should then be placed in the full forward motion, cut out the driver brake, and set the tank brake, block engine truck, and tank truck wheels, then give the engine a little steam.

With the engine standing in this position both engines will be pulling the boxes up against the shoe or dead wedge. Steam being behind the pistons will hold the box up against the shoe. The wedges can now be set up all around without moving the engine. Slack up on the wedge bolt, and pry up on the wedge, until it takes up all the lost motion. The main wedges of a ten wheel engine should be pulled down about 1-16 of an inch. The front and back wedges should be set up in the same manner, and pulled down about 1-8 of an inch.

When setting up any one wedge, the engine can be placed on the top quarter, place the reverse lever so as to get steam behind the piston and set up the wedge as described in the preceding paragraph.

A stuck wedge is indicated by the manner in which the engine rides. The engine does not get the elasticity of its springs and rides with a heavy thud. The box will also run hot as a rule, as the bearing on the brass is changed. In reality the wedge is not stuck as there should not, and is not any motion, or movement of the wedge when the bolts are not broke, and the wedge properly set up, but the box should have a free movement (up and down) between the wedge and the shoe. If due to a broken bolt or improperly set up wedge the box sticks, and does not have this free movement we term it a stuck wedge, when in reality it is a stuck box instead of the wedge. We can now see why the engine rides hard, as well as being able to locate the wedge at fault by reason of no movement of the box when the engine is in motion.

When this condition exists the wedge can usually be pulled down with the wedge bolts, slack off on the lock nut, and screw the bolts up into the wedge, the head of the bolt being under the pedestal will pull the wedge down. It should then be set up in its proper position, and well oiled.

In case the wedge cannot be pulled down by this method, running the driver, with the stuck wedge over a nut on the rail will some times bring it down, if not place a nut on top of the wedge underneath the top rail of the frame, and run the driver over a nut placed on the rail. If this fails to bring it down, as a last resort the nut should be slacked off on the pedestal bolt, or binder bolt. Now run the engine over a nut placed on the rail and the wedge will surely come down. After getting the wedge down it should be properly set up and well oiled.

The usual causes for stuck wedges are improper lubrication, causing them to become dry and cut, broken bolts, allowing the wedge to be pulled up with the box when the engine is running over rough track, and the expansion in a hot driving box will cause the wedge to become stuck. The wedge is not only the life of the valve motion, making it possible to keep the engine square, or get the valve events in perfect unison, but it is also the foundation or origin of most all lost motion and pounds in a locomotive.

The wedge has much to do with the riding qualities of the engine, as on the wedge falls most of the equal or unequal distribution of spring carriage. In order to maintain all these qualities in the wedge, they should never be allowed to run dry or fail to be set up when needed as pounds soon wear the taper off and then there is no remedy but drop the wedge and have it planed off to its proper taper.

16. What position should you place engine to properly key up main rod brasses?

Ans. The proper position to place the engine to key up the forward end of the main rod brass is the bottom quarter. With the engine in this position the brass is being keyed to the largest part of the pin, and if free or moves, on this point it will move on all others. In this position the live brass is being keyed to the pin instead of keying against the weight of the rod. It is also easier to get at the set screws, on any style of an engine especially a four bar guide engine.

To key the back end of the main rod the engine should be placed on the top forward eight, or the lower back eight as in this position the live brass is being keyed to the largest point on the pin as well as keying with the weight of the rod on the dead brass. Placing an engine in this position enables one to key the brass to the pin instead of keying the pin to the brass, as well as the assurance that if the brass is free at this point it be free on all other points, and in all probabilities will run without heating.

17. How would you proceed to key up side rods

on an eight and ten wheel engine? Do you fully understand the necessity of keeping brasses keyed up properly? Explain.

Ans. When keying up brasses on an eight or ten wheel engine, the engine should be placed on the dead center, on the side to be keyed. After the wedges had been set up the side rods should be keyed as follows: Slack off on all keys, key the front end first, and the back end last, try the engine on the opposite dead centers, if the brasses are free on the center they will pass all other points as the center is the dead and rigid point of an engine.

On a ten wheel engine the engine should also be placed on the dead center on the side to be keyed, after the wedges have been set up slack off on all keys, key the middle connection first dividing the difference with the keys or in other words drive both keys alike, key the brass snug to the pin, or key the brass so that there is a little lateral motion in the brass, if there is a key in the front and back key the front first and divide the difference on the back.

It is absolutely necessary to keep rods keyed properly as they not only cause a very disagreeable pound, but are very liable to knock out a cylinder head, break brasses, rods and pins, also cause the bolts and nuts to become loose, is very liable to break the frame, causes the pins to run hot and results in a general decreased efficiency of the locomotive.

18. How often does the ordinary locomotive

exhaust steam during a revolution of the driving wheels, and at what point does the exhaust take place?

Ans. The ordinary locomotive exhausts steam four times during the revolution of the driving wheel, and the exhaust takes place as follows. The position of the pin when the exhaust takes place, depends on the construction of the valve and the position in which the lever is hooked, usually taking place 1-16 past the eight, or 1-16 before the engine reaches the center. A good way to follow these exhausts separately in order to locate valve blows is to watch the cross head on the right engine. When the cross head is at the back end of the guides, the first exhaust or No. 1 takes place, coming from the front head on the right side. When the cross head reaches the center of the guides (on its return), No. 2 takes place from the back head of the left side. When the cross head reaches the forward end of the guides No. 3 takes place from the back head of the right side. When the cross head reaches the center of the guides on its return, No. 4 takes place from the forward head of the left side. By watching an engine when working slowly often this method will aid the engineer in locating valve defects and blows, and he can then in turn make out an intelligent work report.

19. **Why is it necessary to place engine on dead center while keying up side rods?**

Ans. It is necessary to place the engine on dead center when keying up side rods, as this is the dead and rigid point and if they will pass all right on this point they will pass on all other. If keyed on any other point there is a liability of keying the engine out of tram as well as causing the brasses to cramp or bind on the pin, which would be very liable to do damage to rods or pins.

20. What is meant by an engine out of tram?

Ans. An engine is said to be out of tram when the distance from one wheel center to the next is different on the corresponding wheels on the opposite side. An engine is said to be out of quarter when the distance in the pin centers on one side is different on the opposite side. Engines are usually designed out of quarter (when so found), and keyed out of tram.

21. Why should all joints in the smoke arch be kept tight?

Ans. The joints of the smoke arch should be kept tight as the leaks furnish the air to fill the vacuum created by the exhaust steam, instead, of it being supplied through the grates, hence a poor steaming engine. The leaks also cause the cinders to burn, burning out the netting, the front end becomes red hot and is warped out of shape, thus destroying the front end. The air supplied in this manner also causes the expansion and contraction to be un-uniform, and the flues leak in the front end as a result.

22. How would you manage with a burned or broken grate? How if entirely gone with a deep ash pan?

Ans. With a badly burned, or broken grate would proceed as follows: Would try to get into a side track if possible before making any repairs. The supposition is that the engine was not steaming, and that the fire in the pan would do furthur damage, such as burn out the rest of the grates, or the grate shakers, or possibly burn off the ash pan. The fire dropping out of the pan would be liable to set fire to bridges, and culverts. In this case it would not be advisable to try to get into a side track, but would clean out the ash pan and get what fire possible of the burned or broken section and cover the space with angle bars, fish plates, clinkers, or anything that would fill in the hole, would then spread the fire over the repaired section and proceed. Would exercise care to see that the ash pan was not filling up with fire, or that none was falling out to set fire to anything along the right of way and avoid shaking the grates of burnt section. With a deep ash pan would try to clear the main track, disconnect, and be prepared to be towed in as it is impossible to get sufficient steam to be safe in trying to get in with the light engine.

In a very urgent case it might be possible to knock out the fire and build up on brick, with angle bars so as to get in with the light engine but this is not considered advisable only in the most urgent cases. This would only apply in a case where it was impossible to get any one to help you in.

23. **If an engine was throwing fire badly, to what would you attribute the cause? What would you do to prevent it?**

Ans. If an engine was throwing fire it might be caused by too light a fire consistent with the work the engine had to do, or the way the engine was being worked, or it might be caused by a hole in the netting, the man hole in the netting open or, an engine drafted too severe, such as a small nozzle or a badly gummed up nozzle, slipping the engine or working the engine unusually hard. The cause should be ascertained, and repaired if possible. If impossible to make the repairs the train despatcher should be notified (if in dry weather), and be governed by his instructions, as to future actions. On reaching the terminal the condition of the engine should be reported.

24. **What should be done with a badly leaking or burst flue?**

Ans. If a flue was leaking bad enough to interfere with the steaming of the engine, would plug it in the firebox end, with a plug provided for that purpose. If there was no plug, or plugging bar, would plug it with a wooden plug, nail the plug to a fence board and drive it in, or if possible get a limb of a tree and use it as a plug. If the flue was burst would plug it in both ends if possible, but as a rule when a flue bursts the engine dies owing to the steam and water putting the fire out. In this case it would be necessary to get ready to be towed in. If in cold or freezing weather all parts that contain water should be drained, being careful not to drain the boiler and tank near a switch as the water would cause it to be frozen up.

25. **Suppose you shut off, and the water in the water glass dropped out of sight, what would you do?**

Ans. If after closing the throttle, the water dropped out of sight, would open it again, and see if the water could be raised, would try the gauge cocks, and if the bottom cock showed water would put the injector to work. If it did not show water would protect the fire box by dumping the fire.

If the water could be raised by opening the throttle would consider it safe to put the injector to work. If possible would leave the throttle open with the brakes applied until certain the boiler contained a safe water level.

26. (a) What would you do in case of a throttle disconnected closed? (b) Open?

Ans. In case of a disconnected throttle, would be governed by conditions. If it was disconnected closed, and the occasion demanded it, would proceed as follows: Would fill the boiler full of water, blow off the steam, and knock out the fire (would keep the injector working as long as possible), would then take up the dome cover, and connect the throttle up again, replace the dome cover, fire up the engine, and after getting a full head of steam, would proceed. In case this was not necessary or advisable, would disconnect and get ready to be towed in. The valves should be shifted so the cylinders can get the oil from the lubricator. If the cylinders are large it is not advisable to depend on the lubricator, but the indicator plugs should be removed and oil introduced through them to the cylinders.

In case the throttle was disconnected open, would proceed as follows: If it were possible to handle the lever, and the engine safely with a full head of steam, would then take the full train. If it were not possible to handle the engine with a full head of steam, would reduce the pressure, with the pops, or safety valves, until the engine could be safely handled, would then take what the engine could handle. Before moving the engine would notify all men in the crew as to the condition of the engine, and would instruct them as to their duty in case for any reason the brakes failed. When taking coal or water would hold on to as many cars as I considered necessary to hold the engine. The train can and has been taken over the road with a throttle disconnected open but it requires good judgment, and care as this is a very dangerous condition. On reaching the terminal the engine should not be left until a competent man has been informed of the conditions, and he takes charge of the engine. In case the engine should slip, it would be necessary to set the brake to stop it hooking the engine up will some times stop an engine from slipping.

27. **If an engine is to be towed in dead, with main rods up, how and what would you disconnect?**

Ans. An engine being towed dead, with main rods up should be disconnected as follows: If the relief valves were in the front of the steam chest, would disconnect the valve stems and block the valves back, so that the back admission port to the cylinder was open to the exhaust, thus providing relief for the back end of the cylinder through the stack, and through the relief valve for the front end. If the relief valves were in the back would block the valves in the opposite end of the steam chest. The indicate plugs should be removed, and the cylinder oiled through them. If it were impossible to remove them the front head should be wedged open, and the cylinders oiled through the open head. On an engine with piston valves, and having the independent relief valve, or the combined bypass, and relief valves, would turn the relief valves up side down, thus insuring the valve being held from its seat by its own weight, would arrange to lubricate the cylinders as previously stated. On some roads it is not considered advisable to tow an engine any great distance with the rods up as the piston dragging on the bottom of the cylinder is very liable to cut the cylinder, so if the engine was to be towed any great distance it would be advisable to take the rods down, and block the cross head in the guides, disconnect and clamp valves centrally on their seats.

28. Describe the piston valve and state how it differs from the ordinary slide valve. Do all piston valves work the same? Explain.

Ans. The piston valve is a spool shaped valve, and differs from the slide valve in points of construction only. The functions of the valve are the same as the slide valve. The piston valve (as the name implies) consists of two pistons, joined, or held together by a hollow stem, and as the valve is perfectly round it is operated in a bushing. The valve is provided with rings of the packing ring variety.

These rings are from 1-2 to 2 inches in width, from one to three in number, placed on each end of the valve, in slots or grooves and held in place by a pin called a dowel pin. The perfect balancing feature of the valve depends on the width and number of these rings, as well as the rings serving for the admission and exhaust edges of the valve. All piston valves do not work the same as some are inside admission, outside exhaust, while others are outside admission, and inside exhaust. The piston valve has come to be recognized as the leading valve on account of its almost perfect balancing feature, and the ease with which it is operated. The valve also shows a marked saving in lubricating oils, and is considered to be equally as tight and free from steam leaks as the slide valve. The cost of maintenance is much less, as all that is necessary to do in case of blows is to renew the rings.

29. **What is a by-pass valve, and what are its uses?**

Ans. A by-pass valve is a form of compression valve used in connection with a piston valve engine. There are many kinds and makes but the principle of operation is the same with most all types. The by-pass valve consists of a steel valve in a brass cage, placed on the steam chest and connected by steam passages to the live steam cavity, and the admission port. When the engine is working steam the by-pass valves are held to their seats by boiler pressure. During the event in the stroke of the piston known as compression, they are supposed to perform their work.

When compression exceeds steam chest pressure the by-pass is raised or pushed from its seat and the excess compression is allowed to pass into the live steam cavity of the valve. The amount of compression necessary to bring about this action depends on the exposed area of the by-pass valve, in some instances, or in some valve sets, it has been shown that the performance of the engine is greatly benefited by their use, while in others, there does not appear to be any noticeable results obtained from their use. Slide valve engines are not equiped with these valves, although they also have the event in the stroke known as compression, but the valve, by reason of its construction is able to raise off its seat, and relieves itself of the compression by so doing. The most objectionable feature in the use of these valves is that they are very liable to become cut and cause a very bad blow, which decreases the power of the engine, and in many cases has proven a very hard blow to locate and remedy.

30. If a by-pass valve was broken how would you test for it?

Ans. The indications of a broken or badly blowing by-pass valve are much the same as a valve blow. On a standing test a heavy blow is heard at the stack, and steam shows at the cylinder cock, on the end with the defective valve. With a running test, steam is admitted too early, too long, is not cut off and a heavy blow is heard all the while that end is open to the exhaust.

A running test will sometimes locate the trouble, yet there is always a possibility of the blow coming from a broken admission ring, the indications being the same. The running test shows three normal, and one heavy exhaust. The exhaust takes place at the right time in the stroke, but is a very heavy exhaust, followed by a blow. The best method to decide whether it is the by-pass, or admission ring is by the following test: Place the engine on the quarter, on the side to be tested, hook the reverse lever in the center, or plumb the rocker arm, set the brake, or block the wheels and give the engine steam, open the cylinder cocks. If a blow is heard at the stack, and steam shows at the cylinder cock on either end of the cylinder would conclude that the defective valve was on that end. In order to prove that the blow was not from a broken admission ring, instead of the by-pass would move the reverse lever, so as to cause the exhaust ring to be on the admission bridge. If the blow still continued at the stack, and cylinder cock would know that it was a broken by-pass valve. If the blow stopped after the valve had been moved, and the exhaust ring placed on the admission bridge would know that it was a broken admission ring. In case the defect was not found on the side tested would use the same test on the other side.

This method closely followed will usually locate the trouble, so that an intelligent work report can be made out.

31. (a) What is a balanced slide valve? (b) How

is it balanced and why? (c) What is the hole drilled in the top of the valve for?

Ans. A balanced slide valve is a valve, from the top of which a certain amount of steam has been excluded, thus allowing a free movement of the valve over its seat, by reason of the fact that it has not got the boiler pressure holding it to its seat. There are many styles of balanced slide valves, but the balancing feature is much the same in all of them. It consists of strips or rings, held in place by grooves, or a cone on top of the valve and preventing steam from reaching the top of the valve by reason of a balance plate, against which these strips or rings form a steam-tight joint. The balancing plate is fastened to the steam chest cover, and when it in turn is fastened down the balancing feature is complete. Valves are so balanced that the weight of steam pressure may be excluded from the top of the valve, causing it to be moved easier, thereby increasing the efficiency of the engine from all standpoints. The engine is much easier to handle, less wear on the valve gear parts, and does not require such an excessive amount of lubrication.

The holes are drilled in the top of the valve to allow any steam that might leak past the strips or rings to pass into the exhaust cavity, and out the stack, thus not destroying the balance feature.

32. **(a) In the event of a valve, valve stem or yoke becoming broken inside the steam chest, how can the breakage be located?**

Ans. In the event of any of these defects, they can be located in the following manner: Would first place the engine on the quarter, if it were possible to get the engine in this position, would then set the brake, and after opening the cylinder cocks, would move the reverse lever from one corner of the quadrant to the other, if the valve admitted steam to first one end of the cylinder and then the other would conclude that the trouble was on the other side, and would make the same test. If by moving the lever the valve could be pushed ahead, but not pulled back, the trouble would be a broken valve rod inside the steam chest. If it were impossible to exclude steam from the cylinders with the engine standing in this position, and the reverse lever in the center of the quadrant, would conclude that the valve or seat was at fault. Would then proceed as follows to put the engine in running repair: With the lap of the valve broken off would proceed as follows: In case the ports could be covered with the valve so as to exclude the steam from the cylinders, would place the valve in this position, disconnect the valve stem, and clamp it solidly. Would then either take off the cylinder head, and remove the broken parts of the valve or else take down the main rod, and block the cross head back, securing it solidly with good blocking. The engine would then be ready to proceed on one side. If the rod was not taken down it would be necessary to remove the indicator plugs and oil the cylinder through them. In case the lap was broken off so far that it would be impossible to cover the ports, with the remaining part of the valve, would then have to block with steam. With the front lap broken off in this manner, would pull the valve back so that the front admission port was wide open, would then disconnect, and clamp the valve in this position, take down the main rod, and block the cross-head back with good solid blocking, would then remove the back cylinder cock and proceed with the engine on one side. In case it was the back lap of the valve that was broken off, would proceed in the same manner, blocking the cross-head ahead, remove the front cylinder cock or else wedge the front head open. In case the lap of the valve was broken into the exhaust cavity and could not exclude the steam from the exhaust, would take up the steam chest cover, and block the induction, or supply ports to the steam chest, would use good soft dry pine, would then build up on the blocking even with the top of the steam chest, replace the steam chest cover to hold the blocking in place, take down the main rod and block the cross-head back (in case I failed to find all the broken parts of the valve), proceed with the engine on one side.

With a broken valve stem, or yoke inside the steam chest would proceed as follows: With this break it would be possible to push the valve ahead but could not pull it back, in case the steam chest was provided with a relief valve in front end of chest, would remove the relief valve and proceed as follows: First plumb the rocker arm, then clamp the valve stem, disconnect the valve stem from the valve rod and tie up the valve stem, push the valve back against the valve rod, fit a piece of wood in the relief valve and screw it back into place holding the valve centrally on its seat, remove the indicator plugs to oil the cylinder, and proceed with the engine on one side. With the relief valve in the back of the steam chest, would proceed as follows: Would first try to shove the valve ahead, and open the back steam port to the cylinder in case the valve did not travel too far ahead and open the exhaust port. In case it did not, clamp the valve in this position, disconnect the valve stem, and take down the main rod. Would then block the cross-head ahead with good solid blocking, take out the front cylinder cock or else wedge open the front cylinder head. In case the valve would travel too far and admit steam to the exhaust (as previously stated), would then take up the steam chest cover, place the valve centrally on its seat, and block ahead and back of the valve so as to hold it in this position, replace the steam chest cover, remove the indicator plugs to oil the cylinder.

If the distance was short to run the engine in would have oiled the cylinder when the steam chest cover was up. The engine is then ready to proceed on one side.

With the lap broken off of a piston valve (which in all probabilities would be a broken admission ring), would proceed in case the defect did not interfere too much with the valve events, in case it did would disconnect as follows: Would first try to cover the ports with the remaining portion of the valve, in case it can be done disconnect the valve stem and clamp it in this position, remove indicator plugs, to oil the cylinder, and proceed with the engine on one side.

In case this can not be done, would block with steam, as for the lap of a slide valve, proceed with the engine on one side.

With a broken valve stem on a piston valve engine would proceed as follows: First plumb the rocker arm, clamp the valve stem securely in this position, take off the front valve chamber head and push the valve back against the broken stem, would then block between the valve and the front head of the valve chamber, and proceed with the engine on one side.

For a totally demolished valve of the piston valve type, would take off the valve chamber head, and remove the broken parts, would then cut a telegraph pole the proper length and wrap the piece with the canvas from the cab curtain, and drive it back into the valve chamber, replace the head, take down the main rod, as some of the pieces of the broken valve may have fallen into the cylinder, and would do further damage. Block the cross-head and proceed with the engine on one side. When an engine has any of these just mentioned defects, it requires good judgment on the part of the engineer to take the proper course. He should be very careful not to take any more cars than the engine can handle on one side, and must be very careful when using the brake to avoid stopping the good engine on the center. Under most all circumstances it is only advisable to try to clear the main track and then be governed by the train dispatcher's orders in regards to proceeding with the train.

33. If the valve seat is broken, what can be done?

Ans. If the valve seat is broken it can be blocked in the following manner: For the front, outside bridge, would block with steam, place the valve centrally on its seat, disconnect, and clamp it securely, take down the main rod and proceed with the engine on one side, blocking the cross-head back, as with the front lap of the valve broken off.

For the back outside bridge, the blocking should be the same with the exception that the cross-head should be blocked ahead, instead of back.

If the exhaust bridges were broken, and all the pieces could be found the valve should be blocked centrally on its seat, and clamped securely in this position, the main rod can then be left up, the cylinders being oiled through the indicator plugs. If there was any doubt as to whether all the pieces had been removed, the rod should be taken down, and the cross-head blocked in the usual manner.

With the lap broken off or the bridges broken often it is not necessary to do any blocking. So long as the defect does not interfere with the working of the engine it is better to try to come in rather than do any blocking, as these particular defects not only cause an engine failure, but are very hard to handle, from the standpoint of the engine of today.

34. **If engine is disabled on one side, and main rod and piston left up, and good engine stops on center, how can you get engine started?**

Ans. If an engine is disabled on one side, and the good engine stops on center (the main rod being left up), would loosen up on the valve stem clamp, and move the valve by hand so that the disabled engine could take steam, this would help the good engine off center. The valve should then be re-clamped centrally on its seat, and greater care exercised when making a stop to prevent getting the good engine on center. When stopping a disabled engine it is better practice to use the reverse lever, instead of the brake, as the compression in the cylinder when the lever is being used will prevent the good engine from stopping on center. When it is desired to proceed in the forward motion it is better practice to stop the engine on the top quarter on the good side, as the weight of the rod, and the angle assumed will be a great help in getting the engine started. Always try to give the engine a full head of steam with full port opening, and as soon as the engine has gained a little momentum, the throttle can be eased off and the reverse lever hooked up.

If a disabled engine stops on center, and the main rod has been taken down, the main rod may be put up again, and engine moved off center provided there was not some defect that would make this impossible. If the steam chest, valve and cylinder, on the disabled side were intact, and the break happened to be the main rod, take down the rod on the good side, and put it up on the disabled side, the engine can then be moved off center. If it were impossible to do any of these things, or for reason or design, it was possible to gain time by doing otherwise, would proceed as follows: Let out all the slack possible on the tank brake, or driver brake, which ever was the handiest (or both if considered advisable), place a stake against the brake piston, and a tie, open the engine throttle, and set the brake in emergency, the force of the brake piston against the stake will help the engine off center. The engine should then be stopped with the lever, trying to stop the good engine on the top quarter. This method will move the largest engine providing the shoes do not touch the wheel before the engine moves.

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

Ans. These blows are sometimes very hard to locate, but as a rule they may be located by the following symptons and tests. A valve blow is a continuous blow, producing a whistling, or wheezy sound, a cylinder packing blow consists of a heavy blow at the beginning of the stroke and diminishes toward the end of the stoke, opening the cylinder cocks while the engine is working. Steam shows steam on both ends of the cylinder at the same time by reason of the blow by the packing, a valve strip blow has a sound like as if the blower was open, is continuous while the throttle is open, and causes a very hard movement of the valve due to the fact that the balance on the valve is destroyed. Aside from the fact that experience will sometimes assist in locating these blows, by their sounds and symptoms the following tests can be made which will greatly assist in locating the seat of trouble. For a valve blow the engine should be placed on the top quarter on the side to be tested, hook the reverse lever in the center of the quadrant, or plumb the rocker arm, the object being to get the valve centrally on its seat, set the brake, or block the wheels, and give the engine steam. If the valve is blowing there will be a continuous blow at the stack, as well as steam showing at one or both cylinder cocks, depending as to where the valve or its seat is cut.

To test for cylinder packing the engine should be placed on the bottom forward eight, the reverse lever in full forward gear, set the brake or block the wheels, give the engine steam. If steam shows at the back cylinder cock it is safe in reporting the cylinder packing blowing, although it may be the cylinder out of round. In case it is thought that this is the trouble the engine can be placed on the bottom quarter and the same test made, either a cylinder out of round or cylinder packing blowing have the same effect on the engine, and it is necessary to have the machinist caliper the cylinder in order to determine as to which of the two is at fault.

To test for valve strips blowing the engine should be placed on the quarter, set the brake or block the wheels, give the engine steam, move the reverse lever from one end of the quadrant to the other, notice how hard the valve moves, place the engine on the opposite side and made the same test. Whichever side moves the hardest would conclude that was the side with the strip blowing, as the balance is destroyed and the valve with the strip blowing would have boiler pressure on it, causing it to move hard.

For a further test would watch the engine while working steam, the side with the strip at fault, the valve stem would be wiggling due to the load on the valve.

Another test would be to go out on the pilot when the engine was drifting and notice which relief valve sucked the least air, the one sucking the least would be the one with the defective strip.

Another test would be to move the valve slowly over its seat, the engine standing on the quarter with the brake set, open the channel drain cocks, and if steam showed at them it would be coming from a defective strip.

36. What do you mean by working steam expansively?

Ans. By working steam expansively is meant, the act of causing or allowing (by reason of hooking the lever up in the quadrant), the valve to cut off the admission of steam, before the piston has reached the end of its stroke. The steam that is entrapped in the cylinder, forces the piston the remainder of its stroke, due to its expansive force.

37. What is ment by the lead of a valve?

Ans. The lead of a valve is that amount in the fraction of inches, the valve is open to the admission of steam before the piston reaches the begining of its stroke. Lead is some times spoken of as pre-admission and means (admitted before), before the piston reaches the point at which admission usually takes place.

38. What is meant by outside lap? Why are locomotives given lap, and what is meant by inside lap?

Ans. The outside lap of a valve, or the (steam lap), of a valve is that amount in inches that the valve overlaps the inside edge of the outside bridge, when the valve is centrally on its seat. Lap is given to the valve in order to produce an earlier cut off, and to enable the steam to be worked expansively, during the time the valve is traveling the distance of its lap.

Inside lap is the amount in the fractions of inches that the inside edges of the valve, overlap the outside edge of the inside bridge when the valve is centrally on its seat. Inside lap is given to the valve to delay the exhaust, and increase compression.

Negative lap, or clearance, produces an earlier exhaust, and decreases compression, and is usually used on a high speed engine.

39. Why are eccentric blades made adjustable? What effect would be produced on the lap and lead by changing the length of the eccentric blades?

Ans. The eccentric blades are made adjustable, to provide a ready means of squaring up the engine, or causing the valves to travel evenly over their seat. Changing the length of these blades would have no effect on the lap and lead of the valve, as lap is given to a valve by adding to its edges, and lead is either given with the movement of the eccentric in relation to the pin, or else by reducing the lap of the valve.

40. If an engine goes suddenly lame, what might be the cause?

Ans. If an engine goes suddenly lame it may be due to some of the following causes: Dry valves, caused by improper lubrication, priming or foaming, slipped eccentrics, slipped blades, sprung blades, spread link, sprung valve stem, cracked valve yoke, lap of the valve broken off, broken bridges, broken rings, lost cylinder key, broken frame, loose splice bolts, loose expansion plate, or deck bolts, or a broken by-pass valve.

41. Having determined the cause of the irregular exhaust, how would you be governed?

Ans. Would be governed by whatever defect found, in case it was dry valves due to improper lubrication, would increase the feed to valves and cylinders ease off, or shut off the throttle and let the reverse lever down for a few seconds, for priming or foaming, would treat as explained under the head of priming and foaming, for slipped eccentric, or blades would reset them, for any of the defects such as sprung blades or tumbling shaft arms, would try and straighten them if they interfered too much with the working of the engine, for lost cylinder key would substitute with a railspike, file, main-rod key, or any thing that could get to stay in place, for broken frame would handle as explained under (broken frame), for any of the defects in the steam chest, such as broken lap bridges, cracked yoke, broken valve stem, or broken by-pass valve, would treat as explained under these separate heads.

42. What position on the shaft should the eccentric be relative to the crank-pin with a direct motion engine? With an indirect motion engine?

Ans. The eccentrics of a locomotive are placed as follows: With an outside admission valve (indirect motion), or an inside admission valve (direct motion), they are placed following the pin 90 degrees, minus the lap, and lead, or the angle of advance. With an outside admission (direct motion), or an inside admission (indirect motion), they are placed leading the pin 90 degrees, plus the lap, and lead, or the angle of advance. On an engine with valves having no lap, no lead, they would be placed at right angles either leading, or following the pin, depending on the admission of the valve (inside or outside admission).

43. In case you found eccentrics had slipped, how would you proceed to reset them?

Ans. In case the eccentrics slip on the shaft they should be reset in the following manner: In case all the eccentrics are slipped, disconnect the valve stem, shift the valve by hand, and move the engine to one of its dead centers (forward center preferred), set the brake, and block the wheels, would then connect up the valve stem and proceed to set the forward motion eccentric on the side with the engine on the dead center, place the reverse lever in the full forward motion, open the cylinder cocks, and give the engine a very light throttle of steam. Would then get under the engine and move the web, or belly of the eccentric, to or from the pin, depending on the style of valve (inside, or outside, admission), and the motion of the set (either direct, or indirect), until steam showed at the front cylinder cock. Would then move it back again until steam was cut off, would them move it ahead enough to show steam at the front cylinder cock, and clamp it in this position, tightening up on the set screws, and inserting the key if one is in use. The back motion eccentric can then be set in the same manner with the engine standing on the same center, by placing the reverse lever in the full back motion, and moving the web or belly of the back up eccentric until steam shows at the same, or front cylinder cock. Clamp it in this position, and then move the opposite engine on its forward dead center and proceed in the same manner.

When the eccentrics are keyed to the journal they are not very liable to slip, but in case they do all that is necessary to do is to move the eccentric until the key or a substitute can be placed in the keyway. On reaching the terminal they should be reported, even though they were properly reset.

Another method of resetting an eccentric is to disconnect the valve stem from its rocker arm, and move the valve by hand until steam shows at the desired port, corresponding with the lever, and the position in which the engine is standing, then move the eccentric on the journal until the rocker arm, and valve stem can be coupled up. The eccentric should then be clamped in this position. This method is in some cases easier as the weight of steam on the valve does not have to be contended with.

44. **What would you do if the packing blew out of throttle stuffing box?**

Ans. In case the packing blows out of throttle stuffing box, on the road, would be governed by circumstances, and conditions. If the throttle stuffing box was high in the boiler head, would first tighten up on the gland stud nuts and make as good a steam tight joint as possible, would then carry the water in the boiler as low as possible consistent with safety and proceed with full train. If the throttle stuffing box was situated low in the boiler head, this could not be done, would then proceed to repack the throttle stuffing box as follows: Would first get the train on a siding clear of the main track, and blow the steam pressure down to 25 or 35 pounds keeping as little water in the boiler as possible consistent with safety. Would then loosen up on the gland stud nuts, and allow the gland to follow to the end of the threads of the stud bolts. Would then take any such substance as the bell cord, old overalls, waste, rubber, or even the cab curtain, cut up in strips, and after saturating the same with oil would work it into the stuffing box, with a packing iron, as soon as the box was full, would tighten up on the gland stud nuts, and repeat this performance until the stuffing box was well filled, would then after getting a full head of steam proceed. To pack a throttle with the engine under steam requires good judgment, to prevent losing the water in the boiler but with a little care be successfully done. Care should be taken to prevent being burned.

45. Explain why moving the reverse lever from one end of the quadrant to the other reverses the motion of the engine?

Ans. By moving the reverse lever from one end of the quadrant to the other, the motion of the engine is reversed in the following manner: With the Stephenson link motion both the forward and backward motions have a separate set of eccentrics, when the reverse lever is placed in the forward motion, the forward motion eccentric is given control of the link block by reason of it being in direct line of motion with it and above the center line of motion. When the reverse lever is in the back motion, the back-up eccentric has control of the link block by reason of it being in a direct line, and below the center line of motion.

46. What is the throw of an eccentric?

Ans. The throw of an eccentric is that amount of crank-like action the eccentric possesses. It is found by the following rule: Twice the distance from the center of the journal, to the true center of the eccentric, will give its throw, or the difference from the thin edge to the journal, subtracted, from the distance from the thick edge or belly, to the journal multiplied by two, or twice the difference in inches, or fractions thereof will give the throw.

What must be done if an engine truck wheel or axle breaks?

Ans. If an engine truck wheel, or an axle should break, would try to get the engine into a side track in the following manner: If a piece of the wheel was broken away, would place a fulcrum under the journal nearest the broken wheel, move the engine ahead, the good wheel on the rail would in rotating, cause the good part of the broken wheel to be brought to the rail, the broken part being on top would block between it and the pilot, with a piece of a tie, and skid the wheels into a siding. After getting into the siding would take off the pilot, to assist the repairmen when they should come to put in a new set of wheels.

If the axle was broken next to the wheel, would proceed in the following manner: Place a chain around the engine truck frame, underneath the pedestal and around the engine frame proper, would then place a fulcrum underneath the pilot beam, and move the engine back, after elevating the engine as high as possible with the fulcrum, would block underneath the truck frame on the ties, and take up the slack in the chain. This performance should be repeated until the truck frame was raised higher than normal, after which blocking should be placed over right and left No. 2 engine trucks, between the engine frame and truck frame. A chain should then be fastened around the main frame, and engine truck frame, and then across to the opposite side of the main frame to hold the good wheel to the rail. The engine should then be run to a side track very carefully, where a new set of wheels should be sent for, as well as men to put them in. While waiting for the wheels it is the engineer's duty to take off the pilot, so as to have everything in readiness when the wheels arrive.

48. State your method of treating a broken tank wheel or axle.

Ans. A broken tank wheel or axle can be blocked in the following manner: If the journal was broken outside of the wheel, in the oil house, would proceed as follows: Place a fulcrum under both sides of tank truck in the diamond, run the engine ahead until the truck was higher than normal, would then place a block over right No. 3, providing it was right No. 4 that was defective, then place a rail over the top of the tank, building up on top of the tank so as not to injure the coping of tank, would then chain from both sides of the truck to the rail, swinging back of the tank. Would then block on both sides of the journal, in the oil house of good wheel to prevent defective wheel from leaving the rail.

What wheel if the journal was broken between the wheels (right and left No. 4) would elevate both sides of the tank truck by placing a fulcrum in the diamond, and running the engine ahead, elevating so as to remove the broken wheels. Would then place a tie across the rails and lower the tank truck on the tie, would then chain the tie to some part of the truck frame and skid the tank into a siding where a new set of wheels could be put in.

49. **How would you block for a broken engine truck spring or equalizer? How for a broken tank truck spring?**

Ans. If the pilot did not touch the rail, would first get in on the side track before trying to do any blocking. For a broken engine truck spring would first remove the cellar, then place a nut on the pedestal brace, under the jaw of the box, and then place a fulcrum under the truck frame and run the engine ahead, would then block on top of the equalizer, and underneath the top rail of the engine truck frame. Would then run the other wheel up in a like manner and block the same.

For a broken equalizer, would elevate in the same manner, but would put the blocks on top of the truck box, and underneath the top rail of the engine truck frame, removing the broken parts.

For a broken tank truck spring, place a fulcrum under the bolster, and move the engine ahead, remove the broken spring, and insert blocking in place of the broken spring, run the engine off the fulcrum, and proceed.

If the spring was of the semi-elliptical form would place a fulcrum under the frame of tank, and move the engine to elevate the tank, would then block in place of spring, between bolster, and bed of tank, run the engine off the fulcrum, and proceed. If the tank does not settle too low would proceed without blocking.

50. Give location of piston rod packing, of cylinder packing, and how metallic packing on valve stems and pistons are usually held in place; and what provision is made for the uneven movement of the rods.

Ans. Piston rod packing is located on the piston rod, and is held in place in a stuffing box, by a gland, which is in turn fastened to the back cylinder head by studs and nuts.

Cylinder packing is located in the cylinder around the piston, and is held in place by grooves in the piston, or (bull ring), by a follower plate and bolts.

The uneven movement of the rod through the packing is accommodated by a vibrating cup, which in turn forms a ball joint against the gland of the packing stuffing box.

In the newer forms of packing the packing works in a slot bored large and accommodates the uneven movement of the rod.

51. If you do not take down main rod on disabled side of engine, how would you arrange to lubricate the cylinder?

Ans. If the main rod is not taken down on the disabled side of an engine, the cylinder may be lubricated through the indicator plugs, or by turning the relief valves up side down (providing a free drifting engine, the front ports being left open), or in case the engine is under steam, the valve may be clamped in a position to allow the saturated steam and oil from the lubricator to lubricate the cylinder. When an engine is to be towed any great distance it is sometimes advisable to take down the main rods, as there have been cases where the cylinders have been badly cut by reason of the pistons riding on the bottom of the cylinders, even though oil had been supplied to the cylinders. On an engine equiped with by-pass valves, the cylinders may be lubricated by removing the caps and supplying the oil through them. When lubricating a cylinder on an engine that is being towed a sufficient quantity of oil should be used to lubricate the entire cylinder. This is sometimes better accomplished by wedging open the front head, even though it is a more laborious task than removing the plugs.

52. **In the event of the blower becoming disconnected, how could you create a draft on the fire?**

Ans. In case a blower becomes disconnected, a draft may be created on the fire, by making a leak in the air, and allowing the air pump exhaust to fan the fire. Or in case this method fails, the head of the bushing on the 9 1-2 inch pump may be removed and the small slide valve removed, the head replaced, and the pump throttle opened. This will usually create sufficient draft, if not the valve stem may be disconnected and the valve shifted so as to open the axhaust port, then with the throttle opened slightly a draft can be created. Still another method, on an engine equipped with a by-pass valve is to remove the cap and take out the valve, replace the cap and open the engine throttle slightly and a draft will be created on the fire.

The front end may be opened and the blower connected up, but this is not advisable, as conditions in the smoke box on most engines, make it most impossible to do this with a fire in the box. As a rule some one of these first named methods will prove sufficient to get the fire going, so that the exhaust steam from the engine handled carefully will create sufficient draft for the fire.

53. **What should be done if a driver spring, spring hanger, or equalizer, should break on an 8 or 10 wheel engine?**

Ans. In case of any of these breaks, it will be necessary to elevate, and block as follows: With under hung spring rigging, for a broken back hanger, of the back spring, the front hanger of the middle spring, the front hanger of the front spring, front spring, or equalizer is broken. The engine should be elevated and blocked as follows: The back driver should be run up on a wedge, and iron blocking placed on top of the middle driving box. Then run the back driver off the wedge, and run the middle driver on the wedge, then place blocking over the front and back driving boxes, run the middle driver off the wedge, and the engine is then ready to block for any of the following defects.

Forward hanger of the front spring, a block should be placed between the forward end of the front spring, and the lower rail of the frame.

Back hanger of the back spring, a block should be placed between the back end of the back spring and the lower rail of the frame.

Front spring, chain the forward end of the front equalizer to the bottom rail of the frame, or a block should be placed in the forward hanger of the middle spring underneath the lower rail of the frame. As an extra precaution a block should be placed over the front driving box.

Front equalizer, place a block between the back end of the front spring, and the lower rail of the frame. Place another block between the forward end of the middle spring and the bottom rail of the frame.

Forward hanger of the middle spring, place a block between the forward end of the middle spring, and the lower rail of the frame, chain up the front equalizer. Block in the safety hanger of the spring if engine is so equipped.

54. In what way could you distinguish a leaky throttle from a leaky dry pipe?

Ans. A throttle or dry pipe when leaking bad is a very dangerous defect. In order to distinguish between the two the following test should be made: A leaky throttle usually shows dry steam at the cylinder cocks, while the dry pipe shows both steam and water. These indications are not sufficient evidence to make out a report on unless the following test has been made: First shut off the lubricator, and fill the boiler full enough of water to submerge the dry pipe, then open the cylinder cocks. If dry steam continues to show at the cylinder cocks it is safe in reporting the throttle valve leaking. While if water and steam both show at the cylinder cocks, the dry pipe should be reported leaking.

55. With an engine equipped with grease in the driving box cellars, how would you know there was sufficient grease in the cellar to make the trip? If it needed packing on the road, how would you proceed to repack it?

Ans. If an engine is equipped with a grease driving box lubricator, the amount of grease in the cellar can be told by the indicator plugs underneath the driving box. When the indicators are flush with the spring follower, there is usually considered sufficient grease in the cellar for the engine to make at least 200 miles, but they should be reported as soon as the engine gets to a terminal. In case the cellars need packing while on the road, it can be done in the following manner: When provided with a cellar pulling device, hook the hooks in the eyes of the indicators, and pull the follower down by turning on the screw of the pulling device. When not provided with this device, remove the plate on the side of the grease cellar, and pry down on the follower plate, then insert sticks of rod grease cut in halves, place the flat surface of the grease on the follower. This allows the round surface to fit against the perforated plate, and will soon wear down to an even pressure on the surface of the plate. When it is impossible to obtain any grease, saturate waste with valve oil, and place it between the follower and the perforated plate. This will serve to lubricate when nothing else is at hand, such as ordinary laundry soap, graphite, rod grease or even tallow. On reaching the terminal the box should be reported packed. In case the time to do this work was short, and the distance was not great, the grease can be placed on top of the perforated plate, as this is somewhat quicker and easier done than trying to put it between the plate and the follower, but this is not advisable only in the cases mentioned.

HOT BEARINGS.

56. Explain how you treat hot bearings.

Ans. There is probably nothing in the line of engine defects, more annoying than hot bearings. They not only cause serious delays, but are often an item of needless expense to the railroad company if not properly treated.

When any bearing is detected running hot, it should be treated at once, if possible as (an ounce of preventitive is worth a pound of cure). Treat the bearing as soon as possible, and avoid an additional amount of labor, as well as by so doing a certain amount of oil may be saved.

With a hot engine truck, do not wait until the waste takes fire, before treating. First examine the hose, and oil pipe to the brass, it may be out of place, the oil cup may be stopped up and no oil allowed to feed to the brass, examine the brass, it may be broken, or worn out, see that the cellar contains plenty of good packing. If the engine is equipped with a water line turn on the water at once and proceed, being certain that there is sufficient waste in the cellar to carry the water up to the journal, if not put some in. If the trouble is caused by a worn out or broken brass, replace the brass as explained under the subject of replacing engine truck and tank brasses. If the engine has no water line it will be necessary to cool off the journal, and repack the cellar, supplying a sufficient amount of valve for a while, after the brass has begun to run cool, engine oil can then be used again. Engine trucks generally run hot due to improper lubrication, as there is not an excessive weight to contend with, the trouble generally being found in a disconnected oil pipe.

HOT GUIDES.

Guides usually run hot either by reason of being out of line, or else after being closed in they are found to be too tight. If caused by being closed in too tight, the guide bolts should be slacked up on and thin liners inserted both front and back, the bolts tightened up again, and a liberal supply of oil allowed to feed to them for a few miles. If caused by being out of line a good supply of oil should be fed to them and they should be reported as soon as the engine reaches a terminal. If impossible to run them in this condition the engine will have to be disconnected on that side, the main rod taken down, cross head blocked back in the usual manner, and the engine brought in on one side, where the condition of the guides should be reported.

HOT PISTON.

Hot pistons are a very rare thing since metallic packing came into general use, but was a quite frequent occurrence when hemp was used as a packing. When it now occurs it is generally caused by the piston being sprung, or the guides badly out of line. The piston packing gland cramped on the rod, or possibly to the manner in which the piston has been packed. When the piston is found to be hot it should be stopped with as much as possible of it in the cylinder, and the cause for its running hot located. If caused by sprung piston or guides out of line all that can be done is to slack off on the gland stud bolts, and supply some oil, run the engine in and report the condition, on the arrival at the terminal. If sprung so bad that it can not safely be run the engine will have to be disconnected on that side, take down the main rod, and block the piston ahead, wedge the front head open, as a precaution against the valve shifting and proceed with the engine on one side. Never under any circumstances use water on a hot piston.

HOT PIN OR BRASSES.

When the pins run hot it is usually caused by the brass being keyed to the pin too tight, or too loose, a cut pin, or an improper amount of lubrication. The cause for the trouble should first be located, and then be governed by what is found. If due to improper lubrication, a sufficient amount should be supplied. If caused by reason of being too tight, the set screws should be loosened, and the key slacked off, tighten up on the set screws, give the pin a sufficient amount of lubrication and proceed. If pounding hot the brass should be keyed up with the engine standing on the proper points, a sufficient amount of lubrication supplied, and then proceed. If caused by a cut pin or a broken brass, all that can be done is to keep plenty of lubrication on the parts, try to get in where the condition should be reported. When a pin or brass is very hot it is advisable to cool it down with hot water, from the overflow of the injector before supplying a lubricant. When the engine is equipped with grease (as is now the general practice), there is scarcely any trouble aside from the fact that the brasses are keyed too tight or else the cup is allowed to run empty.

HOT DRIVING BOX.

With a hot driving box (oil box), and the engine equipped with a water line, the water should be turned on at once, being certain that there is sufficient waste in the cellar to bring the water up to the journal. If not it should be put in, the top of the box well oiled and the engine is then ready to proceed. If the engine is not equipped with a water line it will be necessary to cool off the box and repack it with good clean waste and valve oil, being careful to get the waste well up under the journal. The top of the box should be well oiled to prevent the wedges from sticking as they are very liable to do when the box is hot. If after all that can be done in the line of packing is done, and the box still runs hot, it will then be necessary to take some of the weight off that particular box, by elevating the engine and blocking between the spring saddle and the frame (with the over hung spring rigging), or by chaining up the ends of the equalizers, nearest the box (with the under hung spring rigging).

With the grease cellar, and the box runs hot, all that can be done is to make certain by an examination that the cellar contains grease, and that it is feeding, if it does not contain grease, or is not feeding, it should be treated as explained under the head of (driving box lubricators). If taking the weight off the box is necessary it can be done as explained in preceding paragraph. Grease boxes run much hotter at all times than an oil box, and consequently the wedges should receive more oil than with the other style. Never use a water line in connection with a grease box, as the water will cause the grease to assume the form of suds, and all the lubricating qualities will be destroyed Driving boxes like all other bearings on the engine usually run hot due to neglect in the proper amount of lubrication. They should receive a sufficient amount of lubricant in time to enable it to get to its bearing before the engine is started, the cellars should be well packed, and little if any trouble will be experienced from hot bearings. If the oil holes in a driving box become stopped up, it can be told by the oil coming back up on top of the box through the other holes, this should be reported as soon as the engine reaches a terminal.

HOT ECCENTRICS.

When an eccentric runs hot it is generally due to the fact that the oil hole is stopped up, or that the strap is too tight. This may be caused by reason of it being closed in too tight, or that the cam in working lose on the journal, has filled in the strap causing it to run hot. If caused by the eccentric slipping on the journal, it should be reset, as explained under the head of (slipped eccentric), being careful not to tighten up. on the set screws too tight and cause the cam to bind in the strap. If the oil hole is stopped up it should be cleaned out with a piece of wire, oil the eccentric well and proceed. If it is running hot due to being too tight, the strap bolts should be losened up on thin liners inserted (top and bottom), the bolts tightened up, a sufficient amount of oil supplied, and the engine is then ready to proceed. The eccentric sometimes run hot due to a very heavy strain placed on them by dry valves, caused by improper lubrication or possible priming and foaming. In these cases the seat of the trouble would have to be remedied. Never use water on a hot eccentric as this would certainly cause the strap to break as it being made of cast iron or steel, would contract and would in so doing be sure to crack if it did not break.

HOT TRAILER.

A hot trailer is usually caused by an insufficient amount of oil, broken, or worn out brass, or possibly the waste in the oil house does not touch the journal, the best remedy is to turn on the water, and proceed. The trailer carries much of the weight of the back end of the engine, and should be very carefully taken care of. If it is necessary to replace the brass it can be done as explained under the head of replacing (engine truck, tank truck, or trailer brasses).

HOT TANK TRUCK.

With a hot tank truck treat as for a hot engine truck, turning on the water if the engine is so equipped.

Proper inspection, and careful oiling of parts, will in a great measure prevent hot bearings, but when they do occur it requires good judgment on the part of the engineer to prevent an engine failure, as well as to prevent serious delay to all train considered.

57. What would you do if you discovered steam chest cracked? What if badly broken?

Ans. If the steam chest were to become cracked, and it did not interfere too fuch with the steaming of the engine, or the view of the engineer in cold weather, would proceed. But in case it was necessary to make repairs, would first get in on the side track, and proceed as follows to get the engine in condition to continue the trip. Would first take up the casing around the chest, and in case the chest was provided with the studs on the outside, would try and wedge in between the studs and draw the crack together. If the studs were on the inside of the chest, would place a chain around the chest and use a jack to draw the chain tight. This would close the crack, and the engine would then be ready to proceed. On reaching the terminal an intelligent work report should be made out, covering the defect. When this method is used the jack should be placed on the front of the chest so that it will not strike anything.

In case the chest was badly broken, it would then be necessary to block the induction ports, to the steam chest. If enough of the studs were left, would fasten down the blocking with fish plates, and the remaining studs. If all the studs were gone, would then build up with blocking on top of the cylinder (blocking the induction ports), and hold it in place with a chain using a jack to take the slack out of the chain. The engine is then ready to proceed on one side, to the terminal, handling what cars the engine was able to one side.

58. How would you proceed to block up for a broken driver spring, spring hanger, or equalizer on an Atlantic type engine? How for a broken trailer spring?

Ans. If a driving spring or an equalizer should break, it can be blocked in the following manner: Front spring, run the trailer on a wedge, and place a block over the main driving box, run the trailer off the wedge, and run the main driver on the wedge, place a normal block over the front driving box (this is to assist in carrying the weight of the front end of the engine), now place a block in the back hanger of the front spring, on top of the top rail of the frame. If it were impossible to place the blocking in, with the engine standing in this position, would then stake up the forward end of the side equalizer. This would bring the equalizer up so that the blocking could be placed in the place just mentioned. If the back hanger of the front spring, was broken the engine should be elevated in the same manner, but the blocking should be placed on the forward end of the front equalizer, on top of the bottom rail of the frame. If the equalizer was broken at the stand (front equalizer), the trailer should be run on a wedge, then place a block over the main driving box, the trailer should then be run off the wedge, and the main driver run on the wedge, then place all the blocking possible on top of the front box. Then run the main driver off the wedge, and place a fulcrum under the back end of the engine frame, move the engine ahead so as to elevate the engine. Would then place a block in the back hanger of the front spring, underneath the top rail of the frame, and also place a block in the front hanger of the main spring, underneath the top rail of the frame. Would then run the engine off the fulcrum, and run the main driver upon the wedge and remove the blocking on the front box. Would then remove the blocking on top of the main box by running the main down, the trailer up, the blocking could then be removed Then run the trailer off the wedge, and the engine is ready to proceed.

If the side equalizer was broken, first run the trailer on a wedge, then place a block over the back, or main driving box, run the trailer off the wedge, and run the main up. Now place a block over the top of the trailer box, between the top of the box and the supplementary frame, at the same time place a block between the cross equalizer and the main frame. The main driver should now be run off the wedge, and the trailer run up, now place a block in the back hanger of the main spring, underneath the bottom rail of the main frame, at the same time remove the block from the top of the main driving box, run the trailer off the wedge, and run the main up, remove the block from the top of the trailer box, the engine is then ready to proceed. If the front hanger of the trailer spring was broken, place a fulcrum under the cross equalizer, and move the engine. This would bring the cross equalizer up so blocking could be placed in the U hanger, underneath the cross equalizer. The engine should then be run off the fulcrum, and the back end of the main frame staked up. This will raise the cross equalizer so that it can be chained to the forward end of the trailer spring. The blocking should then be removed from the U hanger, and the engine is ready to proceed.

To substitute for a cross equalizer, that is broken would proceed in the following manner: Place a fulcrum under the back end of both side equalizer, remove the broken parts, and elevate the engine. Use a piece of a rail as a substitute, placing it in the U hangers, and block solidly underneath, the move the engine off the fulcrum, and elevate the back end of the engine with a fulcrum placed under the back end of the main frame. Now chain the forward end of both trailer springs to the substituted cross equalizer, remove the blocking in the U hanger, and the engine is ready to proceed.

For a broken trailer spring where no substitute is to be used would proceed in the following manner:

Place a fulcrum under the cross equalizer, and after the engine has been elevated block in the U hanger underneath the cross equalizer. Would then move the engine off the fulcrum, and run the main driver upon a wedge, now place the blocking over the trailer box, underneath the supplimentary frame. Remove the broken parts, as well as the time will permit and the engine is ready to proceed.

When the trailer spring is broken and a substitute is to be used, would proceed in the following manner: Place a fulcrum under the cross equalizer and raise them higher than normal, then block in the U hanger, underneath the cross equalizer. Run the engine off the fulcrum, and place the substitute in place of the broken spring, chain one end of the substitute to the supplimentary frame, and the other to the cross equalizer, by placing a fulcrum under the cross equalizer, or else by fulcruming up the main frame. Run the engine up so as to remove the blocking from the U hanger, and the engine is ready to proceed.

59. **Explain how you would adjust grease cups to get the best results, and effect the greatest economy in the use of grease.**

Ans. The proper method of adjusting grease cups is as follows: Fill the cup and turn the plug down about two full turns. This is considered sufficient grease for a trip. In order to tell that the pin is getting the grease, it will be necessary to wait a few seconds after screwing down on the plug. If the plug screws easy after waiting it is safe to say that the grease is feeding to the pin. After the engine is in motion and the pin warms up the grease feeds as needed by the expansion of the grease in the cup.

Another method is to notice the amount of lateral motion in the brass on the pin, then screw the plug down until the rod feels tight on the pin. Do not screw the plug down until the grease shows around the collars as this is considered a waste. After pressure has been applied to the grease in the cup, one or two turns is considered sufficient to run the engine two hundred miles.

60. What must be done if piston, cross head, main rod or crank pin is bent or broken?

Ans. If the piston becomes broken or badly bent it will be necessary to take down the main rod, block the cross head, clamp the valve centrally on its seat and come in with the engine on one side. It depends as to where the piston is broken, or how badly it is bent as to whether it will be necessary to take down the rod and disconnect the engine. If the piston is not badly bent, it may be left up, loosen up on the gland nuts of the piston rod packing, disconnect the valve, and clamp it centrally on its seat. Make provision to oil the cylinder, and the engine is ready to proceed.

In case the piston was broken off close to the cross head, the engine could be disconnected as follows: Were the piston rod broken off close to the cross-head or close to the piston proper the main rod can be left up, the piston should be removed from the cylinder, and after disconnecting and clamping the valve centrally on its seat the engine is ready to proceed.

In case the cross head is badly broken it will be necessary to take down the main rod, and remove the piston from the cylinder, clamp the valve centrally on its seat and the engine is ready to proceed. If there is enough of the cross head left to follow in the guides, remove the broken parts, disconnect the valve and clamp it centrally on its seat, leave the main rod up and proceed.

With the crank pin badly bent it will be necessary to take down the main rod, and side rods. If the side rods have to be taken down on one side all rods on the opposite side must also be taken down. The engine would then have to be run in light with one main rod up. In case the pin was not too badly bent, the engine can be run in with all rods up by slacking off on the keys in the middle connection, and the back end of the main rod, so as to allow the rods to pass the dead centers. Disconnect the disabled side clamp the valve centrally on its seat, and proceed with the engine on one side.

In case of a broken main rod, the engine should be disconnected on the side with the broken rod, clamp the valve centrally on its seat, take the piston out of the cylinder, as an extra precaution in case the valve should shift and do further damage. The engine is then ready to proceed on one side.

61. If the lifting shaft, reverse lever or reach rod should break, what can be done?

Ans. In case the lifting shaft should break, it would be necessary to remove the broken parts, and block as follows: Place a block in both links, top and bottom, at the desired point of cut off, in the desired direction in which the engine is to be operated. The link should be blocked at a point of cut off that will enable the engine to handle the train all over the road. A space of about three-fourths of an inch should be left on each link to allow for the slip of the link block. When it is necessary to reverse the motion of the engine the blocks should be removed, and the long block placed on the bottom the short one being placed on top, in case the links had first been blocked in the forward motion.

In case the reverse lever should break, it will be necessary to block in the links, as for a broken lifting shaft, unless the design of the engine offers some means of securing the remaining parts of the broken lever at the desired point of cut off.

With a broken reach rod, the engine may be put in condition to continue the trip, by blocking solidly in one link (top and bottom), in the desired motion, and proper working point of cut-off consistent with conditions, or if the reversing arm extends through the running board, it can be fastened at the desired point of cut off by nailing blocks on either side of the arm. Some roads object to blocking one link in case of a broken lifting shaft, reversing arm or reach rod, in this case both links should be blocked top and bottom allowing for the slip of the link block. The objection being that by blocking one link an unnecessary strain is placed on the remaining parts of the valve gear.

62. When necessary to block a cross head, how would you do so, and what would you guard against?

Ans. When blocking a cross head it is advisable to block it back, whenever possible. The proper method is to make an allowance for the packing rings, being careful not to block them in the counterbore of the cylinder. On small power this is quite easily done, as the rings are small and the counterbore is large. On the larger power it is not so easily done but in blocking the cross head, on any engine a block about one inch thick should be first placed in the guides to prevent the piston packing rings from getting in the counterbore. The cross head should then be moved back against the small block and then securely held in this position by good solid oak blocking, the blocking being held in place with bell cord or wire, when no other means is at hand, the back cylinder cock should then be removed, as a warning in case the valve should shift. Whenever it is necessary to block the cross head ahead, it is always advisable to wedge open the front head, and then in case the valve does shift, no further damage will result.

When blocking the cross head on some classes of engines, care should be exercised to notice that the pin of the forward driver clears the wrist pin, in case it does not it will then be necessary either to block the cross head ahead or else in some cases in the middle of the guides. On some engines (with alligator guides), the cross head can only be securely blocked back, as the open guides of this style offer no means of securing the blocking if it became necessary to block the cross head ahead.

63. What can and should be done in case of a broken eccentric strap or blade?

Ans. In case of a broken eccentric strap or blade, the method of proceedure depends on the style of the engine as well as the motion in which the engine is working at the time. On some engines, with long heavy blades, or on engines with transmission bars, all that can be done is to take down and remove the broken parts, as well as the mate to the defective eccentric.

BROKEN BACK UP ECCENTRIC, STRAP OR BLADE.

In case the engine is working in forward motion at the time, and is not equipped with the heavy blades or transmission bars, the reverse lever should be placed in the full forward motion, and the train gotten in on the side track, where the engine should be disconnected as follows: In these defects it is always advisable to remove all broken parts, as well as well as to take down the mate to the defective parts, even though the engine can be operated in full gear with the back-up eccentric strap, or blade broken it is only advisable to do so in order to clear the main track, as there is always a possibility of the link turning over and this of course would do further damage. In case of the forward motion eccentric, strap or blade, breaking, and the engine is to be operated in the forward motion, it will be necessary to take down the mate to the broken parts, disconnect the engine, clamping the valve centrally on its seat. The train can then be gotten in on the side track, by taking as many cars as the engine can handle working on one side, and making as many trips as necessary to clear the main line. After putting the engine in safe working condition, would take as many cars as the engine could handle working one side and proceed, or would. be governed by the train dispatcher's instructions. In case any two eccentrics, straps, or blades, should break (that is the two forward, or the two back up), would be governed by the circumstances, with both backup eccentrics, straps or blades broken and the engine working in the forward motion at the time. Would proceed as in the case of any one being broken, the engine would be able to work in the forward motion but could not be operated in the backup motion. With both of the forward motion, eccentric strap or blades broken the engine could be operated in the backup, but not in the forward motion. In case for any reason it became necessary to do this (that is, use both motions), the strap and blade of one of the good eccentrics will have to be taken off and placed on the cam of the defective eccentric. This will give an engine working one side, and would be governed accordingly. Take what cars the engine can handle working one side, and proceed.

64. How would you disconnect, if lower rocker

arm become broken? How for a broken transmission bar or hanger? How for link block pin?

Ans. In case the lower rocker arm becomes broken it will be necessary to disconnect the engine on the disabled side, clamp the valve centrally on its seat, remove the broken parts, oil the cylinder through the indicator plugs and proceed with the engine working one side. If there is any danger of the link striking the remaining part of the rocker arm, the link or the rocker arm will have to be removed (whichever is the easier). If this is not done there is danger of the link striking the rocker arm and shifting the valve. This would be liable to cause further damage.

In case of a broken transmission bar hanger it necessary to remove the broken parts, and also the remaining parts, clamp the valve centrally on its seat, oil the cylinder, in the usual way when the rod is left up, and proceed with the engine working one side.

In case of a broken transsmission bar hanger, it will be necessary to block solidly in the link (on the disabled side), at the desired point of cut off, guard against reversing the engine by placing a block in the other link or by securing the reverse lever. The engine may then proceed with the full train.

In case of a broken link block pin, substitute if possible with any bolt that will fit in the hole (a knuckle pin of a draw bar will serve to get the train off the main track, and will do as a substitute, providing it can be secured in place). If there is a hole in the end of the knuckle a piece of wire may be used to fasten the pin so that it can not work out. In case no substitute is at hand, disconnect the valve and clamp it centrally on its seat, fasten the lower rocker arm so that it can not be struck by the link, if possible, if not the link or rocker arm will have to be removed, as there would be further damage done if the link should strike the rocker arm and shift the valve.

65. How would you move an engine if reverse lever or reach rod was caught at short point of cut-off by a broken spring or hanger?

Ans. In case the reverse lever or reach rod is caught by a broken spring or hanger, it will either be necessary to disconnect the valve stem, or else knock out the reach rod pin. At the same time the engine is to be moved, place blocking so as to elevate and block for a broken spring or hanger. If the engine will move herself with the lever at a short point of cut-off, elevate and block for the broken spring or hanger. After moving the valve by hand, and blocking for the defect, connect up and proceed.

66. What leaks in the front end would affect the steaming qualities of the engine?

Ans. Steam leaks in the front end are most disastrous to the steaming qualities of an engine. They are such leaks as follows: Leaky steam pipes, the gasket blown out of the nozzle tip, or stand, burst flues, or any steam leaks, from any cause such as leaks around the flues or superheater flues, etc. Air leaks from the outside also destroy the steaming qualities of an engine as both steam and air leaks destroy the vacuum created by the exhaust steam.

67. What would you do if one of the safety valve springs broke?

Ans. In case one of the safety valve springs broke, it would be necessary to get both injectors to work, and as soon as the pressure is sufficiently reduced, try to seat the valve with the broken spring by slacking off the lock nut, and screwing down on the tension screw until the valve is forced to its seat. If the bolt or screw was not long enough to accomplish this it would be necessary to place a nut under the screw and then try to seat the valve by screwing down on the bolt. The pressure can then be regulated for the remainder of the trip with the other safety valves. The regulating, or tension, screw is purposely made long, so that the valve can be seated in case the spring should break.

68. If the wedge is up against the top rail of the frame, and the box still pounded, what report would you make?

Ans. In case the wedge is up against the top rail of the frame, and the box still pounds it would be necessary to report the wedge lined down, so that it could take up the lost motion by being set up. The cause for the box pounding, with the wedge up against the top rail of the frame, is that the wedge has worn too small for the space it has to fill, and by lining it down is meant that a piece will have to be riveted to the wedge to take up the lost motion. The wedge can then be set up again until it strikes the top rail of the frame when it will again have to be reported lined down.

69. **In reporting work on any wheel or truck on tank or engine, how should you designate by number which one is meant?**

Ans. When reporting work on any wheel by number, it should be done as follows: Beginning with the right front engine truck, it should be called right No. 1, the second wheel right No. 2, etc., the tank trucks should be spoken of as right No. 3, 4, 5, 6. Or in speaking of the wheels on the right side of an engine they should be called right Nos. 1, 2, 3, 4, 5, 6, etc. The left side should be spoken of as left Nos. 1, 2, 3, 4, 5, 6, etc. The drivers should be spoken of on an eight wheel engine as right and left, main and back; on a ten wheel engine they should be spoken of as right or left front, main and back. On a consolidation engine they should be spoken of as right No. 1, driver, No. 2, 3, or main, 4, or back driver; on the left side the same. On an engine with a pony truck the wheels should be called right or left pony truck. On an engine with trailer they should be spoken of as, right or left trailer truck wheel.

70. **What would be the result, if guides and cross heads were not in line?**

Ans. In case the guides or cross heads are not in line, it causes an uneven wear on the guides, and cross head, piston rod, and cylinder packing cramps the brasses on the pins, causing them to run hot, is very liable to spring the main or side rods, also the piston rod. If allowed to run this way long might be the cause of a broken piston, or cross head.

71. **What can be done in case a link saddle pin, link hanger, or lifting arm should be broken?**

Ans. In case of a broken link saddle pin, link hanger, or lifting arm, it will be necessary to block solidly in the link at the desired point of cut-off (block top and bottom). The engine may then proceed working steam expansively, on the good engine, or the engine under which you have control with the reverse lever, hooking it to the point that is considered most economical. When necessary to reverse the motion of the engine the blocks in the link will have to be changed, the long block in the top of the link and the short one in the bottom if it is desired to back up. On a high speed passenger job, where it is not necessary often to drop the lever, the link block can be blocked centrally in the link. This will prevent changing the blocking when it is necessary to back up, and when the good engine is hooked to its running notch, the valve events will be more in unison.

72. **With one link blocked up, what must you guard against?**

Ans. When it is necessary to block one link, the engineer should guard against reversing the engine without first changing the blocks, in the link of the disabled side. He should also guard against hooking the engine down with the over hung lifting arms, or hooking the engine up with the under hung lifting arms, as there is danger of getting the arms back of the link and doing further damage. With one link-blocked it is always advisable to either place a block in the other link or else secure the lever in such a way that it will be impossible to reverse, or hook the engine either up or down. On most engines there is a set screw hole in the reverse lever for this purpose.

73. **(a) Explain what you would do with frame broken between main driver and cylinder? (b) A broken frame back of main driver? (c) A loose or lost cylinder key?**

Ans. In case of a broken frame between the main driver and the cylinder, it will be necessary to set out the train. In some cases it is advisable to disconnect the engine on the disabled side, but in all cases it is necessary to handle the engine very carefully as there is great danger of doing further damage by shearing the cylinder bolts, knocking out cylinder heads, or by breaking rods and pins. It is not advisable to try to handle any cars, or in some instances to even be towed, in a train, as the strain of pulling on the broken frame is very liable to do further damage when the frame opens up. In case the engine is to be towed in the piston should be taken out of the cylinder, to prevent the heads from being knocked out.

The strain of the broken frame when it then opens up will fall on the rod and pins. If the engine is coming in under her own steam, and the engine has been disconnected, great care should be exercised to prevent the engine from slipping as this would certainly do further damage.

With the frame broken back of the main driver, it is sometimes advisable to take down the back section of side rods. The engine may then proceed with two-thirds of her train. If the train be a light one, or the engine through circumstances is running light, it would not be necessary to take down the back section of side rods, but the engineer should handle the engine very carefully and not impose any unnecessary strain on the broken frame. With the bottom rail of a double rail frame broken proceed to the terminal with the full train and on arrival report the condition of the frame, along with the general condition of the engine. Some authorities take into consideration the nature of the break in these cases, but by the greatest number it is not considered advisable to try to handle a train with the frame broken ahead of the main driver even though it is a smooth break and does not open up to any great extent. The possibility of doing greater damage to the engine offsets the economy of so doing.

With a loose cylinder key, would try to tighten it by driving something in along side of it. When it is lost, would try to substitute, using a rod key, track spike, or a square file, or anything in the nature and shape of the key. Failing in this would treat as a broken frame, as the consequences are the same, so far as damage to the engine is concerned, in case it can not be fixed.

Engines being handled with broken frames and lost cylinder keys should be handled very carefully, reduce the steam pressure (if necessary with the safety valves), and use great care to prevent doing further damage.

74. **Which side rods should come off if opposite ones are broken? Why?**

Ans. When it is necessary to take down a particular side rod, the rod opposite should also be taken down as for example; when it is necessary to take down the back section side rod on one side, the back section side rod on the opposite side must also be taken down. In case the forward section side rod has to be taken down on one side, all side rods will then have to be taken down on both sides. On a consolidation engine the parallel rods ahead of or behind the knuckle joints must be taken down, in case for any reason it became necessary to remove any one rod. The intermediate rods do not necessarily have to be taken down unless they too are defective, in which case all side rods on both sides will have to be taken down.

The reason for taking down parallel rods is, that by reason of the engine being designed at quarters (and the side rods left up on one side), the wheels on one side of the engine have a tendency to lift up, while the wheels on the opposite side are pulled down by the action of the main rod. This action taking place with the engine on the quarters, is very liable to cause the wheel without its side rod to revolve in the opposite direction causing the side rods to be badly bent or buckled, or possibly the pins to be broken off.

75. **(a) Should one of the forward tires of a ten wheel engine break, what must be done to bring the engine in? (b) If the main tire? (c) If back tire? What could you do to keep the flange of the good wheel to the rail? (d) How would you block for a broken trailer tire?**

Ans. In case the forward tire of a ten wheel engine should break it can be blocked in the following manner: Run the wheel with the broken tire, up on a wedge, as thick as the tire or a little thicker to allow for settlement remove the cellar if possible, and place a good solid oak block cut to the shape of the journal in place of the cellar, build up to the false, or substitute cellar with blocking inserted between the pedestal binder, and the false cellar. Cut out the driver brake and run the engine off the block. If there is any doubt as to the ability of the pedestal bolt being able to carry the weight, chain up the equalizer nearest the box, with the under hung spring rigging, or block between the spring saddle and the frame with the over hung spring rigging. In case the cellar can not be removed, use iron blocking between pedestal and cellar to hold the cellar up to the journal when the wheel is run off the wedge. The cellar being of iron will cut the journal, but this is not considered injurious to the journal as it does not cut the bearing. The pedestal or binder bolt on modern engines is considered to be as strong as the frame, and is very able to carry this weight.

With the front tire blocked in this manner would proceed with the train. In case the main tire breaks, and no further damage is done, would run the wheel with the broken tire up on a wedge as thick as the tire or thicker to allow for settlement, block as for the front tire, cut out the driver brake, reduce the weight in the same manner as for a front tire, and proceed. With the main tire blocked in this manner would not attempt to take any cars, would use care in passing over frogs and switches.

For the back tire would block in the same manner as for a front, or main tire, but in addition would place a tie from the deck of the engine to the bed of the tank, chaining it to the frame of engine while on the wedge. Would also place a chain from the disabled side of the engine to some convenient place on the tank, to hold the flange of the good wheel to the rail, cut out the driver brake, and proceed without the train.

With a broken trailer tire would proceed as follows: Run the trailer up on wedge as thick as the tire, or thicker to allow for settlement, remove the oil house cover, and cellar, then block between the journal and the bottom of the oil house, also between the trailer box and the pedestal. Would then either chain the cross equalizer to the supplimentary frame, or block between the cross equalizer and the U hanger, would then lay a tie on the bed of the tank, and place one from this to the deck of the engine, would then while the trailer was on the wedge place a chain around the main frame and the tie so that when the wheel was run off the wedge the chain would be tight. This would help to carry the back end of the engine as well as to hold the flange of the good wheel to the rail. Would then proceed being careful over frogs and switches.

76. If check valves were stuck up, how would you proceed to get them down? How with a globe valve attachment?

Ans. In case the injector check was stuck up, would proceed to get it down in the following manner: Would first obtain a safe water level and maintain the same with the other injector. If the engine was equipped with a check of the globe valve variety, would close off the angle valve, and prime the injector. After the injector had been gotten to prime, would open the angle valve and allow the action of the injector to remove the scale, or whatever obstruction it was that had caused the check to stick up. If this failed to remedy, would again close the angle valve, and take up the cap nut on the check and see what was the trouble, would be governed accordingly. If the check was of the old style cage arrangement, would attempt to get it down in the following manner: First open the primer valve, sprinkler hose valve, and the frost cock if so equipped, would then tap the check lightly with a hammer, or piece of wood expecting the jar, or the vibration of the check inside of the cage to cause it to seat. Would try this method a reasonable length of time, and in case the check failed to seat, would try pouring cold water on the check casing. This has been known to help seat the check. In case these efforts failed to cause the check to seat, would screw out the frost cock (in case it was directly under the check), and try to seat it by using a rod or anything that could be introduced through the hole, would try to raise the check, and allow the boiler pressure to blow the obstruction out that was holding the check from its seat, thus allowing the valve to seat. Failing in this would reduce the pressure low on the boiler, and try to seat it by taking the delivery pipe down. Would loosen up on the connection nut, and move the feed pipe to on side, would then strike the spindle of the check lightly up with the hopes that it would raise from its seat long enough to allow whatever it was holding it up to be blown out, and the check to be re-seated. After trying all these remedies and failing would disconnect the hose from the feed pipe, allowing the steam to blow back under the tank depending on the other injector. If it were possible to keep a safe amount of water in the boiler, and handle the train would do so, if not would be governed by the circumstances, take what cars the engine could handle under the circumstances and proceed. With the globe valve, attachment, and the check of the take down variety, it is possible to shut off the angle valve, and take out the check and remove whatever the obstruction may be, as well as to clean the check of the limey deposits, by pouring in a little car oil, and grinding it on its seat. A small amount of car oil worked through the injectors, is both beneficial to the injector and the check, and will in a great measure reduce the troubles from a sticky check.

77. What are some of the various causes for pounds, while working steam?

Ans. Some of the various causes for pounds while an engine is working steam are brasses loose in the forward, or back end of the main rod, loose bushings in side rods, loose knuckle joints, worn our driving box brasses, wedges down, guides that need closing in, loose piston, piston loose on the piston rod, broken frame, loose or lost cylinder keys, loose splice bolts, loose deck bolts, or expansion plate buckle, broken cylinder bolts, causing the pistons to strike the heads, broken brasses in rods and driving boxes, flat wheels, or the imperceptible slip, or hammer blow in the drivers. Heavy compression, due to an improper valve set.

78. If an engine pounded when steam was shut off, what would it indicate?

Ans. Some of the causes for pounds when an engine is shut off are: Loose spider, loose follower bolts, main rod too long or too short, stuck wedges, flat wheels, and heavy compression in the cylinders, due to an improper valve set, along with lost motion in all parts of the machinery of the engine.

79. How would you locate a pound in driving boxes, rod brasses, etc.?

Ans. In order to locate a pound in driving boxes, and rod brasses, the engine should be placed with the pin (on the side being tested), on the top quarter, set the brake, or block the wheels, and give the engine a very light throttle of steam. The fireman should then pump the engine or move the reverse lever from one corner of the quadrant to the other, the engineer can then watching see where all the lost motion is on that side of the engine. The other side should then receive a like test, and an intelligent work report should then be made out on the condition of the engine in parts as found.

80. In what manner would proceed to give an engine a thorough inspection after arrival at terminal station?

Ans. To give an engine a thorough inspection on arrival at terminal station would proceed as follows: Would first set the brake with a full service reduction, get off the engine on the right side with a lighted torch and a hammer, commencing at the right back driver would inspect the wheel, tire, driving box, spring, hanger, equalizer, indicator plugs in the grease cellars, wedge, frame, rod brass, and pin, tap all bolts and nuts, and proceed to the next driver, and give it a like inspection, also the eccentric, straps, blades, link, top and bottom rocker arm, valve stem, and packing gland, on reaching the guides, give them a careful inspection as to bolts and nuts, close off the guide cups, and note the condition of the cross head, piston engine truck wheel, engine truck oil cup, sanders, note the engine brake piston travel, condition of the shoes, levers and rods, and on reaching the front end of the engine examine the front engine truck wheel, spring, equalizer, pilot, pilot braces, draw bar, pin lifter, headlight, hook up air signal and brakepipe hose, also noticing that the pilot is the proper height from the rail. On reaching the other side of the engine give it a like inspection, note the condition of all air piping, see that it is free from leaks, watch the action of the pump, see that the packing in the steam and air end is not blowing, notice that the pump's stroke is regular, and that the strainer is clean. On reaching the tank, examine the hose between tank and engine, draw bar, chaffing iron, safety chains, grab irons, steps, apron, and shoveling sheet. Examine the tank truck, wheels, oil box, tap the wheels to see that they are not cracked, note the condition of the brake rigging, rods and levers, piston travel, see that the air pipes are free from leaks, give all wheels a like inspection, and on reaching the rear of tender examine the grab irons, pin-lifter, draw bar, center casting, bolts and nuts, hook up signal line and brake pipe hose, and see that proper signals are displayed in accordance with the book of rules. Give the opposite side of the tender a like inspection, and on reaching the point from which you started, summarize the conditions of machinery, and equipment so that an intelligent work report can be made out on the condition of the engine in general as you found it. Climb into the cab, release the brake, hook the reverse lever in the center of the quadrant, open the cylinder cocks, set the independent, or straight air brake if engine is so equipped, leave the boiler at least two-thirds full of water, a good fire in the box, and at least 100 pounds of steam. Report any unusual conditions in the engine or its machinery to the hostlers, register in, make out the work report, and go to your rest.

81. What is meant by friction? Upon what does the amount of friction depend, and what is the effect of introducing oil or other lubricant between frictional surfaces?

Ans. Friction is the resistance offered to bodies moving one over the other. The amount of friction depends upon the physical characteristics of the bodies, their weight, and the speed at which they are moving. Introducing oil, or other lubricants, has the effect of reducing friction by introducing the third body, or a bearing surface for the bodies to move over. This changes a metal friction to a fluid friction which offers the least resistance to the movement of bodies.

82. What examination should be made by the engineer to insure successful lubrication?

Ans. In order to insure successful lubrication, the engineer should examine all bearings, see that all cellars are properly packed, all brasses properly keyed up, and in a condition to receive a lubricant. He should also see that all oil holes are open, and that all oiling devices, and oil cups are properly filled, and adjusted. He should then supply all parts demanding lubrication, with a proper amount of oil or other lubricants, and little if any trouble will be experienced from hot bearings.

83. Why is it bad practice to disturb the waste on driving boxes, while oiling the engine?

Ans. It is bad practice to disturb the waste on top of the driving boxes, as it not only destroys the oil passages, or channels formed in the waste but is liable to cause the dirt and cinders on top of the waste to work down into the box, and aside from cutting the bearings, it stops up the oil holes, which soon results in a hot driving box, due to the fact that the oil in the cellar is soon used up and no other can be supplied, even though the engineer thinks he be giving the driving boxes a good oiling.

84. At what temperature does engine oil lose its lubricating qualities? Valve oil?

Ans. Engine oil ignites at, or looses its lubricating qualities, at about 250 degrees Fahn; valve oil ignites at, or looses its lubricating qualities, at from 450 to 525 degrees Fahn. Some oils have a higher flashing point, but these figures are in accord with the general average of oil used on most railroads.

85. Explain the principle upon which the injectors work. Should your injectors stop working on the road, what would you do?

Ans. The injector works on the principle of an induced flow, or the theory of motion being able to overcome force. Some authorities advance the piston theory, while others favor the theory of the velocity of escaping steam (in comparison to water under the same pressure), and the additional weight of water being able to overcome the pressure on the check. The last named seems to be the general accepted theory. (This subject is treated in the first and second year's questions, and it is felt by the authors, that it is not necessary to repeat it here).

In case the injectors failed while on the road, the engineer should proceed as follows: First protect the boiler by deadening the fire, and if necessary a better plan is to dump it. An engine can be fired up much easier and with less expense to a railroad company, than a crown sheet can be replaced. Aside from the danger of doing damage to the sheets of the fire box, the engineer who fails to protect the boiler is not only taking a chance on his own life, but he is also jeopardizing the lives of others.

After protecting the firebox sheets the engineer should try to find out what is the matter with the injectors. He should first satisfy himself that the tank contains water, and that it is not too hot, for the injectors to work. He should then look for leaks, making a heater out of the injector blowing steam back into the tank. If there are any leaks in the injectors or its pipe connections, or the syphon tank connections, the heater will show them. In case any be found, they should be remedied if possible. Failing to find any leaks he should then see that the main throttle valve on fountain, and injector were open. They may be only partly opened, and in this case the injector would not be getting enough steam. After trying these things and the injector still failed to work, he should take out the throttle and primer valves, run a wire through the nozzles. Possibly some obstruction in them is keeping the injector from working. Take out the water ram, a piece of waste might be caught in the passage, or the spindle broken and the valve held to its seat. Do not give up, have patience, and above all things be cool headed, think, there is always a remedy, first the cause and then the treatment. Surely a man is not entitled to or worthy of the name of an engineer who can not say, I did all there was to do, rather than say I did all I could do. Interchange parts, such as throttle or primer from left to right, in case you find either of these valves defective.

If the injector primes the trouble is ahead of the steam nozzle. If it will not prime the trouble is back of the delivery nozzle (providing there is not a leaky check), possibly the primer valve passage is stopped up, or the primer nozzle turned up side down in the over flow pipe, look for these things. It will be far more satisfactory to say to your officials, I was delayed, due to some cause, rather than have an engine failure, and then have them point out to you the cause of the trouble. If after you have found the trouble, and it is possible for you to remedy it, do so, get sufficient water in the boiler, to fire up again and proceed. In case it is impossible to make repairs, or even find the trouble, disconnect the engine and be ready to be towed in. On arrival at terminal station make out a work report covering the defect, and an engine failure report to the Master Mechanic, giving the facts of the case as you experienced them.

86. What do you consider abuse of an engine?

Ans. There is probably no subject pertaining to a locomotive on which more could be said than this. What some men consider abuse to an engine, evidently others do not. So we will treat the subject from our own viewpoint.

The engineer being the responsible party, should insist on the engine being properly pumped, and fired. There is nothing more injurious to the boiler than improper pumping, or improper firing (from a running stand point). Too much water in the boiler is the cause of more engine failures (that is in regards to time and tonnage), than a low steam pressure. High water wets the valves, destroys lubrication, cuts the valves and seats, destroys cylinder packing, and causes an unnecessary strain on the valve gear parts that soon tells its own story in the form of lost motion, worn pins and bushings, sprung blades and lose eccentrics, a general wear on all of the valve gear parts. Improper firing, such as too heavy or too light, causes the steam pressure to be very much un-uniform, and consequently uneven expansion and contraction. Results, leaks in the firebox sheets, and flues, a thing that causes a complete engine failure, on the larger power of today. Some firemen are allowed to fire the engine most any way in order to keep up steam, their method works all right until the fire in the firebox begins to show leaks, then the engineer begins to tell him his mistakes. He should have done this at the start, and by so doing would have caused himself less trouble, and saved, rather than have cost the company money. Experience is a wonderful teacher. A man should profit by his mistakes, but evidently some men never do. If the engine is pumped and fired, scientifically, by the fireman, then the abuse to the engine must naturally fall upon the engineer. The engine should be properly lubricated, and never worked harder than is necessary (in the judgment of the engineer) to make time, and handle the train, of course taking into consideration the work to be done, physical characteristics of the road, and the train to be handled. Proper lubrication, and oil economy, like coal economy, has become to be a vital question on railroads. The fault of using too much oil is of just as much importance as not using enough. The results are not the same, from a practical standpoint, but are from the economical. Some engineers make time, and handle tonnage on an oil allowance that scarcely takes another man out of the round house. Why is this? There must be a reason. The work slips and general condition of the engine show practically the same, and in many cases the man with the oil record, as some care to term it, has the best engine. Some engineers have the habit of allowing the reverse lever to remain low in the quadrant for a much longer period than others do, under the same conditions. This action taken from the practical or economical standpoint is surely abuse to the engine, as it not only causes the fireman to fire heavier, but the water is raised in the boiler, and being carried over to valves and cylinders washes away the lubrication and does great damage to the entire machinery of the engine. The engineer who practices these methods finds that the fireman has no control of the fire, the engine blows off, making matters worse. Then for the next 25 or 30 miles the engine fails to do its work as it should all to the bad method of pulling out of the station. Willing neglect to any of the appliances of the engine, is also abuse to an engine. Improper work reports, or careless inspection of the engine, before making out the report, not only cost the company money but are an abuse that is entirely uncalled for. By a careful inspection, some of the small things might be found that would be the cause for an engine failure, in case they were not found and reported. The proper use of the blow off cock is also of vital importance in the proper performance of the engine, fewer delay reports, and stalled reports would be the results if the blow off cock were used as all men know it should be used. While it is not the intention of the authors to comment on the ability of men running engines, it is to be hoped that some of the things suggested as abuse to an engine might cause some men to try to change their methods of handling the engine. It is to be understood that we do not attempt to pose as examples in these particular cases mentioned, but a few of the things mentioned as abuse have come under our own personal notice. Hot bearings, injector failures, and in many cases breakdowns are the direct result of some abuse to the parts mentioned, that can be traced to no one but the engine crew. The improper use of the sanders can be termed as abuse to the engine, allowing the sand from one pipe to strike the rail, and none on the other, slipping the engine and catching it on sand causes an unnecessary strain on all parts of the engine, especially pins and rods. This also causes an uneven wear on the tires, that in time causes other defects.

87. Why should the sand from both sand pipes strike the rail?

Ans. It is of the utmost importance that the sand from both sand pipes strike the rail at the same time as the sand acts as preventive to the engine slipping. If the sand only strikes one rail and the engine slips the side with the sand has a tendency to hold the rail and the other side slipping throws a strain on the journal, pins, and rods that is liable to break them off or do serious damage. The sand increases the adhesion between the wheel and the rail, and both wheels connected to the same shaft should receive the same treatment, in as far as their holding and drawing power is concerned. Sand on one side and none on the other causes uneven wear on the tires, that in time causes sheeled out tires, on one side, and this brings about a very slippery condition, as the wheel with the bad tire has not the same chance to hold the rail as the other. The power in the cylinders being the same this wheel will of course be very liable to slip.

88. Suppose the whistle, or one of the safety valves blew out, what would you do?

Ans. When the whistle or one of the safety valves blows out the engineer should at once protect the boiler by dumping the fire. Get both injectors to work, as an extra precaution while doing this. After the pressure had been reduced on the boiler, the hole can be plugged, either by screwing in a plug, in case one is available, or by plugging the hole with a wooden plug. There are several ways of making the plug, but the most common is to take a piece of dry pine about 14 inches long, and after fitting it to the hole, it can be held in place with a board fastened to the hand rails with bell cord or wire. In case it were possible to retain the water in the boiler, the fire may be rebuilt, steam raised, and the engine is then ready to proceed with the train. In case the water is too low to fire up, and there is no means at hand to refill the boiler, the engineer should prepare the engine to refill the boiler while being towed (in case this was considered necessary). If this was not considered advisable he should disconnect, in the proper manner, and be ready to be towed in.

89. To what cause do you attribute the failure of injectors, as a general thing? What should you do to obviate this failure?

Ans. The general cause for an injector failure is non-use. When not in use they become very much corroded up, due as a rule to a back leakage from the injector check. To obviate this failure the injectors should both be used, use one while running on the road, and the other one while doing siwtching. In case the engine is in passenger, or through freight service, the engine should be pumped with first one and then the other injector. This will keep both in good working order, and failures from this cause will be avoided.

90. How can a disconnected tank valve be gotten open without stopping?

Ans. A disconnected tank valve may be gotten off its seat without stopping by making a heater out of the injector, and by turning the steam on strong the valve will be blown from its seat. The broken spindle of the tank valve should first be removed, so that when the disconnected valve is blown from its seat, it will fall out of the socket in which it works, and the trouble will not again be experienced.

91. How would you tell the difference between a leaky injector throttle, check or primer?

Ans. The difference between a leaky injector throttle, primer, or injector check may be determined in the following manner: A leaky check discharges both steam and water, so also does a leaky primer, while a leak from the injector throttle is usually dry steam. The difference between a leaky check throttle, or primer can be ascertained by putting the injector to work. If the leak at the overflow stops, it is an indication that the leak is coming from the throttle or check. In case the leak continues, it is the primer valve that is at fault. To tell whether the leak is from the throttle, or the check, shut off the valve on the injector branch pipe, at the fountain. If the valve closes tight, and the leak continues, it is coming from the check. If the leak stops it was coming from the injector throttle. The defect should be reported as found.

92. Explain the construction and operation of the blow-off cock.

Ans. Blow-off cocks are manufactured in several different styles and sizes. They differ in points of construction, and operation, but however constructed, or operated, they produce the same general results. Some are operated by air, while others are operated by hand. The style of blow-off cock, that is operated with air at main reservoir pressure, consists of a sectional brass cage, containing two compartments, and two sets of valves. Each valve is operated independently, or in conjunction one with the other. The body of the blow-off cock screws into the front sheet of the boiler, usually near the mud ring, this being the point at which the mud as a rule settles. The operation of the blow-off cock is as follows: When it is desired to open the blow-off, air from the main reservoir is admitted to the air chamber of the blow-off valve, coming in contact with the piston. The area of this piston is such that a pressure of 90 pounds of air will force it in against a boiler pressure of 200 pounds per square inch. As the piston moves in it comes in contact with the boiler valve, unseating the same, and allowing the mud and dirty water to be discharged from the boiler. When the air that is holding the piston in is closed off from the valve by the engineer, the air that is trapped in the piston chamber, and pipe connections, is quickly vented to the atmosphere through a port in the controling valve, and the boiler pressure seats the inner valve closing the opening from the boiler. There are several ways of blowing off the boiler, but the generally accepted way is to allow the blow-off cock to remain open for a few seconds, then close it. This action causes a whirling motion of the water, and sucks or draws the mud to the opening. Upon opening the valve again a quantity of mud will be discharged from the boiler. By repeating this performance the boiler can be cleaned of its impurities. The hand operated valves should be operated in the same manner, it having been demonstrated by the use of a glass boiler that this method produces the best results, so far as getting mud out of boiler is concerned.

93. **Describe the manner in which the sight feed lubricator operates.**

Ans. The operation of sight feed lubricator is based on several of the well known laws of science, Hydostatics (or the pressure of fluids at rest), specific gravity of oil in comparison to water and gravitation. All fluids or liquids seek their own true level, water in comparison to oil is much heavier, then the operation of the modern lubricator is (after being based on the natural laws of science) entirely dependent on an equal balance of pressures, and the additional weight of water, which the condensing chamber supplies. The lubricator feeds due to the fact that the pressures are equal, the pressure at the oil outlet (the choke plug) being the same as the pressure on the condensed steam or water in the condensing chamber. The liberated drop of oil at the feed nipple then raises to the top of the water in the sight feed glass by its own specific gravity. On reaching the choke plug it is forced through the hole in the plug by the jet of steam from the equalizing tubes. From here it gets to the point of lubrication, by gravity, or the fact that any body will roll or move down an inclined plane.

94. **(a) If the steam heat gauge showed the required pressure and the cars were not being heated properly, how would you proceed to locate the trouble? (b) How does the steam heat reducing valve control the pressure? (c) In event of steam heat reducing valve being out of order, how can you heat the train until repairs can be made?**

Ans. In case the steam heat gauge showed the required pressure, and yet the train was not being properly heated, would proceed as follows: Would first see that there was a circulation of steam through the steam heat piping on the tender by tapping the indicator, or drips on the hose couplings. If steam showed strong at these points the trouble would be on the train, if not it might be that the reducing valve was not operating properly, the steam heat line might be frozen up, or possibly the angle valve on the steam heat line at the back end of the tender was closed. Failing to find this valve closed, the pipe should be felt from the rear of the tender to the coupling between tank and engine, if the pipe is hot all the way the trouble, is in all probabilities in the reducing valve. Because of the fact that the gauge shows pressure is no safe reason for saying that the valve is all right.

The valve might be leaking slightly and with a stoppage in the pipe, the pressure would quickly equalize high, in many cases reaching boiler pressure. If the steam heat line or any of its connection was frozen up, it should be thawed out with a piece of saturated waste. If necessary these pipes should be disconnected between tank and engine, to facilitate in this work. The only way in which the engineer can tell that the equipment is all right is to get a good flow of steam through the steam heat line.

In case the defect is in the steam heat reducing valve, the supply valve may be blocked open and the pressure regulated with the fountain valve. Care should be exercised to prevent getting too great a pressure in the steam heat pipes, as there is danger of bursting hose, and possibly the steam pipes inside the cars, which would be very liable to injure persons in the car.

95. If the wrist pin, crank pin and driving axle on one side, are in the same straight line, how much power does that side exert to turn the driving wheel? How then is the engine kept going?

Ans. When the wrist pin, crank pin, and driving axle are in a direct line or parallel with the piston, the power exerted upon piston is the same as it is any other time, with the same opening of the valve. The same area of the piston is exposed, at this time that is at any other time, but the force is exerted in a direct straight line, and that side of the engine has no power to move itself.

The engine is kept in motion due to the fact that the pin on the other engine is placed on the quarter, or at right angles with the engine on the dead center. In this position the rod has its greatest leverage, and the engine that is on the center is carried by this point until its rod has assumed an angle, when it does work equal to the expansion of the confined steam in the cylinder. The work performed by a locomotive (even though it consists of two separate engines, set at different quarters, on the same shaft, or journal) for a certain time in each stroke falls upon one of the two engines.

96. Describe the principle of the bell ringer, and how can it be adjusted?

Ans. The bell ringer is an air or steam operated engine, connected by a suitable piston and crank, to the end of the bell shaft. The engine consists of a cylinder, and a double piston, on the same piston rod. One piston acts as the valve, the other is the medium through which the admitted, and confined air (or steam), is allowed to expend its energy in the direction the piston is to operate. This action causes the bell to swing the distance of the lift on the piston and the eccentricity of the crank. As the piston moves upward it carries with it the valve, cutting off the admission of air and after the air has expended its energy the weight of the bell forces the piston down again to the bottom of the cylinder, where it again comes in contact with a fresh supply of air, and is again forced upward. This action is entirely automatic, so long as air is supplied to the bell ringer.

The air is exhausted from the cylinder of the bell ringer, through a very small hole, but before it is all exhausted the weight of the bell forces the piston down trapping a certain amount of air, forming the cushion, for the piston in its cylinder.

The adjustment of the bell ringer is brought about by increasing or shortening the length of the bell ringer piston. This is accomplished by an adjusting screw, on the bell crank. To increase the lift on the bell, slack off on the lock nut and screw the bolt down. To decrease the lift screw screw the bolt out and in both cases after making the adjustment tighten up on the lock nut. The bell ringer proper needs but very little lubrication, the friction of the pistons in cylinder being very little. Oil has a very detrimental effect on the bell ringer, in fact in cold weather, as it causes it to become gummed up, and its action then is very sluggish. The bell itself should be oiled every four hours, when in constant service.

97. **What is superheated steam?**

Ans. Superheated steam is steam heated to a higher temperature than which it is generated at, or steam from which all moisture has been evaporated by reason of being placed in contact with a greater heat than the boiler contains.

98. How is it superheated, and what benefits are derived from it?

Ans. It is superheated by a system of return flues, connected to the nigger head and steam pipes in the smoke box. The steam, after the throttle valve is opened, circulates through these flues, coming in contact with the firebox gases, is heated to a very high temperature before it enters the cylinders of the engine.

The benefits derived, are, the higher the temperature the more expansive qualities the steam contains, less condensation, and a greater degree of heat energy, the medium through which the cylinders of an engine are made to perform a work.

99. How many miles should an engine run to a pint of engine oil? Valve oil, and how would you oil an engine to effect the greatest economy?

Ans. An engine should make from 50 to 100 miles to the pint of engine oil. It should make from 75 to 125 miles to the pint of valve oil. An engine in freight service is allowed the greatest amount of oil, on account of the tonnage handled, and the time on the road. Engines in passenger service make the greatest number of miles but under the more favorable conditions.

The proper manner of oiling an engine varies according to the class of service the engine is in. On through passenger, or freight runs the method differs from local passenger or freight runs. The best method is to make the first oiling a very careful one, supply each bearing with a liberal amount, but do not waste it by pouring on so much that the cups are run over, and the oil runs off on the ground, as this is the waste of which the companies complain. After the first oiling the engine should receive a small amount at stops. Whenever necessary make a careful inspection of all parts, and when taken in time a bearing that is warming up can be cooled with a smaller amount of oil than if allowed to become hot. Of course on runs where stops are few and far between, a greater amount of oil must be supplied at each oiling than on runs that make local stops. The best results would of course be obtained by oiling light, and often, but in many cases this method can not be complied with. The greatest secret in the successful handling of the engine from this standpoint does not lie in the amount, or manner of applying the oil, but rather the condition of bearings, and pocking boxes to receive it. Oil poured in oil holes that are stopped up, or a lubricant of any name or nature supplied to a bearing improperly keyed up produces no results.

All parts of the engine should receive a careful inspection in this regard before supplying each part with the proper amount of oil to produce the results for which the oil is intended (lessening of friction).

100. On monthly coal report, what is meant by miles run per ton of coal, and what by pounds of coal per 100 ton miles?

Ans. Miles run per ton of coal means the miles made by the engine with a train to the ton of coal. By pounds of coal per 100 ton miles is meant the pounds of coal used to haul 1 ton 100 miles, or to haul 100 tons 1 mile.

THIRD YEAR AIR BRAKE QUESTIONS.

1. Trace the air through the air brake system.

Ans. The air used in the air brake system enters the air inlets of the 8-inch, and the strainers of all other sizes, and styles of pumps, where it comes in contact with the piston, and is compressed to a greater pressure than atmospheric pressure. Being forced by the discharge valves in all styles and sizes of pumps it enters the discharge pipe, and then to the main reservoir. From the main reservoir it starts on its travels to the several parts of the air brake system. From the main reservoir the air flows to the red hand of the duplex air gauge, the pump governor, the face of the rotary in the engineer's brake valve, the face of all valves that operate main reservoir pressure, such as (bell ringer, air sanders, blow-off cock, traction increaser, headlight entinguisher, pin lifter, graphite lubricator, air flanger, ditcher, and all such appliances that are operated by main reservoir air). It also flows to the main reservoir side of the air signal, reducing valve, the straight air reducing valve, and the main reservoir side of the slide valve feed valve. Regardless of the position of the engineer's brake valve, main reservoir air always surrounds the rotary in the engineer's brake valve (unless the cut-out cock in the main reservoir pipe leading to the brake valve is closed). With the handle of the engineer's brake in full release, the air flows through the large port in the rotary, or port A, in the blind cavity B, in the rotary seat, under bridge W, of the rotary, into cavity C, of the rotary, from here it enters the direct application and supply port, leading to the brake pipe, also on the underneath side of the equalizing piston (which forms the train line exhaust valve). At the same time the brake pipe is charging, chamber D, or the cavity over the equalizing piston, and the little drum or equalizing reservoir is being charged in two ways, through the running feed port, and preliminary port, and the equalizing port from cavity C, the air also flowing to the black hand of the duplex air gauge. As the air flows through the brake pipe, angle cocks, and hose connections, it comes in contact with the crossover pipe leading to the triple valve, it forces the triple piston to release or charging position, and enters the feed groove, charging up the auxiliary reservoir to the same pressure contained in the brake pipe. With the handle of the engineer's brake valve in running position the air flows through the running feed port in the rotary and the rotary seat, past the excess pressure valve in the D8, and the feed valve attachment of all styles of brake valves, into the direct application and supply port to the brake pipe. From the brake pipe the air backs up into cavity C, of the rotary, charging chamber D, through the equalizing port from cavity C. The air takes the same course through the brake pipe in running position that it does in full release charging the auxiliary in the same manner. With the handle of the brake valve on lap, all ports are blank, and all pressures are separated by the rotary in the engineer's brake valve. With the duplex governor in freight equipment, the low pressure head is cut out of service, and the maximum pressure head takes control of the pump, stopping it at 120 pounds main reservoir pressure. (The manner in which the air flows through the governor will be taken up later). When the handle of the engineer's brake valve is placed in service position, the air in chamber D is allowed to escape to the atmosphere, through the preliminary port, in the rotary seat, the elongated groove in the rotary and its seat, to the direct application emergency exhaust to the atmosphere. The pressure being taken off the top of the equalizing piston, the brake pipe pressure raises the piston up unseating the brake pipe exhaust valve (which is in reality part of the equalizing piston).

The brake pipe pressure is allowed to discharge until the pressure in chamber D, being the greater, forces the piston to its seat. As brake pipe pressure begins to discharge, the pressure in the auxiliary reservoir forces the triple piston to set position, closing the feed groove, the exhaust port, and opening the graduating valve and port, through the medium of the triple piston and slide valve. The pressure in the auxiliary reservoir flows to the brake cylinder until such time as the pressure in the brake pipe is greater than in the auxiliary, when the triple piston moves to lap position, closing the graduating valve and port. On a further reduction from chamber D the same performance takes place, until such time as equalization takes place, when the pressures in chamber D, brake pipe, auxiliary, and brake cylinder, are all equal, or the same. When it is wished to release the brake pipe pressure must be raised higher than the pressure in the auxiliary this pressure forces the triple pistons to release or charging position, opening the feed groove in the triple piston bushing, allowing air to flow into the auxiliary, and closing the graduating valve and port, opening the triple valve exhaust port allowing the air in the brake cylinder to flow to the atmosphere. With the handle of the engineer's brake valve in emergency position, air from the brake pipe is quickly vented to the atmosphere, through the direct application, and supply port, cavity C, of the rotary, and the direct application emergency exhaust port, at the same time the pressure in chamber D is reduced through the preliminary port, and the elongated groove, in the rotary valve, to the direct application emergency exhaust port. This heavy brake pipe reduction causes a quick application of the brakes, the triple piston moves down and compresses the graduating spring, the removed corner of the slide valve allows auxiliary pressure to unseat the emergency piston, the pressure in chamber Y is quickly vented to the brake cylinder, the brake pipe pressure then unseats the brake pipe check, and brake pipe, and auxiliary pressures flow to the brake cylinder through their respective ports until equalization takes place.

The brakes are released in the same manner, restoring the amount of the reduction, plus one pound to overcome the auxiliary pressure, and the frictional resistance of the triple piston and slide valve. The air in the brake cylinder is vented to the atmosphere through the triple exhaust port.

2. **What defects in the brake valve will destroy excess in running position?**

Ans. The things that will destroy excess in running position are a leaky excess pressure valve, broken spring, valve or seat cut, with the D8 brake valve. Cut rotary valve or seat with either brake valve, leaky gasket 32, or feed valve gasket 27, or any one of several defects, in the feed valve attachment with the G6, equipment.

3. **(a) About how long should it take to reduce chamber D, pressure from 70 pounds to 50 pounds, pounds in service application? (b) If the reduction from chamber D, is too slow, what might be the trouble? (c) If too rapid?**

Ans. It should take from 5 to 6 seconds to reduce chamber D pressure 20 pounds in service application position, with all styles of brake valves.

If the reduction from chamber D is too slow it may be caused by a partially closed, or stopped up preliminary port, a leak equalization piston packing ring, a leak in gasket 32.

If the reduction is too rapid it may be caused by a chamber D leak, either at the gauge connections, the equalizing reservoir, or its pipe connections, the equalizing reservoir partly filled up with water, the restricted passage in the pipe connections to the reservoir partly stopped up, or the preliminary port in the rotary seat might be too large, either by accident or design.

4. Explain the effect of a cut rotary valve or seat.

Ans. A leaky rotary cut valve or seat is a very dangerous thing even when known, as it not only causes pressures to equalize on lap, destroys excess in running position, but the main reservoir pressure leaking into the brake pipe causes the head brakes to release. This, aside from being liable to break the train in two, takes from the engineer a considerable part of the holding power of the train brakes, unless properly handled.

5. Do you consider a leaky rotary or seat dangerous? (b) How would you do breaking with a leaky rotary? (c) How would you test for a leaky rotary in a good practical way?

Ans. A leaky rotary valve or seat is dangerous even when known, as it not only robs the engineer of the sensitiveness of the brake application, but the dangers from breaking the train in two, as well as not being able to stop (if not properly handled), are very great.

In order to do breaking (good breaking in the fullest sense of the word can not be done), with a leaky rotary. The first reduction should be sufficient to get the pistons by the leakage grooves (depending on the length of the train), the black hand should then be kept gradually falling, or the brake pipe exhaust should be kept open until the train stops, or it is safe under the existing conditions to attempt to release.

There are several different ways of testing for a leaky rotary valve, further test valve in service or seat, one of which is to make (with the pressures charged up) a reduction of 10 or 15 pounds, lap the valve, if the black hand on the air gauge crawls up and the brakes whistle off, it is a sign of a leaky rotary. Another is to close the cut-out cock in the brake pipe underneath the brake valve, lap the brake valve, if the brake pipe exhaust unseats and discharges air it is a sign of a leaky rotary. The amount of air being discharged suggests the nature of the defect. Still another (yet most too sensitive to be practical) is to drain the brake system, place the brake valve on lap, and start the pump. If air is leaking by the rotary valve bubbles will show in a pail of water with the brake pipe hose (angle cock open) placed therein.

A leak that would affect the operation of the brakes could be told by holding a lighted torch to the open brake pipe hose. Any of these methods if closely followed will satisfy the engineer as to the nature of the leak, and a report should be made out covering the defect found.

6. What defects will cause a blow at the triple valve exhaust port? (b) What will cause a triple to go to emergency position during a service reduction?

Ans. There are several defects that will cause a blow at the triple exhaust, a cut slide valve or seat, broken slide valve, slide valve held from its seat by gum or dirt, on any and all styles of triples. A leaky cut-out cock with the old style plain triple. With the quick action, a leaky B pipe or auxiliary tube, rubber seated valve, body gasket 15, or the gasket between the triple valve and the auxiliary, in freight equipment, and gasket 25, between the triple and the brake cylinder head in passenger equipment.

The things that cause a triple valve to go to emergency position during a service reduction are: A sticky or dirty triple piston and slide valve with all styles of triple valves, a weak or broken graduating spring, in a train of from 5 to 7 cars, a stuck graduating valve, or broken graduating pin, will sometimes cause a triple to set in emergency during a service reduction, depending on the tightness of the fit of the triple piston packing ring, and the amount of leakage by the emergency piston. If the packing ring be good, and the emergency piston tight, the triple will set in emergency with the graduating valve defective. Heavy brake pipe leaks during a service reduction will cause quick action. Too large a preliminary port, with a train of from one to three cars will also cause quick action, or emergency, during a service reduction. There are many other defects, of a combination nature, but they are most too complicated to be practical, so they are not mentioned here.

7. **What are the functions of the pump governor?**

Ans. The functions of the pump governor are to automatically control the air pump. The governor consists of a suitable brass body, of two compartments, one part contains the regulating portion, the other the steam valve and piston. Its operation is brought about by pressure overcoming a tension spring. The spring or regulating portion controls the amount of pressure desired, and the piston and valve cause the flow of steam to be automatically cut-off from the pump when the tension of the spring is overcome by pressure. The operation of the governor in so far as it stops, and allows the pump to resume work, is entirely automatic.

8. (a) If you detect air blowing out of the hole in the neck of the governor, what does it denote? (b) At the hole in the spring casing?

Ans. In case air is detected blowing out of the hole in the neck of the governor, it denotes that the pin valve is held from its seat, either by reason of the fact that the tension of the regulating spring has been overcome, or by reason of gum or dirt, cut valve or seat, there is a leak of air by the pin valve and out of the hole in the neck of the governor.

In case air is detected blowing out of the hole in the spring casing, it denotes that there is a leak by the diaphram, in the regulating portion of the governor. This leak would have no noticable effect (except a waste of air), so long as the hole in the spring casing is not stopped up.

9. (a) What might prevent the governor from

shutting off the steam, when the maximum pressure is obtained? (b) What would you do to fix a governor when it becomes inoperative?

Ans. In case the governor fails to shut off the supply of steam to the pump it may be caused by some of the following defects: The air pipe leading to the air chamber in the governor may be broken off, stopped up, strainer in this pipe stopped up, the restricted passage in the pipe stopped up, or too great a tension on the regulating spring, the hole in the spring casing stopped up, with a leak by the diaphram, the pin valve broken off and held to its seat, the restricted passage in the neck of the governor leading to the governor piston stopped up, no packing rings on the governor piston, the governor piston stuck open in its bushing, a leak by the steam valve stem with the drip pipe stopped up or frozen up, the steam valve held from its seat by scale, steam valve broken, or the valve or seat cut. Any of these defects will fail to allow the governor to shut off the supply of steam to the pump when the maximum pressure has been attained.

In case the governor becomes inoperative, the pressure that controls the governor should be reduced the governor cleaned, or the defect located and repaired. In case it was impossible to make the repairs, the governor should be cut out of service by placing a blind gasket in the pipe leading to it, and the other governor adjusted to the desired pressure. In case of only one governor, and it out of service, the pressure will have to be controlled by throttling the pump. The most usual causes for failures in the operation of the governor, are dirt, and by cleaning it will again be put in a working condition.

10. (a) What would you do if the governor would allow you but 30 pounds of air in spite of all you did to fix it? (b) What causes gum and dirt in the governor? (c) Should a pump be run over ash pits?

Ans. If after reducing the pressure, cleaning and repairing the governor, it would not allow the pump to get over 30 pounds of air, would cut it out of service, and throttle the pump to prevent getting too high a pressure.

Gum and dirt in the governor are caused by excessive oiling of the air end of the pump, running the pump over ash or cinder pits, using the brake valve in emergency position, with the main reservoir partly filled with water and rust.

The air pump should not be run over ash pits as the fine particles of dust are drawn into the strainer of the pump, stopping up the strainer, and after being deposited in the main reservoir, work back into the entire air brake system, clogging strainers, cutting valves and seats, so that they cannot maintain, and separate their pressures.

11. What defect of the governor will cause it to interfere with pump, thus preventing the pump from working?

Ans. Some of the defects in the governor which prevent the pump from working are a weak or broken spring, a broken pin valve, pin valve held from its seat by gum or dirt, valve or seat cut to the extent of causing a leak, the hole in the neck of the governor stopped up, with a leak by the pin valve, thus holding the governor piston closed, the piston stuck in its bushing (closed). These defects will prevent the pump from working.

12. **If short of air, how can distinguish quickly if the trouble is with the pump or the governor?**

Ans. If the air gauge shows that the system is short of air it can be ascertained whether the trouble is in the pump or the governor, by reducing the pressure that controls the governor. If the pump goes to work, and stops again at the same pressure, the trouble is in the governor. If the pump does not go to work, the trouble is then in all probabilities in the pump.

13. **If the pump should stop before the maximum pressure is attained, what should you do to get it to work again, and where look for defects?**

Ans. If the air pump should stop before the maximum pressure was attained it should first be ascertained whether the trouble was with the pump or the governor, and then be governed by whatever defect was found. Presuming that the trouble was in the pump and not in the governor, the first thing to do would be to satisfy yourself that the pump was getting a good head of steam. This can be done by opening the channel drain cocks, or disconnecting the steam pipe between the governor, and the pump. This will satisfy you as to the volume of steam the pump is getting. After finding that the pump is getting sufficient steam, and oil, should next find the location of the piston in the cylinder, so as to enable himself in locating the defect. Take off the cap nut on the bottom of the air cylinder, and insert a piece of wire or a stick to find the location of the piston. In case the piston had stopped at the bottom of the cylinder, would reason that the trouble was in some of the following things: The nuts might be off the bottom head, thus preventing the piston from completing its stroke, the button might be broke of the reversing valve rod, or the packing rings gone on the large end of the differential piston, the tappet plate on the piston might be loose or gone, in which case there would be nothing for the reversing rod to engage, consequently the reversing slide valve could not be pulled down, and no steam would be admitted back of the large end of the differential piston.

If the pump stopped with the piston on its up stroke, it would be reasonable to suppose that some of the following defects had taken place. The shoulder worn off the reversing valve rod, the tappet plate loose or gone, keeper nut loose on the small end of the differential piston, preventing the piston from completing its stroke, or the packing rings badly worn, or broken on the differential piston, loose studs on the reversing plate, preventing the piston from completing its stroke. Would be governed by whatever defect found, make what repairs possible and proceed.

14. **(a) How fast should a pump be run? (b)**

Under what conditions will a pump compress air in one direction only?

Ans. An air pump should be run from 60 to 70 single strokes, 120 to 140 double strokes, per minute. The best results being obtained at this speed as the air cylinders do not have time to fill if the pump be run faster than this, soon the pump heats and little if any air will then be pumped. The air pump should never be run any faster than necessary to maintain the required pressure.

An air pump will compress air in one direction only with any of the following defects: When the oil cup cover is gone, and the cup is open, when the piston rod packing is blowing (air end), when the gasket around the heads are leaking, when the cap nut is gone off the bottom head of the pump, or when any one of the receiving or discharge valves are leaking or broken.

15. **(a) How does water get into the air brake system? (b) What parts should be drained, and how often? (c) What damage does water do?**

Ans. The water in the air brake system gets in by way of the strainer, and a small percentage by the piston rod packing. About 95 per cent. gets in by way of the strainer, being squeezed out of the atmosphere. About 5 per cent. gets in from the steam end of the pump, coming down the piston, which works equally in both cylinders.

All parts that contain water should be drained, at least once during a round trip, or oftener in cold and freezing weather. Such parts as the main reservoir, equalizing reservoir, brake-pipe, auxiliary reservoirs, all drains and wells, and the triple valves at least once a week, in cold and freezing weather.

Water in the air brake system takes up valuable air space, causes rust to form, the rust working back into the air brake system, clogs strainers, cuts valves and seats, thus making it impossible for them to properly maintain and separate their pressures. A poor working system is the results. In winter the water freezes causing pipes to burst, and untold delays, all due to the fact that the parts containing water was not drained.

16. How much brake pipe pressure should be carried on any engine?

Ans. The standard brake pipe pressure on both freight and passenger is 70 pounds. The high speed pressures on passenger range from 90 to 110 pounds. Schedule U pressures are 70 and 90 pounds, and they are used in districts with very heavy grades, the lower pressure being used going up, and the higher pressure coming down. (Used in freight service.)

17. How is brake pipe pressure regulated with each brake valve?

Ans. With the old style (D8) brake valve, brake pipe pressure is regulated with the pump governor. With the new styles (F or G6, or ET equipments) it is regulated with the feed valve attachment, when the proper main reservoir pressure is maintained, and the handle of the engineer's brake valve is carried in running position.

18. (a) What is excess pressure, and when should you try to carry it? (b) What is excess pressure used for? (c) How much excess should you carry with each brake valve? (d) How do you regulate excess with each brake valve? (e) Why a different amount for freight than passenger?

Ans. Excess pressure is pressure carried in the main reservoir, over and above the pressure in the brake pipe. It should be carried at all times except when charging trains at terminals, releasing brakes, or descending long grades, the place for it then is back in the brake pipe.

Excess pressure is used to make certain a rapid recharge of brake pipe, and auxiliaries, a prompt release of brakes, and to operate all appliances on the engine, that are operated with main reservoir pressure (such as the bell ringer, air sanders, blow-off cock, headlight extinguisher, pin lifter, air flanger, ditcher, traction increaser, and all such devices), without interfering with the brake pipe pressure.

With the old style (D8), should carry 15 on passenger and 20 pounds on freight. With the single governor, of the (F and G6, low pressure head of the Duplex, Schedule U, and excess pressure head of the ET equipment), should carry 20 pounds. With the high pressure head, or maximum pressure head of the Duplex would carry 50 pounds. With the Duplex on the high speed 10 pounds should be carried.

With the D8 brake valve excess pressure is regulated with the excess pressure spring and plug.

Increasing the length of the spring gives a higher excess, shortening the spring, or relieving the tension decreases the amount of excess to be carried. With the F and G6 brake valves, excess is regulated with the pump governor, when the feed valve is properly adjusted.

Increasing the tension on the regulating spring, gives a higher excess. Decreasing the tension on the regulating spring, decreases the amount of excess to e carried. With the ET equipment, the low pressure, or excess pressure head is automatic in its operation, while the maximum pressure head is adjusted the same as other styles of governors. The low pressure or excess pressure head has an adjusting screw, but after the spring has a tension of 20 pounds placed on it, it should not be changed, as it by its points in construction takes care of the amount of excess in running position, regardless of the brake pipe pressure.

The reason that a larger volume of excess is carried on freight than passenger is that there is a larger volume of air to control, more auxiliaries to recharge, and more difficult brakes to release. Due to the uneven piston travel, which causes some brake cylinders to equalize very high with their auxiliaries, while others equalize quite low. The passenger brake equipment is kept in much better repair, and the trains never reach in length, any comparison to the freight train.

19. **(a) How can you distinguish between the**

different kinds of triples? (b) How should each be cut out of service?

Ans. The different kinds of triples are distinguished by their points in construction. The old style plain triple is a smaller triple in proportion to the size of others, and the cut-out cock is placed in the body of the triple. The new plain, or special driver brake triple is a large triple having larger ports and pipe connections, and the cut-out cock is placed in the cross-over pipe leading to the triple. The quick action triple is a much larger triple, and differs materially in points of construction. It has all the features of the plain, and in addition thereto the quick action feature, which is the means by which they are distinguished from other kinds of valves. This feature consists of a cast body fastened to the side of the body of the triple, and contains the emergency piston, rubber seated valve, and brake pipe check.

The type K freight triple looks much like the older style of quick action triple, but aside from the performance of its duties being different, it has a distinguishing mark on the outside of the cage known as the fin. This fin is cast on the body of the triple, near where it bolts to the auxiliary. The triple possesses all the features of the ordinary quick action, and in addition features known as retarded release, quick service, and uniform recharge.

The type L passenger triple is a much different triple, both in appearance and operation. The body of the triple has a pop valve attached, something that no other triple but the L possesses. In its operation it has all the features of the old style passenger triple and additional ones known as retarded release, quick service, uniform, or rapid recharge, providing the supplimentary reservoir is in operation, in which case it has several advantageous features (not here explained). When this reservoir is cut in service, in connection with the L triple, the schedule is known as the LN Schedule.

All other triples except the old style plain, are cut out of service by turning the cut-out cock in the pipe leading to the triple. When cut in the handle of the cut-out cock should stand at right angles to the pipe. When cut-out the handle of the cut-out cock should stand parallel with the pipe. To make certain of the triple either being cut-in or cut-out, the groove in the plug of the cut-out cock should be observed. It should stand crosswise of the pipe cut-out, and lengthwise of the pipe cut-in.

20. Where is compressed air stored, and what is each pressure used for?

Ans. The compressed air used in the air brake system is stored in the main reservoir, brake-pipe, chamber D, auxiliary reservoir, straight air piping and straight air brake valve, signal line piping, and chambers A and B in the signal valve, chamber Y, water pressure drum under Tourist and Pullman cars, and in the brake cylinder, when a brake application has been made. The pressure in the main reservoir is used to furnish air for all other parts of the air brake system.

The main reservoir being the store house as it were to the entire air brake system. Main reservoir pressure is used to charge brake pipe and auxiliaries, release the brakes, and operate all appliances on the engine that are operated with compressed air.

Brake pipe pressure is the medium through which the auxiliaries are charged, the brakes applied and released.

Chamber D pressure is the pressure that holds the equalizing piston to its seat, operates the black hand of the air gauge, and makes it possible for the engineer to make light gradual service reduction, in an application of the brakes.

Auxiliary pressure is the pressure that is vented to the brake cylinders during a brake application, and also the place from which pressure is taken to charge the water pressure drum in Pullman and Tourist cars.

Straight air pressure is the pressure that is supplied to the brake cylinders in a straight air brake application.

Signal line pressure is the medium through which signals, are transmitted from the train to the engine crew.

Chamber Y pressure is the pressure that holds the brake pipe check to its seat, and helps to operate the quick action parts of a quick action triple, in emergency applications.

Water pressure, is the pressure used to force the water into washbowls, and ·toilet necessities, in the Pullman and Tourists cars.

Brake cylinder pressure is the pressure used to develop power in the brake cylinders, forcing the piston out, and it in turn being connected with rods, levers, beams, and shoes, produce the friction between the shoe and the wheel, which brings the vehicle to a slow down, or a stop.

21. Where do the different pressures begin and end?

Ans. The pressures, in the air brake system begin and end as follows: Main reservoir pressure begins at the discharge valve of all styles of pumps, and ends at the red hand of the duplex air gauge, the pump governor, the face of all valves operating appliances operated by main reservoir pressure, the further walls of the main reservoir, and its pipe connections and the face of the rotary in the engineer's brake valve.

Brake pipe pressure begins at bridge W, in full release, and on the brake pipe side of the excess pressure valve and feed valve, in running position, and ends on the underneath side of the equalizing piston, the walls of the brake pipe, angle cocks, hose connections, brake pipe side of the triple piston, chamber Y, in the quick action triple valve, the conductors valve, in coach, or way car, the air gauge in way car, and at the first closed angle cock in the train.

Chamber D pressure begins at the preliminary, and equalizing ports, in full release, and at the equalizing ports in running position, and ends on top of the equalizing piston, the black hand of the air gauge, the further walls of the little drum, or equalizing reservoir, and its pipe connections.

Auxiliary reservoir pressure begins on the auxiliary side of the triple piston, and ends at the face of the slide valve in the triple valve, the auxiliary side of the water pressure valve in the Pullman and Tourist cars, and the further walls of the auxiliary and its pipe connections.

Straight air pressure begins on the straight air side of the straight air reducing valve, and ends in the straight air piping, and the face of the application valve, in the straight air brake valve.

Signal line pressure begins on the signal line side of the signal line reducing valve, and ends in the walls of the signal line piping, chambers A and B, in the signal valve, the signal line side of the car discharge valve, and the first closed angle cock in the signal line.

Chamber Y pressure begins on chamber Y side of the brake pipe check, and ends in the cavity between the rubber seated valve and the brake pipe check.

Waterpressure begins on the water pressure side, of the water pressure valve, and ends at the further walls of the water pressure drum, and on the water in the tank.

Brake cylinder pressure begins at the graduating valve and port, in an automatic application, and at the application valve in the straight air brake valve in a straight air application, and ends in the walls of the brake cylinder, and its pipe connections, the brake pipe side of the double check, the brake pipe check in the triple valve, the red hand of the brake cylinder gauge, the brake cylinder side of the pop valve, the straight air side of the double check, and the release valve in a straight air application. Also the brake cylinder side of the high speed reducing valve, when one is in use.

22. (a) How rapidly does an auxiliary charge? (b) When should you bear this in mind particularly?

Ans. The feed grooves in the triple valve are so proportioned that an auxiliary would charge from 0 to 70 pounds in 70 seconds a constant pressure of 70 pounds being maintained in the brake pipe. But owing to the usual condition of feed grooves and strainers, and the fact that a constant pressure of 70 pounds cannot be maintained in the brake pipe, it takes from 2 to 2 1-2 minutes to charge an auxiliary on a short train, and from 8 to 10 minutes on a long train.

The engineer should bear this in mind when charging trains at terminals, before trying the brakes, before releasing to recharge in a two application stop, and before releasing to recharge on a grade. He should bear in mind the length of time it takes to restore the amount of air he has taken out of the auxiliary, as the pressure in the auxiliaries is the pressure that sets the brake.

23. Does the black hand of the air gauge show brake pipe pressure at all times?

Ans. The black hand of the air gauge shows chamber D pressure, but the brake pipe pressure is the same, when charged up and equalized, in full release, running, and on lap positions, when equalized, at the beginning, and ending of the brake pipe exhaust, in service applications. But does not during the brake pipe exhaust, in service applications, or in emergency.

When the D8 brake valve is in emergency position, the black hand of the air gauge shows main reservoir pressure, owing to the position and construction of the rotary.

24. **Where does the air that enters the brake cylinders come from? Explain fully.**

Ans. The air that enters the brake cylinders with both plain and quick action triple valves, in service applications, comes from the auxiliary reservoir. With the type K and L, triples, the air that enters the brake cylinders, in service applications, comes from both the brake pipe and auxiliary reservoirs. This performance is what is known as the quick service, and produces a serial action in the operation of the rakes in service, that compares to the emergency, in the older style of triple valves.

With the old style plain triple in emergency, the air that enters the brake cylinders comes from but the auxiliary reservoir, while with the quick action, type H, K, and L in emergency, the air that enters the brake cylinders comes from both the brake pipe and auxiliaries. This produces a serial application throughout the train, the brakes applying much quicker and harder, due to the fact that a certain per centage of brake pipe air is vented to the brake cylinders, causing equalization to take place higher.

25. What is the duty of the triple valve?

Ans. The duty of the triple valve, as its name implies, is to (triple), perform three things, charge an auxiliary, apply and release the brakes. The valve as well as performing three things, consists of three separate, and distinct valves, embodied in one, and the triple is likewise connected to three things, the brake pipe, the auxiliary, and the brake cylinder. Hence the name of triple valve.

26. Explain the duty of the triple piston, the slide and graduating valve.

Ans. The triple piston forms the dividing line between the brake pipe and the auxiliary reservoir pressures, and is the valve that opens and closes the feed groove in the triple piston bushing. The triple piston controls the movement of the slide, and graduating valves.

The slide valve opens and closes, communication between the auxiliary reservoir and the brake cylinder and between the brake cylinder and the atmosphere, in conjunction with the movement of the triple piston. The removed corner of the slide valve, in its movement (in emergency applications), in conjunction with the triple piston, causes the emergency parts of the quick action triple to operate.

The graduating valve, in conjunction with the triple piston, and slide valve, controls the flow of air from the auxiliary reservoir to the brake cylinder, in service applications of the brake.

Air moves the triple piston. The triple piston moves the slide and graduating valves. The triple piston moves every time air is taken from, or supplied to, either side of the piston. The graduating valve moves every time the triple piston moves (providing it is properly connected to the triple piston stem), and is in no way defective. The slide valve does not move every time the triple piston moves, as it has a certain amount of lost motion, that at certain times is not affected by the movement of the piston.

This peculiar action is best understood from the study of the valve itself.

27. (a) When would you use emergency? (b) When does emergency jerk most? Going fast, or slow?

Ans. Emergency applications of the brake should only be used in cases of actual emergency. When for any reason it becomes actually necessary to so use the brakes, the engineer's valve should be placed in the emergency position, and allowed to remain there until the train stops. Do not treat every spot, stop as an emergency stop, or the location of coal sheds, and water tanks as a danger zone, as these points are the places, and times at which damage is done.

Emergency jerks most when the speed of the train is low. The friction between the shoe and the wheel is practically the same at all speeds, but at a high speed the wheel has a tendency to throw the shoe away from the wheel, while at low speeds the shoe grips the wheel harder (due to the nature of the frictional surfaces), there being not so great a tendency for the wheel to resist the action of the brake.

Therefore the cause for the wheels sliding at slow speeds.

28. In making a service application with any given pressure, what proportion of it would you reduce to get a fully applied brake? Why?

Ans. In making a service application of the brakes, a 2-7 reduction of any given pressure will produce equalization at 5-7, and this is all the power obtainable in a service application of the brakes, the auxiliary reservoir, brake cylinder, and brake pipe being equal so far as the amount of pressure is concerned. The reason for this the auxiliary reservoir is so proportioned in size (or capacity), in comparison to the size of the brake cylinder, that a 2-7 reduction of its pressure will produce equalization, or all power obtainable in a service application of the brakes.

Whenever a car has a brake cylinder too large, in comparison to the size of the auxiliary, it is spoken of as being over cylindered. Whenever the cylinder is too small for the size of its auxiliary, it is spoken of as being under cylindered. Cars so equipped obtain their brake power by excessive leverage, the amount of reduction to obtain the proper cylinder pressure for equalization not being taken into consideration. Most all cars of the present are properly cylindered up so that a 2-7 reduction of a given pressure, gives all the power obtainable in a service application of the brake.

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

Ans. In making a service application of the brakes, the first reduction should be sufficient to get all pistons by the leakage grooves. This reduction depends upon the length of the train, usually from 5 to 10 pounds being sufficient. The reason this is necessary is that when a reduction is made on a train of any considerable length, the air that is vented from the auxiliary to the brake cylinder will all be carried off by the leakage groove, unless the reduction be heavy enough to get the brake piston by this groove on the first reduction. The head brakes would apply on the first reduction, and on the second or subsequent reductions would apply that much harder, causing a run in off the slack, that would be liable to drive in draw bars, and then again is very liable to cause wheels to slide, due to the fact that a few cars are helping to stop the whole train, or the slack running out would be very liable to pull draw bars, by reason of finding the brakes set on the head end of the train. Had the first reduction been sufficient to get all brakes in operation, this would have been avoided, as the train would have remained stretched, and the holding power would have been practically the same throughout the train.

30. Why are there leakage grooves in brake cylinders? How long are these grooves?

Ans. Leakage grooves are placed in brake cylinders, to carry off any pressure (by the non-pressure head) that may be vented to the brake cylinder, owing to a sensitive triple assuming set position, during slight brake pipe leaks. Were it not for the leakage groove in the cylinder, any slight leak in the brake pipe would cause the brake to apply, and it would remain applied. But owing to the leakage groove this does not take place as the small amount of air is carried off by these grooves. These grooves are from 2 1-2 to 3 inches in length, and are placed either in the side or top, of the cylinder. They are so placed as the groove being quite small would soon fill up with dirt, if placed in the bottom of the cylinder. A stopped-up leakage groove helps to get slid flat wheels.

31. **(a) After making a full service application, how much pressure is there in the brake cylinder? (b) When, and how can you get a greater pressure than this?**

Ans. After making a full service application, there is as much pressure in the brake cylinder as there is in the auxiliary, and brake pipe, providing an over reduction has not been made. In case there has been an over reduction made the auxiliary, and brake cylinder will be the same, but the brake pipe pressure will be as much lower, as its pressure was over reduced or reduced below the point of equalization. For example, with a 70 pound pressure in brake pipe and auxiliary, standard piston travel, after a full service application has been made, there is a pressure of 50 pounds in brake pipe, auxiliary, and brake cylinder.

A greater pressure than this can be obtained by using emergency, by using a higher brake pipe and auxiliary reservoir pressure, by a shorter piston travel, or by the use of retainers on the second application.

32. What do you mean by an over-reduction? What is the result of making an over-reduction?

Ans. By making an over-reduction is meant the act of reducing the brake pipe pressure, below the point at which equalization takes place between the auxiliary, and brake cylinder.

The results of making an over-reduction are a needless waste of air, a hard and difficult brake to release, and a needless labor placed on the air pump.

The reason the brake is hard to release is that in releasing brakes, the auxiliary reservoir pressure must be overcome in order to force the triple piston and slide valve to release position. This is done through the medium of the brake pipe pressure, and if an over-reduction has been made, the amount of the over-reduction, plus the amount of pressure necessary to overcome the frictional resistance of the triple piston, and slide valve, will have to be restored to the brake pipe before the brake can be released.

33. (a) If you do not make an over-reduction, how much pressure is necessary to add to brake pipes air to release the brakes? (b) How much if an over-reduction has been made?

Ans. If an over-reduction has not been made, by raising the brake pipe pressure, 1 pound (over and above the auxiliary reservoir pressure), throughout the entire length of the train is considered sufficient to release all brakes.

One pound over and above the auxiliary pressure is considered sufficient to overcome the frictional resistance of the triple piston and slide valve, and move these parts to release and charging position.

If an over-reduction has been made it will be necessary to restore the amount of the over-reduction, plus one pound throughout the brake pipe, over and above the auxiliary pressure to release the brakes.

34. **(a) How many applications are necessary to make a stop, and what is the objection to more? (b) What is the difference between an application and a reduction?**

Ans. One application is necessary to make a stop on any, and all trains, two, or possibly three is advisable on passenger trains, to make smooth and accurate stops. The objection to more is that it is a waste of air, and a loss of braking power.

An application of the brakes is from the time the brakes are applied until they are released, and may consist of one or more reductions.

35. **When would you make more than one application on a passenger train; that is, under what circumstances? How would you handle the brake valve?**

Ans. A two application stop should be made on all passenger trains, at all times except when the stop can be made with a reduction of from 8 to 10 pounds as in suburban service, where the speed can not be gotten up between stations to over 20 miles per hour. When the speed is greater than this, or the stop could not be made with a reduction of from 8 to 10 pounds, a two application stop should be made.

In making a two application stop the brake valve should be handled as follows: The rails should be sanded the entire length of the train before shutting off to apply the brake, the train should be run into the station as close as possible (in the judgment of the engineer), the stop can be made safely. The first reduction should consist of from 15 to 18 pounds, while the speed of the train is high, if necessary a full service should be made, and when the train has reduced to from 12 to 15 miles per hour, or the train is stopping short of the intended stop, the brake valve should be placed in full release, and left there 1-2 second for each car in the train, returning the valve to lap position without recharging. Finish the stop with a light reduction, low brake cylinder pressure, and make a prompt release of brakes just before the train comes to a dead stop.

36. (a) When should the brakes be released when making a stop with a passenger train consisting of fewer than 10 cars? (b) When on passenger trains of 10 cars or more? Why? (c) When should you release on freight trains? Why?

Ans. The brakes on a passenger train consisting of less than 10 cars, should be released just before the train comes to a dead stop, in order to allow the trucks to right themselves, thus avoiding that disagreeable lurch felt if held applied until the train stops. The cause of this is that the brakes are hung to the trucks, and the car body lurches as the wheels come to a stop Or the trucks come to a stop and the car body has a tendency to continue in motion.

On a train of 10 cars or more the brakes should be held applied until the train comes to a full stop, unless the engine be equipped with the combined automatic, and straight air retainer, or the ET equipment. In case the engine is so equipped it would be possible to release the train brakes (holding the engine brakes applied), just before coming to a full stop. The object of holding the brakes applied with a train of this length, is the danger of pulling out a draw bar, if a release is attempted at slow speed. The brakes on the rear of a long passenger train could not be gotten off, without a noticable overcharge on the head end, then when the rear brakes were in release position, their auxiliaries drawing air from the head end would cause a re-application of the brakes, and consequently severe shocks.

A release of brakes on a freight train should not be attempted, until the train comes to a full stop. If the engine is equipped with the combined automatic, and straight air, or the ET equipment, a release of brakes at certain speeds can be safely affected. This subject will be treated further under the head of releasing brakes ordinarily.

37. **How would you handle the brake valve to release brakes ordinarily? What distinction would you make between long and short trains.**

Ans. The manner in which the brake valve should be handled in releasing the brakes depends on the length of the train, and the style of the equipment.

Usually one second for each car in the train is considered sufficient.

The size of the main reservoir, the amount of pressure it contains, and the length of the train must be taken into consideration in releasing brakes.

The release of brakes should be affected as follows: After a reduction of at least 10 pounds, has been made (the train brought to a slow down, or a stop), the brake valve handle should be placed in full release position, and allowed to remain in this position until the hands on the air gauge come well together, and start to settle. Just before the black hand stops stationary above 70, the handle of the brake valve should be returned to running position. After the black hand has stopped falling below 70, the handle of the brake valve should again be placed in full release position, for a few seconds, to release any brakes that may have reapplied due to the fact that the head end of the train being over-charged, and the rear auxiliaries drawing air from the head end of the train cause a re-application of the brakes on the head-end of the train. The distinction to be made between a long and a short train is that the brake valve should be left in full release longer for a long train that it should for a short train, and on trains of from 28 to 30 cars or more the first release should be followed up with a kick-off or second release.

38. On passenger trains at a high rate of speed, where should a train be steadied by brakes, on the curve or approaching it?

Ans. On a passenger train at a high rate of speed, the brakes should be applied just as the train is taking the curve and left applied until the last car of the train is well in the curve. Recording instruments placed on trains show that there is no shock or jar felt as a train is leaving the curve, but the shock comes just as the train takes the point in the track that is out of the direct line of motion. Hence the necessity of having the brakes applied at this point.

39. Why is it necessary to keep the rotary, feed and excess pressure valves clean?

Ans. It is necessary to keep these valves clean, and in good working condition, that they may properly maintain and separate their pressures. The brake application depends largely upon the proper working condition of these valves.

40. What is the purpose of the brake valve drum?

Ans. The purpose of the brake valve drum (or equalizing reservoir) is to enlarge the capacity of chamber D, without increasing the size of the engineer brake valve. This additional capacity of chamber D enables the engineer to make light, gradual, service reductions in an automatic application of the brakes.

41. If this drum should spring a leak on the road, what would you do to accomplish good braking?

Ans. In case the little drum (or equalizing reservoir) should spring a leak on the road (good braking can be done), the brake valve can be handled in service applications by making the following repairs: If possible repair the leak, if not a blind gasket should be placed in the pipe leading to the little drum, and the exhaust elbow should also be plugged. The brakes can then be applied by using the brake valve in partial emergency, during the time it is wished to operate the brakes in service, being careful not to return the brake valve to positive lap position too quickly, as there is danger of causing the head brakes to be released. This would be brought about by reason of stopping the brake pipe exhaust too suddenly, causing the flow of air to bank in the head end of the train, and consequently the brakes would release. This, aside from robbing the train of that much braking power, would be very liable to break the train in two, as well as do damage to draw-bars, and draught rigging.

42. What is the result of leaving the handle of the engineer's brake valve in full release too long, and then to running position?

Ans. With the handle of the D8 brake valve in full release for any considerable length of time, the excess pressure would be lost, then when the handle was returned to running position, the pump would resume work pumping up the excess pressure, but no pressure would be fed to the brake pipe, until such time as the full amount had been obtained, or the amount for which the tension of the excess pressure spring is set. During this time the brake pipe leaks would cause the brakes to drag. With the G and F6 valves the brake pipe would be over-charged, as well as the excess pressure destroyed.

When the brake valve was returned to running position, the feed valve would be closed off, and would so remain until such time as the leaks reduced the pressure in the brake pipe. This would cause the brakes to apply.

This increased pressure would be liable to burst hose, and cause wheels to be slid, due to too high a braking power. The fact that the brake pipe is overcharged is due to the fact that with these equipments, the brake pipe pressure is regulated by the feed valve attachment, and with the handle of the engineer's brake valve in full release, this feed valve is cut out of service, there being a direct opening between the main reservoir, and the brake pipe. The brake pipe pressure would in this case be the same as the main reservoir, and after the valve had been returned to running position, it would be necessary to wait until such time as the brake pipe pressure leaked below the tension of the regulating spring in the feed valve, before the feed valve would open and supply the leaks in the brake pipe.

43. (a) What harm is caused by leaving the 1889 engineer's valve on lap a long time, and then releasing it? Explain. (b) Would you run a pump fast with the 1889 valve when on a grade?

Ans. By leaving the handle of the 1889 brake valve on lap position a long time the pump would compress air up to boiler pressure, owing to the fact that on lap position the governor is cut out of service. Then by returning the valve to running position there would be great danger of bursting hose, or in case the brake was applied, the wheels would be liable to slide. The pump could not go to work until such time as the brake pipe pressure leaked below the tension of the governor. The leaks in the brake pipe would cause the brakes to apply.

The air pump should only be run fast enough to maintain the pressure, while descending a grade. The pump should have sufficient time to allow the cylinder to fill with air, and should not be run so slow that the pressure escapes by the packing ring as the pump is making its stroke. The best results are obtained by running the pump at a moderate speed.

44. If you find the brakes dragging, how should you release them?

Ans. If a proper reduction, and a prompt release of brakes have been made there will not be any brakes dragging, that could be released from the engine. But if found dragging, and the cause was laid to some one of things, they should be released as follows: If the brake pipe pressure was below 70 and the main reservoir contained sufficient excess pressure, the handle of the engineer's valve should be quickly moved to release position. This action would cause a brake to be released. If the brake pipe contained 70 pounds pressure, and the main reservoir sufficient excess, a reduction of at least 10 pounds should be made, followed up with a prompt release of brakes. If the brake pipe contained 70 pounds pressure and there was no excess a reduction of 10 pounds should be made, and the valve allowed to remain on lap until sufficient excess had been accumulated in the main reservoir to make a prompt release of brakes. If the brake is applied due to an over-charged brake pipe, and the conditions were such that by setting the brake to reduce the pressure there would be danger of stalling, it would then be advisable to leave the brake pipe over-charged until such time as it would be possible to make the proper applications and releases to get the pressures normal.

The conditions under which these releases should be tried depend upon the physical characteristics of the road, speed and make up of the train. If moving at a speed of less than 20 miles per hour, it is advisable to bring the train to a full stop before making the release of brakes.

45. Will a 10 pound reduction from 65 set the brake harder than 10 pounds from 50 pounds brake pipe pressure?

Ans. A 10 pound reduction from 65 pounds brake pipe pressure will not set the brake any harder than a 10 pound reduction from 50 pounds pressure will providing the existing conditions are the same. This is brought about by the fact that only 10 pounds go to the brake cylinder, and this is below the point of equalization.

46. If you had but 35 pounds of air, how much would you reduce to get full power obtainable?

Ans. With but 35 pounds of air a 2-7 reduction (or 10 pounds) should be made to get all power obtainable in a service application of the brakes. That is if the car had standard 8 inch piston travel.

47. What is the proper method of testing brakes on a train? Give trainmen's duties complete, with this answer.

Ans. The engineer should make a thorough inspection of the engine equipment before leaving the round house. He should know that the engine had the proper piston travel, that all parts of the equipment, such as rotary, feed valve, and governors were clean and in a good working condition. He should know that the pump maintains the standard pressures, and the operation of it is such that it will be capable of furnishing air for the train, during the trip. He should then proceed to the point where he is to get the train and prepare the engine to be coupled to a train. The trainmen should have been on duty at least 30 minutes before the engine arrives, and should have the train ready for its departure. This work should consist of coupling up the air hose between each car, opening up all angle cocks except the last one which should be closed. He should close all doors, let off all hand brakes (if the location of the train on its track will safely permit of it), turn down all retainers, cut-in cars found cut-out, and give the train a good inspection for any defect in the brake equipment, such as, brake beams down, shoes gone, and brake rods broken. The head man should then proceed to line up switches, and couple the engine to the train. The engineer should have had the brake valve on lap and a full pressure in the main reservoir. He should make several applications and releases just before the engine is coupled onto the train, holding the brake valve on lap, until given a signal that the air is cut-in. The brakeman backing the engine on to the train should be careful and see that all switches are properly lined up, and that all cars clear as he is backing in. After making the coupling he should blow out the hose on rear of tender, and couple the same to the hose on the head end of the train. He should then give the engineer a signal or else by word of mouth inform him that all is ready to charge the train. On receiving this signal from the brakeman the engineer should move the handle of the brake valve to full release position, and charge the train in this position. The engineer should leave the handle of the brake valve in this position until the black hand of the air gauge registers 70 pounds pressure, as the pump not only works much more freely, but the air that is being compressed is pumped direct into the brake pipe. The brakeman at the head and the one at the rear of the train should start towards each other, looking for brake pipe, and auxiliary leaks. Any leaks found should either be repaired by them or else have the car repairer do so. As soon as the train was charged the engineer would signify the fact that he was ready to try brakes by one blast of the steam whistle, and upon a signal from the trainmen to apply the brake he should make a reduction of 25 pounds noting the length and strength of the brake pipe exhaust (which would tell him approximately the number of cars in the train, whether there are any triples setting quick action, any partially closed angle cocks, or collapsed hose. The head man should be at the head end of the train, and the rear brakeman at the last car of air in the train, when the signal to try brakes is given, and as soon as the brakes are set they should walk toward each other, looking for brake cylinder and auxiliary leaks, noting the piston travel, and the fact that all brakes are applied. The brakeman should adjust all excessive piston travel, examine all cylinder leaks, see that there is a brake on each car if possible, under circumstances, to obtain it. When the condition of the brakes is ascertained, a signal to release should be given. The engineer will signify with two blasts of the steam whistle that the signal is received, and will at once make a prompt release of brakes. (This subject is explained under the head of releasing brakes). The trainmen will then retrace their steps, noticing that all brakes release, if not the cause should be ascertained, and the brake cut out if necessary. If in a section of the country where retainers are used, the brake should be reapplied and the retainers turned up, the brakes released, and the retainers turned down. If the retainer exhausts air after the handle has been turned down, it is considered to be in good condition, and can be depended upon in case it becomes necessary to use them. Retainers found defective should be carded, and the fact reported at the car repair station where set out, if not repaired at the point where found defective. As soon as the two trainmen have met and exchanged notes in regards to the condition of the brakes as found in each of their respective sections, they should report the same to the conductor, who will in turn inform the engineer as to the condition of the brakes, the number of loads and empties, the manner in which the train is made up, and the tonnage of the train. The engineer is then in a position to do good braking, make smooth and accurate stops. These instructions may vary in regards to the manner of trying brakes on some roads, but if lived up to on any road, will be found sufficient.

48. (a) Where else except at starting points should you insist on a brake test being made? (b) Of what should this test consist?

Ans. The brakes should be tested, or a brake test made at such points as follows: One thousand feet from the starting point, two miles from such places as railroad crossings, interlocking plants, drawbridges, ends of single and double track, junction points, bad curves, important stations, or at any place in the track where slow order boards are in vogue, or by train order a slow down is necessary. A two hundred feet test is also required, where trains are backed, that, or a greater distance with a tail hose. A brake test should also be made every time the train has been for any reason parted, such as taking coal or water, setting out or picking up cars, or any time a crossing has been cut, and recoupled again.

The one thousand feet test consists of applying the brake against the working of the engine, one thousand feet from the starting point. The brake should be held applied until all parties concerned, are satisfied that the air is in operation. A two mile test on passenger should consist of at least a 10 pound reduction, two miles from any of these points mentioned, and the following things noticed, the length and strength of the brake pipe exhaust (telling approximately the length of the train), and the manner in which the brakes take hold, should be noticed. On a freight train a reduction of about three pounds should be made and the length and strength of the brake pipe exhaust noticed. A two hundred feet test on a passenger train being backed up with a tail hose should consist of a sufficient reduction made with the tail hose to stop the train against the working of the engine. It should be made two hundred feet from the starting point, and if not made by the back up crew, a stop should be made and the reason why ascertained. A brake test consists of a sufficient reduction to satisfy the parties concerned that the brakes from engine to way car apply and release from the engine. When cars are picked up in route, a brake test should be made (and a terminal test made on the cars picked up) on the rest of the train.

The method for testing brakes on passenger trains are as follows: The engineer handles the brake valve in the same manner attaching his engine to the train, as on a freight train. After the engine has been coupled to a train, brake pipes and air-signaling connections have been made and the train charged, he would proceed to test brakes as follows: The brakeman would start from rear of train looking for brake pipe and auxiliary leaks, also try each car discharge valve to see that it is working properly; upon reaching head of train he should notify the engineer by word of mouth that he is ready to test brakes. The engineer will (if the train is charged) then make a 25 pound service reduction, noting the length and strength of the brake pipe exhaust, also note whether there are any partially closed angle cocks or collapsed hose, or whether any triples set quick action. The brakeman will pass along the train noting that the brakes have set, and that the brakes have the proper piston travel, and whether there are any brake cylinder leaks. On reaching the rear of the train he will signal to release brakes by pulling the signal cord in the rear coach, four separate times, so that four distinct signals may be transmitted to the engineer. The engineer will then on receiving the signal, make a prompt release of brakes. The man in charge will then inform the engineer, as to the condition of the brakes.

49. In testing brakes why not use emergency application?

Ans. When testing brakes, emergency should not be used as it is improper to do braking in this manner, only in cases of actual emergency. Emergency applications produce an unnecessary strain on the brake rigging, and aside from this the object of testing brakes is to find out the condition of the brakes as they are to be operated. The brakes are not always operated in emergency so it is advisable to find the condition of them in the manner in which they are to be operated the percentage of the time. If the brakes be applied in emergency the blow of the brake pipe exhaust is lost, it can not be told as to whether there are any triples setting quick action during a service reduction, the length of the train can not be told as the exhaust is lost in emergency applications. Neither can it be told, if there are any partially closed angle cocks, or collapsed hose, and then again some brakes would set in emergency that would not set in service, and this of course would rob the engineer of imaginary brake power if the brake be applied in service after being tried in emergency.

50. Why make a full reduction and not 5 or 6 pounds?

Ans. It is advisable to make a full reduction rather than a 5 or 6 pound one on the account of the fact that in some lengths of trains this would not be sufficient to get all pistons by the leakage grooves on a long train, and some triples might set with a full reduction that would not set with 5 or 6 pounds and could not tell whether there were any defective triples in the train.

51. If one triple goes to emergency will the others follow? Explain.

Ans. When one triple sets quick action the others will follow providing there are not too many piped cars, or too many plain triples together in the train. The reason that other triples follow in quick action is that the defective triple setting quick action makes a local reduction which reduction robs the brake pipe and causes other triples to set in emergency.

52. In making test with train standing can you detect if any brake in train sets quick action? Explain.

Ans. Yes as when a triple sets quick action it can be told by the sudden stoppage of the brake pipe exhaust. This stoppage is caused by the air in brake pipe rushing to the brake cylinders on the cars that have set in emergency.

53. How would you proceed to ascertain which car it was?

Ans. If a triple sets quick it can be ascertained as to the defective triple by a sectional test, which should be done as follows: Take 20 cars, release the brakes and charge up, then make sufficient reduction to get the pistons by the leakage grooves, usually 5 or 6 pounds, then have the brakeman find the car that has not set. When he has done so he would signal the engineer to make a further reduction.

If the triple responds to the second reduction, and the piston on the car moves out with a jump, it is reasonable to think this the defective car. The triple should be cut out, and the auxiliary bleed cock opened and left in this manner. The car should then be carded, and another sectional test made to ascertain if there be another defective triple in this particular section. Failing to find any, the brakes should be released and the train charged. When charged a brake test should be made, to satisfy that all cars were cut in and that the train contained no more defective triples.

54. Why is it necessary, in making a thorough test, to hold brakes applied for a minute or longer?

Ans. The brakes should be held applied for a minute or longer, so as to give the brakeman a chance to look the train over, and a brake that would not remain applied for a minute would be considered a very poor brake. The car should be carded but the brake should not be cut out.

55. In switching with an air braked train, and picking up uncharged cars, how would you handle the engineer's brake valve?

Ans. When switching is being done with an air braked train the train brakes should be applied in the service application position, and great care used to prevent doing damage to draw-bars and draught rigging. Each brake application should be made to go as far as possible, and as little air used as possible, bearing in mind that the pressure in the auxiliary is the pressure that sets the brake, the length of time necessary to recharge being taken into consideration. When picking up uncharged cars, a service reduction should be made so as not to hit the cars too hard. When the coupling has been made the brakes should be released and the engineer's brake valve placed on lap position. When the brakeman has coupled up the hose, a reduction of about ten pounds should be made, as soon as the signal has been given to release, the engineer should place the brake valve in full release, and he is then able to charge the uncharged section as he is pulling out to couple on to the rest of his train. When backing on to the rear section of the train he should make sufficient reduction to prevent coupling too hard. After coupling he should release and then make a reduction of 10 or 12 pounds to prevent quick action, when cut in to the rest of his train.

As soon as the cars have all been cut in and charged up a brake test should be made on the train and a terminal test on the cars picked up made before leaving the town, this brake test to consist of knowing, after a sufficient reduction had been made that the head and rear brakes apply and release from the engine.

56. Why should the brakes be released before uncoupling from a train?

Ans. The brakes should be released before uncoupling from a train for the following reasons: So as to enable the train to be readily switched, to enable the car inspector to examine the wheels, to prevent the brake shoes from freezing to the wheels in winter weather, or possible triples might freeze in set position giving trouble when it is wished to release the brake. If the air is set and the hand brake be set on top of the air as when setting a car out on a siding, there is danger of the air leaking off and the strain placed on the chain would be very liable to break it. The car would then be left without a brake and a serious wreck might result by reason of the car running away.

When a car is set on a siding it is better practice to set the hand brake. In case the car had no hand brake, and there was any danger of the car moving it would be advisable to block the wheels and notify the train dispatcher, if no agent be present.

57. With the same piston travel will empty and loaded cars hold alike?

Ans. With the same piston travel, empty and loaded cars have the same braking power (that is if the brake beams be hung to the truck body) and will hold alike, but will not stop alike as the load has the momentum of its load to be overcome by the brake. If the brake beams be hung to the car body they will not hold alike as the load causes the shoes to hang much lower on the wheel, hence a longer piston travel, which gives a weaker braking power, in comparison to the empty.

58. What has the piston travel to do with the breaking power? Explain fully.

Ans. The piston travel has much to do with the power developed in the brake cylinder, the pressure, rods, and levers, with a permissible piston travel for the car govern the brake force. The shorter the piston travel, the higher the auxiliary and brake cylinder equalize, the greater the auxiliary is over the brake cylinder, and the lesser the amount of the reduction to produce equalization. The longer the piston travel, the lower the auxiliary and brake cylinder equalize, the lesser the amount the auxiliary is over the brake cylinder, and the greater the reduction necessary to produce equalization. Short travel holds the best and long travel holds the least. Unequal piston travel causes an unequal distribution of braking power, causes bad jerks and jars in a train, due to the action of the slack, and the brake when applied in full, is hard to release owing to the difference in brake piston travel which caused some cars to equalize high, and others low.

59. Can you tell approximately by a 5 or 6 pound reduction how many air brake cars are coupled up?

Ans. By a 5 or 6 pound reduction you can tell approximately the length of brake pipe but can not tell the number of cars cut in and working.

60. Approaching what points would you make the two mile test? Of what should this test consist?

Ans. The two mile test should be made at the following places: At railroad crossings, draw-bridges, interlocking plants, junction points, meeting points, end of double track, coal chutes, water tanks and dangerous places and important stops. This test on passenger trains should consist of a 10 pound brake pipe reduction, feel the brakes hold and note the brake pipe exhaust. On freight trains it should consist of from 3 to 4 pound reduction, sufficient to get the brake pipe blow.

61. In descending a grade, how can you best keep a train under control?

Ans. You should approach the grade with the train under control, with the brake pipe and auxiliaries high, and the speed of the train low, would make each application go as far as possible, bearing in mind the length of time it takes to recharge an auxiliary, and taking advantage of letups and curves to release and recharge. When releasing the brakes, the engineer's valve should be placed in full release and left in this position until fully charged, or it is wished to use the brakes. Would upon reaching the foot of the grade, make sufficient applications and releases to get brake pipe and auxiliaries down to their proper pressures, and have all brakes released.

62. How would you ordinarily apply and release the brakes on a part air brake train (freight train)?

Ans. The manner in which the brakes should be applied and released on a part air brake train is as follows: The engine should be shut off in good time, and the slack allowed to bunch against the engine, then a sufficient reduction should be made to get the pistons by the leakage grooves (this depends on the length of the train) and allow the slack to further bunch. The stop should then be completed by making whatever reduction necessary, care being used to prevent making an over-reduction, the brakes being released just as the drivers stop turning. This should be done so as to prevent doing damage to the equipment in case the slack would run out and find the brakes applied on the air part of the train.

63. When brakes go on suddenly without the action of the engineer, what is the cause, and what would you do?

Ans. When the brakes go on suddenly without the action of the engineer, it may be caused by some of the following causes. Train parted, burst hose, or the conductor's valve held open, or possibly the rear angle cock opened. The engineer should at once shut off the engine and lap the valve, whistle broken in two until answered by the trainmen.

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

Ans. In case the train was found to be broken in two, and after the brakeman had closed the angle cocks, the engineer should place his brake valve in full release, making a prompt release of brakes, on the section of the train to which the engine was coupled. On a signal from the brakeman the engineer would back on to the rear section of the train being careful not to do damage by coupling too hard as the brakes would be rigidly set on the rear section and if struck hard damage would result. As soon as the brakeman had made the coupling the engineer should make at least a 10 pound reduction to block quick action, and as soon as he had been cut in he should make a prompt release of brakes. He is then ready to proceed.

65. If after coupling up, you could not release all brakes at once, how would you handle the brake valve to do so most quickly?

Ans. If after coupling up the brakes could not be released, the engineer should place the brake valve in full release, and allow the pump to pump the brake pipe pressure up to about 60 or 65 pounds, he would then place the brake valve on lap position, and after sufficient excess had been stored in the main reservoir, a prompt release of brakes could be made. With a train of from 28 to 30 cars or more a second release, or kick off should be made, in order to release head brakes that have reapplied due to the over-charged condition of the head end of the train. After all brakes had been released a brake test should be insisted on before leaving this point.

66. How would you handle engineer's valve when backing up a train, where a "tail hose" is being used at rear end of train?

Ans. When a train is being backed up with a tail hose in use, the engineer's valve should be handled as follows: The engineer should carry the brake valve in running position at all times, except on a signal from the rear of the train to apply brakes. After the train had been brought to a stop by a reduction made with the tail hose, the engineer should place his brake valve in full release, to release all brakes before backing up. Some brakes might not feed off and this would be a precaution against any slid flat wheels.

67. When two or more engines are coupled together, which engine should do the braking?

Ans. When two or more engines are coupled together the leading, or head engine, should do the braking. This is not only required by law, but the leading engineer has a much better view of the track, and can use better judgment in making stops. There should never be any deviation from this set rule, as in cases of this kind, there is always the greatest possibility for something to happen, and then the engineer finds he can offer no plausible, or acceptable excuse.

68. What would you do on the other engine?

Ans. The man on the second, or following engines, should place the brake valve in running position, close the cut-out cock in the brake pipe underneath the brake valve, on such equipments as the D8, G or F6, or ET6. On the number 5 ET he should carry the brake valve on lap position, with the cut-out cock in the brake pipe closed. With the old style D8 there being no cut-out cock in the brake pipe, it was necessary to carry the valve on lap position. With the ET number 5 the brake valve should be carried on lap position, the cut-out cock under the brake valve being closed.

69. What is the proper piston travel on cars? On tenders? On cam driver brakes? On American driver brakes?

Ans. The proper piston travel on cars is from 6 to 8 inches, on tenders it is from 6 to 9 inches, on cam driver brakes it is from 2 to 4 inches, on engine trucks it is from 6 to 9 inches, and on American driver brakes it is from 4 to 6 inches.

70. How is the slack taken up in each case? And how can you keep shoes from rubbing continuously on cam driver brakes?

Ans. The slack is taken up on cars by dead levers, turn buckles, and automatic slack adjusters; on cam driver brakes by cam screws, and lock nuts; on engine trucks by turn buckles, and dead levers;

on American driver brakes by fulcrum screw, and lock nut.

The shoes on a cam brake are kept from rubbing against the wheel by springs, or a rod that acts as a spring to prevent the shoe from rubbing against the wheel.

71. **Does a poor driver and tender brake have any tendency to increase the flat wheel record on cars? How?**

Ans. A poor driver brake has a tendency to increase the flat wheel record on cars by reason of the fact that a heavier reduction must be made on the cars in order to stop the train, the cars having to help stop the engine, instead of the engine helping to stop the cars. By reason of this heavy reduction the wheels are liable to pick up and slide. Heavy brake power, unequally distributed such as no driver brake, brings about a condition known as the wheel being knocked off its feet. By this is meant that a good brake with a heavy reduction made on the same, in trying to stop cars behind it with poor brakes is forced to slide due to the resistance of the brake in comparison to the amount it is trying to stop.

72. **Why is it important to have driver brakes in good order?**

Ans. It is important to have a good driver brake as it is the best brake in the train, the most expensive brake, the hardest brake to keep up, a good tire dresser, slack buncher, prevents the engine from breaking away from the train, or tender, and helps to reduce the slid flat wheel record on cars.

73. **How do you test for leaks in the air brake equipment, especially driver, and tender brakes?**

Ans. The leaks in the air brake equipment, especially driver and tender brake can be found in the following manner: With full pressures, a reduction of 15 or 20 pounds should be made, lap the brake valve and shut off the pump. Then note the air gauge. If the red hand falls, there is a main reservoir leak, the black hand remaining stationary. If the black hand as well as the red hand falls slowly, it is a brake pipe, and main reservoir leak. If the black hand crawls up quickly, and the brake releases slowly it is a leaky gasket 32. If the black hand crawls up quickly and the brake whistles off, it is a leaky rotary valve. The pump should then be started, and if the black hand falls and the brake does not release it is a brake pipe leak. If the black hand falls and the brake releases it is an auxiliary leak. If the black hand remains stationary and the brake leaks off it is a brake cylinder leak.

74. **What bad results follow if engine is reversed when making a stop with air brakes applied?**

Ans. The bad results that would follow in case the engine was reversed with the air brakes applied are that the pistons in the cylinders form air compressors, and they act as a brake, retarding to a certain extent the motion of the engine. The brakes being applied even though not holding as they should with the additional power of the engine reversed, would certainly cause the wheels to lock and slide.

75. **(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?**

Ans. If when making a stop with a heavy freight train, the drivers should pick up and slide (a drawbar should be sacrificed for a pair of tires), would consider it advisable to release. If it were absolutely impossible to release as, when nearing a draw bridge, or interlocking plant, the reverse lever should be placed in full gear and the engine throttle opened wide. This will usually start the wheels turning, but in case it would not and it were possible to reach the bleed cock on the auxiliary reservoir, from the cab window, or the steps, would either open it or knock it off. This would release the driver brake but probably not soon enough to prevent flattening the tires.

If the engine was equipped with the combined automatic and straight air, the driver brake bleed cock should be opened, and the brake will then release. As soon as this had been accomplished, the brake could be reapplied by the use of the straight air brake, applying the brake gradually, until the desired pressure had been obtained.

If the engine was equipped with the ET equipment, the handle of the independent brake valve should be moved to full release position (which position is the same to this equipment as a driver brake bleed cock is to the other equipment), this will quickly release the brakes. They may then be reapplied the same as with the combined automatic and straight air, using the independent brake valve.

76. When do wheels generally slide, at a high or a low speed? Why?

Ans. The wheels generally slide at slow speed as the friction between the shoe and the wheel is greater than the adhesion between the wheel and the rail. At high speeds the wheel has a tendency to throw the shoe from the wheel, while at slow speed the shoe grips the wheel, hence the reason for the wheel sliding. By some it is argued that there is less friction at high speeds than at low but the majority consider that the friction remains the same in either case, but the holding power of the brake is accounted for by the action of the wheel in relation to its shoe.

77. Which is most liable to slide, a freight or a passenger car? Why?

Ans. The passenger car is most liable to slide as it is broke to a higher per cent of its light weight, hence as long as it has a greater brake force it will of course be more liable to slide than the freight car. Passenger cars are broke to 90 per cent. of their weight, while the freight car is generally broke to about 70 per cent. of its light weight.

78. How would you make a stop in slippery

weather, with a passenger train? What kind of a rail is most slippery?

Ans. In making a stop with a passenger train on a slippery rail would use at least two and possibly three applications. Would first sand the rail the entire length of the train, and then make a heavy service reduction of from 15 to 18 pounds while the speed of the train was high, would bring the train down to about 15 miles per hour, then release, if time and space permitted would recharge, and if not would place the brake valve on lap, would finish the stop with light application, having the brakes released going over muddy road crossings, or just before the drivers stop turning. A light sprinkled, or a frosty, rail is the most slippery. A rail in this condition is the same as though the rail had been greased.

79. **If it is impossible to depend on sand as with a side wind, or sand pipes stopped up, how would you do breaking?**

Ans. If it were impossible to depend on sand as with a side wind, or the pipes stopped up the breaking should be done as follows: The engineer should shut the engine off sooner than usual, and do his braking heavier in the start, slowing the train down to a speed of from 15 to 18 miles per hour, then releasing and making the second application in much the same manner, as all two application stops should be made. In case time and space will permit it is always advisable to recharge. This should be done as an extra precaution in case danger should arise. The engineer would then have the full pressures, and an emergency application would be possible, in case emergency arise.

80. What can be learned by noticing the discharge from the brake pipe exhaust?

Ans. The brake pipe exhaust tells approximately the length of the train, that is it tells the number of air cars cut-in. It also tells whether there are any partially closed angle cocks, or collapsed hose in the train or whether any triples set quick action during a service reduction.

81. Are the brake pipe and auxiliary pressures always the same?

Ans. The brake pipe and auxiliaries are not always the same, but are the same when fully charged, when the brake valve is on lap, and the pressures are equalized. They are not the same when charging, applying, or releasing the brake in an over reduction, emergency application, or when bleeding an auxiliary.

82. What is the pressure retaining valve, and what is its use? To what is it connected?

Ans. The pressure retaining valve is a weighted valve, generally placed on the end of the car so as to be convenient for trainmen to operate. Its use is to maintain from 15 to 50 pounds in the brake cylinders while a release, and recharge of brake pipe and auxiliaries is being made. The retainer is connected to the triple exhaust port, and even though the triple valve be in release position this valve prevents all the brake cylinder pressure from passing out to the atmosphere. The amount being vented to the atmosphere being the difference between the pressure developed in the brake cylinder, and the weight of the valve in the retainer. This acts as a safe guard when releasing brakes and makes it possible to release on grades, where it would otherwise be impossible (and keep the train in control) were it not for the holding feature of the retainers.

83. If the air signal blows every time the brakes are released, what is wrong? Explain.

Ans. If the signal whistle blows every time the brakes are released, it is an indication that the signal line is over-charged. The signal line being charged to main reservoir pressure, due either to too great a tension on the signal line reducing valve, or some defect in the valve which has brought about this over charged condition. The reason the whistle blows is that the signal line being charged to main reservoir pressure responds to the reduction in its pressure (it being the same as main reservoir) when the brake is released.

84. What defect will cause the air signal whistle to give two or more blasts each time the cord is pulled properly?

Ans. The defects that will cause the air signal whistle to give two or more blasts each time the cord is pulled properly are: A badly worn stem, this stem being worn so loose in its bushing that the differential in pressures in chambers A and B cause it to dance when a reduction is made. Hence the whistle gives two or more blasts. The rubber diaphram being too stiff, or all the elasticity gone due to the fact that the whistle valve has been exposed to heat, will cause two or more blasts of the whistle each time the cord is pulled properly. The diaphram being stiff causes a rebound, and the valve opens two or more times, when only once was intended.

85. If the air signal pipe does not charge what might be the cause? If its does charge but does not respond when proper reduction is made, where would you look for the trouble?

Ans. If the air signal pipe does not charge, it may be due to the fact that the cut-out cock in the pipe, in the signal reducing valve is closed, or the restricted passage in the signal reducing valve stopped up, the regulating spring in the signal reducing valve broken, or the reducing valve frozen up.

If the signal line is charged and the whistle does not respond to the reduction, it may be due to the following causes: The strainer in the T pipe connection of the car discharge valve is partly stopped up (the reduction is made in the car, but is not felt in the signal valve), the signal valve not being charged, due to the fact that the passage in the signal valve being stopped up, the diaphram cracked or baggy, the port in the pipe connection signal valve, leading to the whistle stopped up, a crack, or split in the pipe, or a blind gasket placed in the pipe, the bowl of the whistle filled with dirt, the whistle improperly adjusted, or wind from an open cab window blowing across the whistle will prevent the whistle from blowing.

86. Name three complete parts that are added to the ordinary brake to make the latter a high speed brake. How would you change from low to high pressure, or from high to low?

Ans. The three complete parts that are added to the ordinary brake to make the latter a high speed brake are, the duplex feed valve attachment, the duplex governor, and its pipe connections, and the high speed reducing valve.

To change from low to high pressure it is necessary to turn the cut-out cock in the low pressure governor, cutting in the high pressure, or maximum pressure head, and turn the handle of the cut-out cock in the duplex feed valve towards the high pressure side cutting in the high pressure feed valve.

To change from high to low it is necessary to turn the cut-out cock in the feed valve, cutting out the high, and cutting in the low pressure feed valve also turning the cut-out cock in the pipe connection leading to the governors, cutting out the high, and cutting in the low.

87. With full high speed pressure, at what amount will the auxiliary and brake cylinder equalize when using emergency? Explain how the high speed reducing valve works. Should the emergency be used with the high speed brake at a speed of less than 40 miles per hour?

Ans. With full high speed pressures (110 pounds brake pipe) the auxiliary and brake cylinder will equalize at 88 pounds (with 8 inch piston travel).

The high speed reducing valve is composed of a slide valve, piston and a regulating spring, in a suitable cast body. The slide valve is connected to the piston, and the piston rests on the regulating spring. The slide valve has a triangular port, that registers with an oblong port in the face of the slide valve seat. The piston is exposed to brake cylinder pressure by suitable pipe connections from the triple valve. The normal position of the slide valve is closed. Any air that is vented to the brake cylinder is free to pass on top of the piston and around the slide valve. The tension of the regulating spring is 60 pounds on cars, and 50 pounds on the engine. When the brakes are applied in a service application the brake cylinder pressure forces the piston down, taking with it the slide valve and setting up connection with the atmosphere.

The tension of the spring allows the base of the triangular port to register with the oblong port in the face of the slide valve seat, and the excess pressure (or pressure over the tension of the regulating spring) is allowed to escape to the atmosphere. When the pressure is reduced below the tension of the spring, the piston is forced up bringing with it the slide valve, and the oblong port is blanked. The remaining pressure in the cylinder is retained until the brakes are released.

When the brakes are applied in emergency, the brake cylinder pressure forces the piston in the reducing valve the full length of its travel, taking with it the slide valve. The apex of the triangular port now registers with the oblong port, and the brake cylinder pressure is reduced slow, until such time as the spring being the stronger forces the piston up, taking with it the slide valve, and as it moves up the triangular port increases the opening venting the brake cylinder pressure quickly, as the speed of the train reduces.

Emergency should not be used with the high speed brake, at a speed of less than 40 miles per hour, as there would be danger of the wheels locking and sliding, owing to the fact that the reducing valve could not reduce the pressure sufficiently fast to prevent it, with the high cylinder pressure.

88. With full high speed brake pressure, how many full service applications can be made without recharging auxiliaries, and have left as much pressure as is used with the ordinary quick action brake?

Ans. There could be two full service applications of 20 pounds each made, and still have left as much pressure as though none were made with the ordinary brake. Three could be made with the high speed pressures, and have left as much as though one had been made (20 pounds reduction) with the ordinary brake.

This is a great advantage as more applications can be made without recharging brake pipe and auxiliaries.

89. What parts are necessary to add to the engine

and tender automatic brake to make it the combined automatic, and straight air brake?

Ans. The parts necessary to add to the engine and tender automatic brake, to make the combined automatic and straight air brake are a straight air reduction valve, straight air brake valve, two double check valves, two safety valves, two grade bleed cocks, straight air gauge, necessary piping and hose connections.

90. For what purpose is this class of equipment designed?

Ans. This class of equipment is specially designed for heavy freight, and switch service, but is also of great advantage in heavy passenger service.

91. What are the positions of the straight air brake valve, and what does each position do to the pressure?

Ans. The positions of the straight air brake valve are full release or running, lap or holding, and application position.

Release position closes communication between the application chamber, and the brake cylinder, and opens communication between the brake cylinder, and the atmosphere.

Lap position closes communication between the application chamber and the brake cylinder, and between the brake cylinder and the atmosphere, by allowing both the application and release valves to be closed, or seated.

Application position establishes communication between the application chamber and the brake cylinder, by opening the application valve, and closes communication between the brake cylinder and the atmosphere, by seating the release valve.

92. What is the duty of the double check?

Ans. The duty of the double check valve is to form the dividing line, while using either the automatic, or the straight air brake valves. When using the automatic, it closes communication between the brake cylinder, and the straight air exhaust. When using the straight air it closes communication between the brake cylinder and the triple valve exhaust port,

93. What is the duty of the safety valve?

Ans. The duty of the safety valve is to relieve the cylinders of any and all pressure, over and above the tension of its regulating spring. It is supposed to operate at 53 pounds, or above, and is a precaution against developing too great a brake cylinder pressure, in case for any reason the reducing valve might become inoperative, or the tension on its regulating spring be too great.

94. What is the purpose of the grade bleed cock?

Ans. The purpose of the grade bleed cock is to make it possible to release either the driver, or tender brake, or both without interfering with the train brakes, in case for any reason it became necessary, such as wheels sliding, and etc. By opening the grade bleed cocks, it makes it possible to alternate, in the use of engine and train brakes, in grade service. The bleed cock being left open on engine and tender while an automatic application of the brakes is being made. When it is wished to release and recharge, the straight air can be applied, on the engine, while the automatic is recharging. In this manner the danger of run aways are lessened as well as preventing doing damage to tires, by over-heating.

95. While using either the automatic or the straight air brake, in what position should the other brake valve be placed? Why?

Ans. When using the straight air brake, the automatic should be carried in running position, so as to maintain excess pressure, for if left in other position, and there was a leak in the brake pipe, the triple would assume set position, and pressure would be vented to the brake cylinders. The pipe between the automatic, and the double check, being small, the pressure would equalize high, and overcome the double check. Then when it was wished to release the brake, it would be impossible as the only air that would be released would be the air between the double check and the straight air brake valve. It would then be necessary to make a further reduction and a release with the automatic, in order to get the brake released. If the handle of the automatic was left in full release position, excess pressure would be destroyed and an application with the straight air would be reducing pressure in the main reservoir, the brake pipe being the same under these conditions, would also cause an automatic application, and the same trouble would be experienced in releasing the brake as has been previously explained.

If the handle of the straight air brake valve be placed on lap, and an application made with the automatic (with a leak by the double check) pressure would bank between the double check and the straight air brake valve, and the same trouble would be experienced in releasing the brakes. When using the automatic, the straight air brake valve would be carried in release position.

96. When should hand brakes be used on the rear end of a train?

Ans. Hand brakes should be used on the rear of a train when called for, or when backing in or out of a siding, when it is wished to keep train standing, when taking the slack, and when cars are set out on a siding, the hand brake should be used. Hand brakes may be used behind air cars, to help stop the train, in case the train is so made up.

97. How many air brake cars should be operated by one engine?

Ans. All air brake cars in the train should be coupled up and in operation, at all times it is necessary to have 100 per cent. air, this also meaning that all cars in the train from the engine to the way car must be air, and all cars so coupled up must have their brakes in operation. One hundred per cent. air, and 100 per cent. operative brakes, is the present Inter-State Commerce Law.

98. (a) Do you consider a good light on the air

gauge as important as on steam gauge? How often and at what places do you look at the air gauge? (b) What position of the engineer's brake valve practically tests the air gauge?

Ans. It is more important to have a good light on the air gauge, than it is on the steam gauge, as the amount of steam pressure can be told by the working of the engine, and the amount of air can only be told by either seeing the pressure registered on the gauge, or by its performance when in use. The engineer should look at the air gauge when making all tests, or releases of brakes, whenever a reduction in pressure is to be made for any cause, and each and every time he sounds the whistle, for road crossings, or at any time he looks at the steam gauge. The fireman should also make it a practice to observe the pressure on the air gauge as well as on the steam gauge. Many wrecks might have been prevented had this practice been lived up too.

When the engineer's brake valve is in full release position, the correctness of the air gauge may be observed, as in this position all pressures should be equal, and both hands should come well together. If they do not stand over 2 or 3 pounds the gauge may be considered correct, but if any farther the gauge should be reported.

99. How often and how many times should you report work?

Ans. Work should be reported until done.

AIR BRAKE

QUESTIONS AND ANSWERS

AIR BRAKE.

QUESTIONS AND ANSWERS.

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1. **What is a brake?**

Answer. A brake is a mechanical device, or mechanism for retarding or bringing to a stop, the rotation of the wheels on a vehicle.

2. **What is a power brake?**

Ans. A power brake is one whose operative energy is supplied by some form of mechanical power, such as compressed air, hydraulic pressure, spring, chain, vacuum, or friction. A hand brake operated by manual labor, consisting of a lever, or wheel, suitable rods, beams, levers, and shoes, is not considered a power brake.

3. **What is meant by a continuous brake?**

Ans. A continuous brake in one which works jointly, or in conjunction with all vehicles in the train. Hand brakes are individual brakes, and can not be considered power brakes.

4. **What is an air brake?**

Ans. An air brake is one whose operative energy is compressed air.

5. **What was the first form of an air brake?**

Ans. The first form of an air brake was what was known as the straight air brake. This form of air brake was invented by Mr. George Westinghouse, Jr., in the year 1869.

6. Why was it that the straight air brake was not satisfactory?

Ans. The straight air brake was not a success for several different reasons; some of which were, if for any reason a leak took place in the brake pipe, on the tender, or any car in the train, the operation of the brakes was destroyed as the pressure from the main reservoir (when the brakes were being applied), in stead of going to the brake cylinders was allowed to escape to the atmosphere through the leak. The brakes could only be applied from the engine, as all the pressure used in the brake cylinders, was stored on the engine.

Another draw back to the successful operation of this form of brake was, on a long train the brake application was too slow, owing to the fact that the air from the engine had to travel the entire length of the train in each application, the release was equally as slow as all the air in the brake cylinders, had to pass back through the entire length of the train and out the engineer's brake valve. Another damaging feature was due to the fact that the first car getting its air from the engine first, had tendency to stop first, consequently the shocks from slack running in were very great, and often damage was done.

8. What form of air brake followed, the invention of the straight air brake?

Ans. A brake invented by Mr. George Westinghouse, in the year 1873, and known as the automatic brake, followed the straight air brake.

9. In what way was this brake an improvement over the other from of air brake?

Ans. This form of air brake was an improvement over the older style in several different ways; the action of the brake in one sense of the word was entirely automatic. Each car being supplied with its own storage of air to supply its own brake cylinder, the application was much quicker. The brakes could be applied from the rear of the train as well as from the head end of the train, by reason of the fact that a reduction in brake pipe pressure caused them to apply, automatically, regardless of where this reduction was made. The brakes applying when a train parted, called the attention to the train crew that the train was broken in two. The fact that each car carried its own pressure made it possible for a high brake cylinder pressure on each car regardless of the length of the train.

10. What were the objectionable features of the plain automatic brake, if any existed?

Ans. The most objectionable feature of this form of brake was, while satisfactory on a freight train, at a moderate speed, it was not entirely satisfactory on a high speed passenger train, as when an emergency application was desired, with a train of any considerable length, the brake application aside from being too, slow, produced severe shocks, to the rear of the train, on account of the head brakes applying much sooner than those on the rear. The stop was therefore longer with a long train than with a short one.

11. **By whom was the quick action brake invented?**

Ans. The quick action brake was invented in the year 1887, by the data furnished by a series of tests made on the C. B. & Q. R. R. by the Master Car Builders.

This test demonstrated that on a freight train of 50 cars or more the plain automatic brake set the brake on the head cars first, with its consequent damage to the equipment.

12. **Did this form of brake give the desired results in both service and emergency stops?**

Ans. The brake application was as desired in both service and emergency stops after its improvement.

13. **What was it that made this form of brake more serviceable?**

Ans. The introduction of the quick action triple valve.

14. **Of what does this form of triple valve consist?**

Ans. This from of triple valve consists of two separate and distinct parts, one operating in service and both in emergency. The service features consist of the same operative parts that the plain triple possess. The additional features, or emergency features consist of a suitable body casting, in which are found the emergency piston, rubber seated valve, and brake pipe check.

15. What were the operative parts of the old straight air brake?

Ans. The operative parts consisted of an air pump or compressor, a main reservoir, and an engineer's brake valve, suitable pipe connections, to convey the air from the engine to the brake cylinders on the cars, an air gauge which registered the amount of pressure being carried. On the car the parts consisted of a cylinder, in which the energy of the compressed air was allowed to perform a work, levers, rod, brake beams and shoes.

16. In what manner were the brakes applied with this from of an air brake?

Ans. The brakes were applied by means of a valve known as the engineer's valve, or three way cock, so called from the fact that the valve had three positions. When it was desired to set the brake, the engineer turned the three way cock so as to allow the stored air in the main reservoir to be emptied into the brake pipe, and it in turn carried the air to the brake cylinders. The amount of air in the brake cylinders was governed by the opening, and length of time the valve was allowed to remain in service position.

17. How were the brakes released, when it was so desired?

Ans. The brakes were released by the engineer's brake valve, in the following manner; the three way cock was placed in release position, and the admission of air was cut off and at the same time, an opening made from the brake pipe to the atmosphere was made through the engineer's brake valve.

18. In the evolution of the air brake how many different kinds of equipments, were there?

Ans. The first equipment was known as straight air, then came plain automatic, then the quick action, automatic, then the high speed, schedule Y E T equipment, and the latest known as P C equipment for passenger trains. During this time there has been many changes in parts, but the operation is on the same standard it was when invented. The feature that made the brake automatic (the triple valve) has undergone a remarkable change since its introduction. At present we have triple valves that are in themselves miniature brake valves, they in seral operation vent air to the brake cylinder, much the same as the brake valve vents it to the atmosphere. It now is possible to realize practically the same braking power on the rear car as on the head one, and it is and can be got in practically the same length of time.

19. What were the essential features in the quick action brake?

Ans. The main features were, the air pump, or compressor, to supply the air in the air brake system, the main reservoir, in which the air used in the system is stored, and the engineer's brake valve by which the air was allowed to pass from the main reservoir to the brake pipe and brake cylinders, of each car.

An air guage, that registers the amount of pressure in the drum, and some form of pump governor, are also used with this equipment.

19-a. What are essential features of the quick action brake?

Ans. The quick action brake, or automatic brake, consists of practically the same operative parts, an air pump, or compressor, a main reservoir, an engineer's brake valve, an air gauge, and some form of pump governor. The additional features consist of a quick action triple valve, and an auxiliary reservoir for each vehicle, in the train. This auxiliary reservoir acts as a storage drum for each particular brake, and was one of the distinguishing features (when the automatic brake was adopted) in the automatic brake, over the older form of brake or straight air.

20. What is the most essential part in the automatic brake?

Ans. The most essential part in the quick action brake, is the quick action, triple valve. This valve consists of all the operative parts of the plain, and the additional ones, or emergency features, that cause the brake to be known as the quick action brake.

21. In what manner does this valve operate the brake?

Ans. The triple valve operates the brake through the medium of the brake pipe adding to, or gradually taking from, this brake pipe a certain amount of air causes the triple valve to move in parts. The piston is moved one direction by the air stored in the auxiliary, and the other by the pressure in the brake pipe.

The movement of this piston causes the slide and graduating valves to be moved, and when this action takes place gradually, and air is vented to the brake cylinders, it is known as a service application of the brake.

22. How is an emergency of the brakes made?

Ans. When an emergency application of the brakes is desired, it is obtained by making a sudden brake pipe reduction. This heavy reduction causes the quick action parts of the triple valve to operate, and the brake application becomes much quicker, and more severe.

23. In what manner are the brakes released?

Ans. The brakes are released by restoring air to the brake pipe, when this pressure becomes a little greater than the pressure in the auxiliary, the triple valve parts move to release, and charging position. This action allows the pressure in the brake cylinder to escape to the atmosphere, and the same movement of the triple valve establishes communication again between the brake pipe and auxiliary reservoir, charging it through the feed groove to the same pressure as is in the brake pipe.

24. Can an auxiliary reservoir be re-charged, without releasing the brake?

Ans. Yes, the auxiliary can be re-charged without releasing the brake by using what is known as a retainer.

25. In what manner can this be done?

Ans. The retainer is a weighted valve, connected by a pipe to the triple valve exhaust port. When it is desired to re-charge, and a certain per cent. of the holding power of the brake desired, the handle of the retaining valve is turned up. In this position the air in the brake cylinder must pass the weighted valve in order to get to the atmosphere. As soon as the weight becomes stronger than the pressure, the weight seats, and the remaining pressure is trapped in the brake cylinder, holding the brake applied.

26. What is the main characteristic of the automatic, quick action brake?

Ans. The main feature in the operation of this brake is that the brake will apply (when a reduction in brake pipe pressure is made) from any cause. This acts as a safety feature, and was the main cause for the present development of the brake.

27. What are some of the causes for a brake application without the action of the engineer?

Ans. The brakes apply automatically, in case the train breaks in two, if an air hose should burst, if a hose springs a leak, if the hose open as in cold weather, a conductor's valve being opened, or the angle cock on the rear of the train being opened.

28. Considering the equipment as an automatic quick action brake, what are the parts necessary?

Ans. The parts necessary are, an air pump, main reservoir, brake valve, auxiliary reservoir, triple valve, brake pipe and all necessary piping. An air gauge, and some form of pump governor, are used with this as well as all equipments, although the operation of the brake would not be materially affected if the engine was not supplied with these parts.

29. If a description of these parts was to be attempted what part of the equipment bears the greatest relation to the same, and should first be understood before taking up other parts?

Ans. The air pump bears the greatest relation to the equipment as without air the system could not be operated automatically.

30. If an air pump was to be the first part of the equipment the student should attempt to learn what part of the pump should first be studied?

Ans. The steam end, or power end, of the pump should first be thoroughly understood, before the air end, or compressor end, should be studied.

31. When studying the air pump (there being many different kinds) what pump should first be taken up?

Ans. There are many different kinds of air pump, but the ones in general use are the 8 inch, 9 1-2 inch, 11 inch, and the 8 1-2 cross compound. There were other styles of pump such as the trigger form of pump, and the 6 inch pump with the reversing gear much like the 8 inch. There is also a pump known as the water-jacketed pump, used in power plants where the compression capacity requirement is great, and the work on the pump very great.

32. In general railroad practice what pump is in general use?

Ans. The 8, 9 1-2, and the compound, the 11 inch being used in some instances but usually where it is necessary to have a large compression capacity, two 9 1-2 inch pumps are favored.

33. In all Westinghouse pumps, which has the greater air compression capacity?

Ans. The general opinion seems to favor the 8 inch cross compound, in this respect.

AIR PUMP OPERATION.

The Westinghouse 8-inch Air Pump.

34. In which end of the pump is the power developed to operate it?

Ans. The upper end of the pump is known as the power end, or the engine end of the pump.

35. What is the lower cylinder for?

Ans. The lower cylinder, or air end is the compressor end of the pump.

36. How many parts are in operation in the air end of the 8, or 9 1-2-inch pump?

Ans. There are 5 operative parts in the air end of these pumps. They are the two receiving, two discharging valves, and the air piston.

37. Explain the operation of the air end of the pump?

Ans. The air piston being connected to the steam piston, is forced to move in its cylinder each and every time the steam piston moves. The movement of the air piston causes a vacuum to be created behind the piston, and the air receiving valves lift, the amount of their lift, and supply air at atmospheric pressure to the cylinder of the air end. When the piston is on its return stroke, the air that entered the cylinder is squeezed or compressed, to a greater pressure than the pressure in the main reservoir. This action causes it to be forced by the discharge valve into the main reservoir. When the piston has completed its return stroke, it has made one cycle, and has performed work on each of its strokes.

38. Explain the movement of the valves in the air end of the pump.

Ans. When the piston moves away from the head of the cylinder, in either direction, the air at atmospheric pressure enters the air inlets, and lift the receiving valve from its seat, remaining in this position until the piston completes its stroke, and starts on its return. The receiving valve that allowed the air to enter the cylinder is then forced to its seat, and held in this position. While the air that enters the cylinder is being compressed, the piston in its movement in the air at atmospheric pressure. As soon as the air in the cylinder is compressed to a greater pressure than main reservoir pressure, the discharge valve unseats, and allows the pressure to pass into the main reservoir. The piston then returns, repeating this operation.

39. What is the lift of the receiving and discharge valves of an 8-inch pump?

Ans. The receiving valves lift 1-8 of an inch, and the discharge valves lift 3-32 of an inch.

40. Why is it that the receiving valves have a greater lift than the discharge valves?

Ans. In an 8-inch pump the receiving and discharge valves are both placed on the same side of the pump. If for any reason it becomes necessary to remove the receiving valves it would have to be done through the seats of the discharge valves, hence the reason for them being smaller. The receiving valve are smaller, consequently the greater lift.

41. What is the size of the cylinders, and stroke of the piston in an 8-inch pump?

Ans. The steam cylinder is 8 inches in diameter, the air cylinder is 7 1-2 inches in diameter. The stroke of the piston is 9 inches.

42. Explain the general construction of the steam end of the pump.

Ans. The steam end of the pump consists of a cylinder, piston, and a form of valve gear, that gives a valve motion, admitting and exhausting steam to and from each side of the piston.

43. How many operative parts are there in the steam end of the pump?

Ans. There are five operative parts consisting of a main steam piston, main valve, reversing valve, reversing rod, and reversing piston.

44. What is the duty of the reversing valve piston?

Ans. The duty of the reversing valve piston is to assist the smaller main valve piston to overcome the pressure underneath the larger valve piston when it is being moved to its lower position.

45. What is the duty of the reversing slide valve?

Ans. The reversing slide valve admits and exhausts steam from the top of the reversing piston.

46. **What is the duty of the reversing valve rod?**

Ans. The duty of the reversing valve rod is to raise and lower the reversing valve whenever the main piston makes a stroke. This rod is the connecting link in the pump's valve motion.

47. **What is the duty of the main valve pistons?**

Ans. The main valve pistons control the admission and the exhausting of steam to the cylinder of the pump.

48. **What pressure is always present between the two valves of the main valve piston?**

Ans. Boiler pressure is always present between these two valves, when the pump throttle is open.

49. **What pressure is always present on the outer ends of the main valve piston?**

Ans. The outer ends of this valve is always exposed to exhaust steam pressure, or atmospheric pressure.

50. **Trace the steam from the boiler through the pump, and then to the atmosphere?**

Ans. When the pump is at rest the main piston after a time settles to the bottom of the cylinder, and as it does so the reversing valve rod being connected to the top of the piston, moves the reversing parts to a position so that the next stroke of the pump would be on the up stroke. The steam now if the pump throttle be opened, passes by the governor, and through suitable piping, where it enters the pump on the left side, about the middle of the steam cylinder. The steam as it enters surrounds the inner face of the main valve piston, and is always present in this chamber so long as steam from the boiler is supplied. The steam in this chamber is likened to the steam chest of an engine and is always waiting for proper port connections to be set up in order for it to do its work. A small amount of steam passes through a small port that leads to the reversing slide valve chamber, and causes the cavity around this valve to always be filled with steam at boiler pressure.

As the reversing slide valve is now in its lower position, steam passes through a port that leads to the top of the reversing piston. This reversing piston stem rests on the top of the larger end of the main valve piston, and the combined area of the reversing piston, and the small end of the main valve piston cause the main valve piston to be forced to its lower position. In this position the upper row of ports in the lower end of the main valve piston bushing are open, and steam passes under the main piston causing it to rise or be forced up in its cylinder. As the main piston is about to complete its stroke the reversing valve plate on the top of the main piston engages the shoulder on the reversing valve rod, raising it, with the reversing slide valve up. The reversing slide valve now being in its upper position, connects two ports together through the cavity in the reversing slide valve, and the steam that was on top of the reversing piston is exhausted to the atmosphere. The steam that was on top of the reversing piston now being removed, the boiler pressure that is between the main valve pistons forces the main valve piston up in its bushing. This movement of the main valve piston causes the lower row of ports in the upper end of the main valve bushing to be opened, admitting steam at boiler pressure on top of the main piston, causing it to be forced down. At the same time the main valve piston was opening the ports in the top end of the pump to admission, it was opening the lower row of ports in the bottom of the main valve bushing to exhaust.

The steam that caused the main steam piston to move up in its stroke is now allowed to pass to the atmosphere, having done its work, and as the steam piston nears its downward stroke the same valve events take place in the top end of the steam cylinder, and steam from the top of the piston is allowed to be exhausted to the atmosphere. The pump has the completed one double stroke or cycle.

WESTINGHOUSE STANDARD AIR PUMP.

9 1-2 Inch.

51. What is a Westinghouse standard 9 1-2 inch air pump?

Ans. This air pump is so called from the fact that it is more in general use than any other style of Westinghouse pump, it seeming to fill all the requirements for all kinds of train service. This pump differs slightly, in that it is a larger pump as well as having a somewhat different arrangement of air valves, as well as a different form of reversing valve gear. This pump is also manufactured in either a right, or left handed pump. This fact under some conditions seems to offer an advantage.

52. Why is one form of this pump called a right hand pump?

Ans. The right hand pump is so spoken of as the steam pipe connections are on the right hand side of the pump.

53. If all 9 1-2 inch pumps are not so arranged what is the difference?

Ans. Some styles of the 9 1-2 inch pump are furnished with steam, and exhaust pipe connections, on each side of the pump, and in this case may be either right, or left hand pumps.

54. What is the difference between the right, or left hand pump?

Ans. A right hand pump has but one steam connection, and that is on the right side of the pump. The exhaust pipe connection being on the left side, and is a single pipe. The right, or left hand pump has a steam and exhaust connection on each side.

55. Is there any difference in the size of piping used when piping up a pump, and how can the difference between the steam, and exhaust connection be told?

Ans. The steam pipe connection is the lower one, and is always smaller of the two pipe connections. On a right hand pump it is found on the right side, while the exhaust pipe is on the left side.

56. Describe the general arrangement of the parts in the steam end of the pump.

Ans. The steam end, or top end of the 9 1-2 inch pump, like all other styles of Westinghouse pump, is the engine end of the pump. It consists of a cylinder, and a suitable number of valves, and a valve gear that controls the admission, and exhausting of steam to the piston in the cylinder.

57. Name the operative parts of the steam end of the pump, and how many parts are there?

Ans. The names of the parts are the main steam piston, the main slide valve, the reversing slide valve, reversing valve rod, and the reversing or differential piston, being five parts in all.

58. How does the 9 1-2 inch pump compare in size to the 8 inch?

Ans. The 9 1-2 pump is not only larger in size, but has a greater air compressing capacity. The steam and air cylinders are both 9 1-2 inches in diameter, and the piston has a stroke of 9 1-2 inches. The air valves are four in number, two receiving and two discharge, they being the same size are interchangeable.

59. What valve controls the admission of steam to the cylinder?

Ans. The admission of steam to the cylinder is controlled by an ordinary form of D slide valve operating in conjunction with the differential piston.

60. What ports does this slide valve cover when in its central position?

Ans. This valve covers three ports, one leading to the bottom head, one to the top head, and one to the exhaust passage in the walls of the cylinder casting.

61. **What duty does the reversing valve rod perform?**

Ans. The reversing valve rod controls the movement of the reversing slide valve in conjunction with the movement of the main steam piston. The shoulder and button on this rod, engaging the tappet plate on the top head of the main steam piston (when it is in motion cause its motion.

62. **What is the duty of the reversing slide valve?**

Ans. The reversing slide valve controls the admission, and the exhausting of steam to, and from the large end of the differential piston, or the chamber known by letter, as chamber D.

63. **What duty does the differential piston perform?**

Ans. The differential piston, and the slide valve, controls the admission of steam to and from the cylinder of the pump.

64. **What duty does the main steam piston perform?**

Ans. The main steam piston (being connected to the piston in the air cylinder by a rod) causes the movement of this piston, and operates the compressor end of the pump.

65. **When the pump throttle is opened, what compartments in the pump contain steam at boiler pressure?**

Ans. The passage in the cylinder casting, the bushing in which the differential piston works, and the reversing slide valve bushing all contain steam at boiler pressure, regardless of the position of the main piston, or the reversing valve gear of the pump.

66. How are the two cavities in the differential piston, and the reversing slide valve bushing, connected together?

Ans. These two cavities are connected by a small port leading from the differential piston bushing into the slide valve bushing.

67. Explain the operation of the reversing valve gear of the 9 1-2 inch pump.

Ans. The parts being known, their operation is as follows: When steam has passed the throttle valve, it enters the pump, on the left side (right hand air pump) and passes through a cavity in the cylinder casting, up through a square port hole in the differential piston bushing. It exerts its pressure on the inner face of the two pistons, of the differential piston, and a small amount passes through a port leading to the reversing slide valve bushing. Steam from the boiler is always present in these two compartments so long as the throttle is opened. When the pump is at rest, the main piston settles to the bottom of its cylinder, due to its own weight, or gravitation, and as it falls to the bottom of the cylinder, the button on the reversing valve rod engages the tappet plate, on the top of the steam piston, and causes the reversing slide valve to be pulled down. In this position, the back end of the large piston, on the differential piston, is connected to the exhaust, and any pressure that may be in chamber D is allowed to escape. The steam between the two heads of the differential piston causes the piston to move to the right, this being the case due to the fact that the area exposed on the two pistons is greater on one than on the other, naturally the greater overcoming the lesser would cause the movement to the right. As the differential piston moves to the right it carries with it the slide valve, uncovering the admission port to the bottom of the cylinder. The steam is now admitted underneath the main piston, and this causes it to move up. As it moves up in its stroke, the shoulder on the reversing valve rod engages the tappet plate on the top of the steam piston, and causes the reversing slide valve to be moved up. This movement of the reversing slide valve causes proper port connections to be set up, and steam is admitted behind the large piston, of the differential piston, or into chamber D. Pressure being supplied to the outside of this piston, causes the pressures on either side of the piston to be balanced. The smaller of the two pistons, now has the greater area, and as there is no pressure behind it, it moves to the left, and in so doing carries with it the slide valve. The slide valve uncovers the port leading to the top head, admitting steam to the top of the piston. At the same time the slide valve is uncovering this port to admission, it is also connecting up the exhaust arch in the slide valve, with the opposite admission port. The steam that forced the piston up is now exhausted to the atmosphere and the steam that is admitted to the top of the piston forces it down, completing one double stroke, or one cycle of the pump.

68. In as few words as possible what causes the reverse of the stroke?

Ans. The reverse of the stroke is brought about by the reversing slide valve working in conjunction with the main steam piston, through the medium of the reversing valve rod. The fact that this valve admits to and exhausts steam from the back end of the large piston, of the differential piston, causes the differential in pressures, due to the area of the exposed surface of this piston, brings about the reverse of the stroke.

69. For what purpose is the small port, in the reversing cap nut, connecting this cavity with the top head of the steam cylinder?

Ans. This port is to allow any excess pressure that might accumulate in the upper end of the reversing slide valve bushing (where the reversing valve rod works) to escape to the top head of the steam cylinder. It also furnishes this rod with sufficient lubrication.

70. For what purpose are the channel drain cocks on the steam cylinder?

Ans. This affords a means of ridding the steam cylinder of condensation. They should be opened whenever the pump is shut off for any considerable length of time.

71. Why should an air pump be started slowly?

Ans. The pump should be started slowly to allow the condensation to be worked out and a pressure of from 25 to 40 pounds to be accumulated in the main reservoir to form a cushion for the piston.

72. **Why is this cushion necessary?**

Ans. This cushion is necessary as there is no clearance in either the steam or air cylinders, and if not allowed to form, might be the cause of knocking out a cylinder head, or doing damage to the piston.

73. **Before starting the pump what should first be done?**

Ans. Before starting the pump the air pump feed of the lubricator should be opened, and a few drops of oil allowed to feed to the steam end of the pump. The lubricator should then be set to feed not less than one drop per minute, while the pump is working. The air end should also receive about one teaspoonful of good clean valve oil, if no other means of lubrication are provided.

74. **Should the air cylinder of the pump ever be oiled through the strainer?**

Ans. This should never be done as it not only stops up the strainer of the pump but also causes the passages, or channels in the pump, as well as the air valves to become stopped up, and the air valves stick. This causes the pump to run hot and greatly reduces its capacity.

75. **How should the pump be run while descending a grade?**

Ans. The pump should be run fast enough to maintain the pressure, the pump throttle being well opened. The pump should not be run too fast or raced, as this will cause it to pump less air than if the cylinders be given time to fill with air.

76. **Should any low flashing point oil ever be used to lubricate, or clean out the air end of the pump?**

Ans. Such oil as kerosene, car oil, carbon oil, or coal oil, should never be used to lubricate the air cylinder of the pump as its low flashing point causes it to carbonize. The gas given off by these oils is very liable to cause an explosion, when subjected to the heat generated in the air end of the pump.

77. **Of what benefit is a well oiled swab, on the piston rod?**

Ans. A well oiled swab increases the life of the piston rod packing, causes a free movement of the rod through the packing, and a certain portion of the oil being carried down into the cylinder helps to lubricate it.

78. **How should the piston rod be packed?**

Ans. The piston rod should be packed sufficiently tight to prevent it from leaking, and no tighter.

79. **How should the air pump be taken care off?**

Ans. The air pump should receive proper care, as the work done by it is not only very laborious, but the lives of all concerned to a great extent depend upon the performance of this wonderful piece of machinery. The pump should never be raced, sufficient oil should be supplied to insure successful lubrication, and all necessary work should be reported to keep it in first class condition.

WESTINGHOUSE 11-INCH AIR PUMP.

80. What kind of a pump is a Westinghouse 11-inch pump?

Ans. A Westinghouse 11-inch pump is a pump very much like the 9 1-2 inch pump, except in size, the cylinders being 11 inches in diameter, with a 12-inch stroke. The reversing valve gear is identical with the 9 1-2 inch pump, the difference being in the fact that it is in proportion to its size. Its operative parts and its operation are the same. The operation of the air end is the same as in the 9 1-2 inch.

81. What then is the advantage, if the two pumps are so much similar?

Ans. The advantage lies in its ability to compress air, under the same conditions it has about 30 per cent. greater capacity than the 9 1-2 inch pump.

82. What lift have the air valves of the 11 inch pump?

Ans. The air valves have the same lift as the 9 1-2 inch pump, 3-32, of an inch. These valves are interchangeable in the same manner as in the 9 1-2 inch, but the valves of the 9 1-2 inch pump could not be used on a 11 inch pump as they are much smaller.

83. In regards to the care of this size of pump, how should it be treated?

Ans. This size of pump requires the same kind of care that other styles of pump should receive. The pump being larger would require slightly more lubrication.

84. For what class of service was this pump designed?

Ans. This pump was not designed for any special kind of service, but was rather designed to fill the want for a class of service, where a large compression capacity was desired.

WESTINGHOUSE WATER-JACKETED AIR PUMP.

85. What is a water jacketed air pump?

Ans. This is an air pump, in which flowing water, or water under pressure is allowed to circulate through a jacket, around the air cyplinder, to keep it cool.

86. For what class of service was this pump designed?

Ans. This pump was designed for power houses, or places where the work to be performed was of an extraordinary nature, such as compressing air to a very high pressure.

87. In what respect does this pump differ from other pumps, aside from its water jacket?

Ans. Aside from the water jacket, there is no difference between this and the 9 1-2 inch pump. The steam end of both pumps being the same, one part interchangeable, one with the other. The air end has the same number of valves, and they are the same size as in the 9 1-2 inch pump, but are somewhat differently arranged, being placed on top and at the bottom of the air cylinder heads. These are the same in other respects, as in other styles of air pumps.

88. What is the size of the cylinders in this style of pump?

Ans. The size of the steam cylinder is the same as in the 9 1-2 inch pump, while the air cylinder is built according to special requirements.

89. Would this style of air pump be a success for train service?

Ans. This style of air pump would of course be a success from some standpoints, but under certain conditions would be operated at a disadvantage, that is supplying it with water.

90. What care should this style of pump receive?

Ans. The same care that other pumps receive, and in addition the air end should receive the proper supply of water in the jacket to prevent over heating.

DEFECTS IN THE OPERATION OF AIR PUMPS AND THEIR REMEDIES.

When for any reason, the air pump stops its work, the engineer should bring his train to a stop as best he can, calling for hand brakes if necessary. He should then make all efforts to get the pump in running repair, as soon as he is satisfied as to the nature of the defect. In many instances pump failures were rather man failures, and not break downs. The only time when a man is justifiable in having an engine failure (and that is what a pump failure today means, as according to Inter-State Commerce Law, no train can under any circumstance be operated without air brakes) is when some part of the air pump is broken beyond repair, or replacement. Many roads are today equipping their engines with two air pumps to obviate this failure, and this seems in a great measure to have solved the question, as well as lessened the work on the single compresser. Some roads requiring pumps with a large air compression capacity favor the compound pump but the leading roads have almost universally adopted the two pump idea.

91. Why do air pumps as a rule fail?

Ans. Air pumps, as a rule, fail due to their abuse. There is no part of the equipment on the engine (in the nature of mechanical appliances) that receives an equal amount of abuse.

92. What are some of the things classed as abuse, that tend to cause pump failures?

Ans. Improper lubrication, allowing the pump to run dry (the extra strain placed on the small reversing parts, is liable to break them), running the pump too fast, running the pump over ash pits, allowing the pump to become loose on its bracket, allowing the pump to pound, allowing the pump to work against a high main reservoir pressure. When there is some defect in the governor, or too great a tension on its adjusting spring allowing the pump to work against, leaks that could be repaired, improper method of starting the pump (failing to wait for the condensation, to work out, or cushion to be formed), or neglecting a work report on the noticeable condition of the pump are things which can be classed as abuse, and tend to cause pump failures.

93. If the air pump should stop while in route, what can and should be done?

Ans. It should first be ascertained that the pump throttle is open, and that the trouble is in the pump, and not in the governor, before proceeding to locate the trouble. Reducing the pressure that controls the governor will enable the engineer to tell whether the trouble is in the pump or governor. Failing to locate the trouble in the governor, it can then be laid to the pump. The pump may be dry, the nuts on the piston rod in the air end may be loose, the reversing valve rod may be broken, the reversing plate, or tappet plate, may be loose on the top head, the packing rings on the large end of the differential piston may be broken, the lock nut on the small end of the differential piston may have come off and is preventing the piston from completeing its stroke, the reversing valve rod may be bent, the main piston in the steam cylinder may have pulled off the rod, or the pump might have been put up with the top head gasket either blind, or turned wrong.

94. What should first be done in order to get the pump to resume work?

Ans. The pump throttle should be closed (if open) and the lubricator allowed to feed for a few seconds quite fast, the pump throttle should then be opened suddenly. This generally causes the pump to resume work. A little more oil should then be supplied to prevent its stopping again.

95. In case this failed to start the pump what else might be done?

Ans. Tapping lightly on the reversing cylinder will sometimes cause the pump to resume work.

96. Why not tap the reversing cap nut?

Ans. The trouble is not in the reversing slide valve. If it was tapping would do no good as the reversing valve rod, or tappet plate, would have to be at fault, besides by tapping on this cap nut, there is a liability of fracturing the cap or causing the threads to become stripped, there being a port leading almost to the top of the nut, which makes it quite frail.

97. What should be the first thing to examine in case this method failed?

Ans. The first thing to examine should be the nuts on the piston rod. This can be done by removing the plug in the bottom head of the air cylinder. This too will enable the engineer to locate in which end of the cylinder the piston has stopped, and by so being informed, he can better locate the defect.

98. In case these nuts be found loose, how can the piston be prevented from turning, while they are being tightened up?

Ans. After removing the bottom head, the larger head of the differential piston bushing should be removed, and the piston forced over to the smaller end, and blocked in this position. Then after replacing the head, give the pump steam.

The differential piston being moved in this position, causes steam to be admitted to the top of the main piston, and after forcing it to the bottom of its stroke, will hold it in this position while the nuts are being tightened.

99. **What should next be done to locate the trouble?**

Ans. The reversing valve cap nut should then be removed, and the reverse valve rod examined. The main piston must either be on the up stroke, or held up by means of a packing iron, introduced through the plug hole in the bottom head before the rod, and slide valve can be removed in a 9-inch pump. If on an 8-inch pump the packing rings on the reversing piston should be examined. If the rings are gone, substitute with candle wicking until the trip is finished.

100. **If these parts are found to be in good condition, what should then be done?**

Ans. With the 9 1-2, or 11 inch pumps the large head of the differential piston bushing should be removed so as to examine the differential piston and slide valve. With an 8-inch pump the top head will have to be removed, in order to examine these parts. It is not always necessary to do these things just mentioned, as for example; when steam is blowing into the exhaust, and out to the atmosphere, it eliminates the reversing piston from the trouble. The main valve being the dividing line between the admission and exhaust ports would be the seat of the trouble. Hence to this point, the engineer's attention should be directed.

The packing rings on the main steam piston seldom blow bad enough to interfere with the operation of the pump.

101. What might be the trouble with the main valve?

Ans. With the 9 1-2 inch pump the blow may be caused by a cut valve or seat, or the seat worn badly, or possibly the valve is held from its seat by some foreign substance. With the 8-inch, the trouble may be that either end of the valve has come off, or possibly broken packing rings, or broken stop pin, allowing an over travel.

102. What are some of the causes for blows in an 8-inch pump?

Ans. Loose or broken rings on the main piston, reversing piston, or the main valve pistons, reversing valve rod not fitting properly in the cap, reversing slide valve held from its seat, cut slide valve or seat, or the reversing valve bushing cap nut not making a good tight fit.

103. What will cause blows in the 11-inch pump?

Ans. Blows in the 11-inch pump are caused from the same defects as in the 9 1-2-inch pump.

104. If the air pump is found to be running hot, what might be the cause?

Ans. Working the pump against a high main reservoir pressure, racing the pump, the lift destroyed on the air valves, leaky valves, or piston packing rings, the air valves stuck shut, the ports and passages in the pump stopped up due to the use of too much oil, or when using fibrous packing the pump will sometimes run hot. If the pump is properly taken care off, and not required to do an excessive amount of work, such as trying to keep up the pressure on a train of bad leaks, there will be little if any trouble with the pump running hotter than the natural heat of compression.

105. **At what speed does a pump give the best results?**

Ans. The best results are obtained by running the pump at a speed of from 60 to 70, double strokes, 120 to 140 single strokes, per minute.

106. **In case the air pump runs hot, what should the engineer do?**

Ans. When the pump is running hot, the engineer should ease off the throttle, and if possible reduce the amount of work the pump is trying to do, look the train over and see if there are not some bad leaks, possibly there is a leak in the equipment about the engine. The engineer should try to cool the pump with a quantity of good valve oil put in the air cylinder. The pump should then be run slow, and given a chance to cool. If the cause is due to some defect, it should be located, and reported.

107. **How can the trouble be located?**

Ans. The condition of the packing rings can be told by noticing the suction at the air inlets, or the strainer. The suction should be good during the full stroke of the piston. There being nothing wrong with the packing rings, the lift of the air valves should then be measured. If the lift of the valves be found correct, then the only trouble could be in the manner in which the pump is treated.

108. In case the pump has been long in service, and the passages are stopped up with gum, due to oil, how can they be cleaned out?

Ans. These passages may be cleaned out by working a strong solution of lye, or potash, and water through the pump. When the engine is to stand in the round house for a length of time, it is advisable to fill the pump with this solution, and allow it to stand for awhile. When this can not be done, the solution should be worked through the pump by working the pump slow. If the solution is not too dirty it may be worked through a second time, after which the pump should be rinsed by working clean water through it. The pump should be oiled well, and if not equipped with metal packing, should be repacked. The use of kerosene is not advisable as it is liable to cause an explosion, and does not do the work as well as the lye solution.

109. If the pump should work lame, or make irregular strokes, where might the trouble be?

Ans. The irregular pump action is generally due to a stuck or broken valve. The valve at fault can be located by noticing the action of the piston. There is little or no suction, when the piston moves away from the stuck valve. If it be a broken valve, the pressure will blow back when the piston is moving towards the defective valve. With a discharge valve at fault, the piston moves towards the valve slow, and fast away from it.

110. **If the pump seems to be working all right, and yet fails to keep up the pressure, what might be the trouble?**

Ans. The trouble may be due to the fact that the pump is being run too fast, or that the strainer is stopped up. The strainer sometimes appears to be clean but the small holes are stopped up with gum and dirt. The strainer should be taken off and cleaned by holding it under the overflow, and blow steam through it. If the fault is due to running the pump too fast, it should be slowed down, allowing the cylinders time to fill with air on each stroke.

111. **What causes the pump to pound?**

Ans. The pump pounding, is due to some of the following causes, such as the pump loose on its bracket, bracket loose on the boiler, too great a lift on the air valves, tight rings on the reversing piston, or the main valve, loose nuts on the piston, or worn packing rings, destroying the cushion for the piston by churning the air.

MAIN RESERVOIR.

112. **What is the main reservoir?**

Ans. The main reservoir is a metal drum, cylinderical in shape (generally made of 3-8 inch boiler plate), placed at some convenient place on the engine, generally under the running board, or between the frames of the engine. The purpose of the main reservoir is to furnish a place for the storage of air, used in all parts of the air brake system. The main reservoir also acts as a trap or catch basin to collect moisture and dirt in the air, thus preventing it from working back into the air brake system.

113. **Is there more than one main reservoir on an engine?**

Ans. There is but one main reservoir, although there are often two or more drums connected together by a pipe. The object of this being to prevent making the drum so large that it would be clumsy, and hard to place, and secure about the engine.

114. **What is the usual size of the main reservoir?**

Ans. The size of the main reservoir differs on the different roads, the smallest permissible on freight is 4,000 cubic inches, on passenger 2,000 cubic inches.

115. **Are there any reservoirs with a greater capacity than this?**

Ans. Yes, on some roads the main reservoirs run in size from 4,000, to 100,000 cubic inch capacity. These large main reservoirs are generally used in heavy freight service.

116. **What is the advantage of a large main reservoir?**

Ans. A large main reservoir permits of carrying a large volume of air, which aids materially in charging up the brake pipe and auxiliaries, on a long freight train, and makes certain a prompt release of brakes, after a brake application.

117. **Aside from this added volume in air, are**

there any other benefits derived from the use of a large main reservoir?

Ans. The large main reservoir acts as a cooling chamber, in which to cool the air after it leaves the pump. This allows it to pass into the brake pipe, through the brake valve at a moderate temperature.

118. **What are the benefits derived from cooling the compressed air?**

Ans. The moisture in the air is allowed to settle in the main reservoir, where it can readily be drained out. Thus preventing it from working back into the entire system.

119. **What is the objection of the water working back into the pipes, triples, auxiliaries, etc.**

Ans. In winter the water freezes, causing pipes to burst, in summer it causes rust to form, stopping up strainers, cutting valves and seats, and the water aside from taking up valuable air space, washes away the lubrication.

120. **Why do engines in freight service require a larger main reservoir than engines in passenger service?**

Ans. Engines in freight service require a larger main reservoir, owing to the fact that these engines have a much larger volume of air to control, more auxiliaries to charge, and more difficult brakes to release.

121. **Why is it that the air can not be pumped direct into the brake pipe, thus doing away with this large volume of air carried in the main reservoir?**

Ans. This method of releasing brakes would be very unsatisfactory, as the pressure being raised so slow, would be liable in some cases to fail to release all brakes, and even so a large amount of work would be required of the pump in a very short period of time, which would be liable to cause the pump to run hot.

122. What is the standard main reservoir pressure?

Ans. Local conditions govern this amount, generally 90 pounds, with the handle of the engineer's brake valve in running position, and 120 pounds with the brake valve on lap position (the duplex governor being used).

123. Why is it that a small reservoir with a high pressure is not as good as a large reservoir with a lower pressure?

Ans. So far as releasing the brakes is concerned it would answer the purpose, but the pump working against this high pressure would run hot. This would in a very short time destroy the efficiency of the pump.

124. Why is it that a pump will heat when working against a high pressure?

Ans. This is caused by the fact that the higher the pressure to which the air is compressed, the greater the degree of heat generated during compression.

125. Are there any advantages so far as points in construction go, in the shape of main reservoirs?

Ans. The most desirable style of main reservoir (if space on, or about the engine will permit), is a long slender cylinderical drum, as it gives a greater radiating surface.

126. Is it advisable to place the main reservoir on the tender?

Ans. This is not advisable as the pipe connections soon give trouble by springing a leak. They should, however, be placed on the tender in preference to sacrificing the proper volume by placing the small reservoir on the engine.

127. Is the pressure in the main reservoir ever called any other than main reservoir pressure?

Ans. Yes, the pressure in the main reservoir over and above the brake pipe pressure is called excess pressure.

128. What is this pressure used for?

Ans. This pressure is used to insure a prompt release of brakes, a rapid recharge of brake pipe, and auxiliaries, and to operate such devices on the engine, as are operated with main reservoir pressure without interfering with the brake pipe pressure.

129. What bad effect has water in the main reservoir?

Ans. Water in the main reservoir takes up valuable air space, better occupied by air, causes rust to form, and the rust working back into the pipes stops up strainers, cuts valves and seats, so that they cannot maintain and separate their pressures.

130. From where does this water come that is found in the main reservoir?

Ans. The water in the main reservoir comes from the atmosphere. The atmosphere carries with it more or less moisture, which is condensed into water in the main reservoir, after being compresed.

WESTINGHOUSE AIR PUMP GOVERNOR.

131. What is an air pump governor?

Ans. An air pump governor is a mechanical device, consisting of a suitable brass body, in which are found a regulating spring, diaphragm, pin valve, and a governor piston, controlling the movement of a steam valve, which in turn automatically stops, or allows the pump to resume work.

132. What pressure controls the operation of the governor?

Ans. The operation of the governor is controlled by a tension, or regulating spring, and compressed air, either from the brake pipe, or the main reservoir.

133. How many pipe connections is there to the single governor?

Ans. There are two, one admitting the steam, and the other the compressed air.

134. What is the normal position of the governor?

Ans. The normal position of the governor is open.

135. At what time is the governor in its closed position?

Ans. The governor is in its closed position when the tension of the regulating spring is overcome by pressure.

136. What is the duty of the square nut on top of the body of the governor?

Ans. The duty of this nut is to increase or decrease the tension on the regulate spring.

137. What is the duty of the diaphragm?

Ans. The diaphragm is the dividing line between the spring and the pressure that operates the governor, and controls the movement of the pin valve.

138. What is the duty of the pin valve?

Ans. The pin valve opens and closes communication between the diaphragm chamber and the governor piston, in conjunction with the movement of the diaphragm.

139. What is the duty of the governor piston?

Ans. The governor piston controls the movement of the steam valve, in conjunction with pressure, or a spring, when the pin is raised from its seat.

140. What is the duty of the steam valve?

Ans. The steam valve opens and closes communication between the boiler, and the pump, in conjunction with the operative parts of the governor.

141. What is the duty of the hole in the neck of the governor? Spring casing?

Ans. The hole in the neck of the governor is to make the governor sensitive, to the reduction in pressure, which the governor is supposed to control. This hole allows the pressure between the governor piston, and the diaphragm to escape, when the diaphragm and spring returns the pin valve to its seat.

The hole in the spring casing is to allow any pressure that might leak by the diaphragm to escape to the atmosphere, thus preventing an additional pressure being built up on the spring.

142. How does the steam pass through the governor to the pump?

Ans. When the pump throttle is opened, the steam passes through the pipe connection leading to the governor. The spring under the steam valve has raised the governor piston, and with it the steam valve, allowing the steam to pass to the pump. The pump in its operation caused air to be compressed, and as it feeds from the main reservoir through its different pipe connections, a portion of the pressure is also allowed to feed to the chamber between the diaphragm, and the pin valve seat. When the compressed air exceeds the tension of the regulating spring, the diaphragm is raised up, unseating the pin valve. The compressed air in the diaphragm chamber, and the pipe connections, now pass down to the governor piston (the area of which is such in square inches that a pressure of 25 pounds can seat the governor piston and steam valve against 200 pounds of boiler pressure) seating the steam valve, and causing the admission of steam to the pump to be cut off. This condition exists until such time as the controlling pressure has reduced below the tension of the regulating spring when the regulating spring forces the diaphragm down seating the pin valve. The pressure trapped between the pin valve and the governor piston quickly escapes through the hole in the neck of the governor, allowing the spring under the governor piston to raise the piston and unseating the steam valve. Steam is now free to pass to the pump causing it to resume work.

143. How long does this performance continue?

Ans. So long as steam is supplied to the governor.

DUPLEX AIR PUMP GOVERNOR.

144. What is a duplex governor?

Ans. A duplex governor is two governors (identical in points of construction as the single governor) connected to a bracket, known as the Siamese connection.

145. What is the object of the duplex governor?

Ans. The duplex governor permits of double control, or controlling the pump with two separate and distinct air volumes. It also permits of a ready means in pump control from one pressure to another, without the necessary readjustment of the governor.

146. In what respect does the duplex differ from the single governor?

Ans. The duplex differs only in that with the duplex, there is two regulating heads, and one controlling portion, while with the single governor there is but one regulating head as well as one controlling portion.

147. Is the principal of operation the same in each of these tops?

Ans. The principal in either governor is the same.

148. Do both regulating portions operate the same?

Ans. They operate the same in a certain sense, but one operates at a low pressure, while the other at a high. The adjustment of the heads being different, it requires different pressures to operate them.

149. Does it make any particular difference which of the two heads is set for the high or low pressure?

Ans. It does not so far as the governor top is concerned, but the desired, and controlling pressure, must be piped and connected, to the desired regulating top, according to their adjustment.

150. What is the object in having one of the holes in the neck of the governor plugged with the duplex?

This is done to prevent a needless waste of air, the Siamese fitting connecting both tops, only one port in the neck of the governor being necessary to get the desired results. And further only one of the two tops is in operation at a time.

151. With what equipments is the duplex governor most commonly used?

Ans. This governor is used with the High Speed Brake, High Pressure Control, or Schedule U, and the Duplex Main Reservoir Control.

152. What is the pipe connection on the governor piston portion of the governor for?

Ans. This is known as the drip pipe connection, and is to allow any steam that might leak by the stem of the steam valve to escape to the atmosphere, thus preventing a pressure from forming under the governor piston, in which case it would be impossible for the governor to stop the pump when the desired pressure, for which the top had been set had been reached.

DEFECTS IN THE OPERATION OF THE GOVERNOR.

153. **What are the defects in the operation of the governor that will prevent the pump from stopping when the pressure for which the governor is set is reached?**

Ans. The pipe connection leading to the governor stopped up, or broken off, the strainer in the pipe stopped up, the re-stricted passage in the pipe connection stopped up, too great a tension on the regulating spring, hole in the diaphragm, diaphragm buckled, leak by the diaphragm with the hole in the spring casing stopped up, pin valve broken off from its convention to the diaphragm, the port between the pin valve and the governor piston stopped up, the packing rings gone on the governor piston, the piston stuck in its bushing (open), the drip pipe stopped up, or frozen up in winter with a leak by the steam valve stem, the steam valve held from its seat by gum or some foreign substance, the steam valve or seat cut, the hole in the valve worn large, or the valve broken will prevent the pump from stopping when the tension of the regulating spring has been reached.

154. **What are the defects that will stop the pump**

before the pressure for which the governor is set is reached?

Ans. A weak, or broken regulating spring, pin valve too short, pin valve broken off the diaphragm, or pin valve held from its seat by gun or dirt.

155. **What will destroy the sensitiveness of the governor?**

Ans. Gum or dirt, the pin hole in the neck of the governor, or the regulating spring, short and stiff, making it less sensitive to adjustment.

WESTINGHOUSE ENGINEER'S BRAKE VALVE

156. **What is an engineer's brake valve?**

Ans. An engineer's brake valve is a mechanical appliance, the purpose of which is to enable the engineer to apply or release the brakes.

157. **What is the general style of engineer's brake valve in use at the present time?**

Ans. The present style is known as the equalizing discharge type.

158. **What are the benefits derived from this type of brake valve?**

Ans. This type of brake valve permits the engineer to make light gradual service reductions with all lengths of trains sufficiently fast to get all pistons by the leakage grooves, yet not obtain the emergency application, unless it is so desired. The equalizing feature consists of an equalizing piston that closes the brake pipe exhaust gradually, thereby prevent the head brakes from releasing.

159. What are the names of the valves in general use at the present time?

Ans. The valves in general use are the D8, F6, or G6, valves.

160. What is the principal difference between the D8, and the other types of brake valve?

Ans. The principal difference lies in the brake pipe controlling feature. With the D8 the excess pressure valve is used, the brake pipe pressure being controlled by the pump governor, while with the other valves this pressure is controlled by the feed valve attachment. The excess pressure being taken care of by the pump governor.

Ans. The positions are the same with all three types of valve.

162. What is the difference between the F6 and G6 valves?

Ans. The difference is very slight, being a little difference in the construction of the rotary valve so far as the wearing surface is concerned, the ports being the same in both.

163. For what purpose is the excess pressure valve?

Ans. This valve is to enable the engineer to carry a certain amount of excess pressure in the main reservoir, and it also feeds the air to the brake pipe, when the handle of the engineer's brake valve is in running position.

164. What amount of excess does this valve maintain?

Ans. Whatever the tension of the spring calls for, usually 15 to 20 pounds.

165. **When the handle of the engineer's brake valve is in running position, will air pass to the brake pipe until the excess pressure is obtained?**

Ans. No, air will not pass into the brake pipe until the excess pressure is obtained.

166. **With the D8 type of brake valve, what volume of air does the governor control?**

Ans. The governor controls the brake pipe volume with this equipment.

167. **What are the positions of these types of brake valve?**

Ans. Full release, running, lap, service, and emergency application position.

168. **How many charging positions are there?**

Ans. There are two, full release, and running position.

169. **How many application positions are there?**

Ans. There are two applications, service and emergency.

170. **For what purpose is lap position?**

Ans. Lap position is for the purpose of holding the brakes applied, to prevent main reservoir pressure from passing into the brake pipe, when it is so desired and is the position of the brake valve in which all ports are blank, or are covered by the rotary valve.

171. **What is the improvement in the feed valve over the excess pressure valve?**

Ans. The feed valve controls the brake pipe pressure regardless of the amount of excess pressure, a thing the excess pressure valve would not do. The feed valve is more sensitive in its action, permits of a much easier and broader means of adjustment.

172. **What are the names of the two styles of feed valve?**

Ans. The poppet valve, and the slide valve feed valve.

173. **On what style is the poppet valve used? The slide valve?**

Ans. The poppet valve is used on the F6, while the slide valve is used on the G6 equipment.

174. **What is full release position of the brake valve used for?**

Ans. Full release position is used to charge brake pipe and auxiliaries and to make certain a prompt release of brakes, by reason of the direct opening between the main reservoir, and the brake pipe, consequently the rapid flow of air.

175. **What is running position used for?**

Ans. Running position is the position in which the brake valve is carried while running over the road, when it is not desired to operate the brakes, and is the only position in which the engineer can carry the brake valve, to allow the feed valve to regulate the brake pipe pressure, and maintain excess pressure.

176. **What is lap position for?**

Ans. Previously explained.

177. **What does service position do to the pressures?**

Ans. Service application position reduces the pressures in chamber D, and the brake pipe gradually, causing a service application of the brakes.

178. What does emergency position do to the pressures?

Ans. Emergency position of the brake valve, causes a heavy, sudden reduction in brake pipe pressure that produces an emergency application of the brakes.

179. Could the engineer get along without the brake valve?

Ans. Yes, but he would not have the nicety of control, when making an application of the brakes. He would be unable to release brakes, but would have to depend upon the ability of the pump to pump them off. and there would be no means at hand by which excess pressure could be carried.

WESTINGHOUSE TRIPLE VALVES.

180. What is a triple valve?

Ans. A triple valve is a mechanical appliance used in connection with the operation of all automatic brakes, and is the medium through which, and by which the operation of the brakes is automatic.

181. What features about this valve caused it to be called a triple valve?

Ans. The triple is so called from the fact that it consists of three separate and distinct valves, in a manner connected together, and operating in conjunction, one with the other.

182. What three things is the triple connected to?

Ans. The triple valve is connected to the brake pipe, the auxiliary reservoir, and the brake cylinder.

183. **What three things does the triple valve do?**

Ans. The triple valve charges an auxiliary reservoir, applies and releases, the brake.

184. **How many kinds of triple valves are there?**

Ans. There are two, practically speaking.

185. **What are these two kinds?**

Ans. The plain, and quick action, under the plain we have the old style plain and the special driver brake. While under the quick action we have the Type H. K. and L.

186. **What are the operative parts of a plain triple valve?**

Ans. The operative parts of a plain triple are the triple piston, slide valve, graduating valve, graduating stem, graduating spring, and slide valve spring.

187. **What are the different positions of the triple valve?**

Ans. These positions are full release, or charging position, service, lap, and emergency position.

188. **What is the normal position of the triple valve?**

Ans. The normal position of the triple valve is full release or charging position.

189. **When fully charged, how do the pressures compare on either side of the piston?**

Ans. The pressures on either side of the piston are equal in this position, when fully charged up.

190. The pressures being equal, what moves the triple piston?

Ans. A reduction in the pressure on either side of the piston moves the piston.

191. What moves the slide and graduating valve?

Ans. The triple piston moves the slide and graduating valve.

192. Does the graduating valve move every time the triple piston moves?

Ans. Yes, when the graduating valve pin is not broken.

193. Does the slide valve move every time the triple piston moves?

Ans. No, the slide valve does not move every time the piston moves.

194. What is the purpose of the graduating stem, and spring?

Ans. This stem acts as a bumping post for the triple piston to abutt against, thus preventing the parts from moving to emergency position during a service reduction.

195. What is the duty of the triple piston, slide, and graduating valve?

Ans. The triple piston forms the dividing line, between the brake pipe and the auxiliary reservoir and is the medium through which the slide and graduating valves obtain their movement. The slide valve opens, and closes communication, between the auxiliary reservoir, and the brake cylinder, and between the brake cylinder and the atmosphere. The graduating valve graduates the flow of air from the auxiliary to the brake cylinder (in conjunction with the triple piston and slide valve) in service applications of the brake.

196. **If a reduction of 5 pounds is made from the brake pipe, how much pressure will leave the auxiliary reservoir?**

Ans. A pressure of a little more than 5 pounds will leave the auxiliary reservoir as the pressure in the auxiliary must be lower than the brake pipe pressure in order for the triple piston to move and close the graduating valve. This action is known as triple valve lap, in which position all ports in the triple valve are closed.

196. **Does the slide valve move on the second reduction?**

Ans. The slide valve does not move, until the brakes are fully applied, or released, or if an over-reduction be made, in which case the slide valve is moved.

198. **How much of a reduction is necessary to apply the brakes in full service?**

Ans. With a 70 pound brake pipe pressure, and standard 8 inch piston travel, a reduction of 20 pounds pressure will give a fully applied brake.

199. **These being the conditions, how much pressure will remain in the brake pipe, and the auxiliary reservoir? What will the brake cylinder pressure be?**

Ans. There will remain a pressure of 50 pounds in the brake pipe and auxiliaries, and the brake cylinder will contain 50 pounds pressure.

200. **What must be done in order to release the brake, under these conditions?**

Ans. In order to release the brake, the brake pipe pressure must be raised above the auxiliary reservoir pressure, or else the auxiliary reservoir pressure reduced below the brake pipe pressure, in which case the triple valve will move to release position, allowing the pressure in the brake cylinder to escape to the atmosphere, and the auxiliary reservoir to recharge.

201. **What benefits are derived from an emergency application of the brakes?**

Ans. The brakes are not applied any harder with the plain triple in emergency application, but the brake application is much quicker, owing to a more direct opening between the auxiliary reservoir and the brake cylinder.

202. **What is the noticeable difference in the two styles of plain triples?**

Ans. The old style plain has the cut-out cock in the body of the triple, while the special driver brake triple has a cut-out cock in the pipe connection leading to the triple. The special driver brake triple is a large triple in proportion, having larger ports, and pipe connections.

203. **What are the dimensions of the graduating spring used in the plain triple?**

Ans. This spring is made of Phosphor bronze spring wire, number 14. This spring consists of 12 coils (2 1-2 inches long), and is 25-64 of an inch inside diameter.

WESTINGHOUSE QUICK ACTION TRIPLE VALVE.

204. What is a quick action triple valve?

Ans. This is a triple valve combining all the features of the plain triple and the additional features, known as the emergency features.

205. What results are derived from its use?

Ans. The same results are derived from it in service applications that were obtained from the old style plain, and some additional ones, when the brakes were applied in the emergency, namely: A quicker application throughout the entire train, and a higher brake cylinder pressure due to the construction, and operation of the emergency parts.

206. What are the names of the parts in the emergency feature, or quick action part.

Ans. The emergency piston, emergency valve, or rubber seated valve, check valve spring, and brake pipe check.

207. In what branch of service is this triple used?

Ans. They are used in freight, and passenger service, there being but little difference in the triples used in either, that being only in size, in accordance with the size of the auxiliary reservoir and brake cylinder used, for the car.

208. What distinguishing feature has the freight triple other than its size?

Ans. The freight triple has two exhaust ports, while the passenger triple has but one.

209. Why is this necessary?

Ans. Owing to the position in which the triple is often placed on the car, it is done for convenience in piping up the retaining valve. One exhaust port is always plugged.

TRIPLE VALVE DISORDERS.

Location and Remedies.

210. What is the usual cause for disorders, or defects in the triple valve?

Ans. Dirt, or the lack of lubrication, or foreign matter getting into the valve cause most triple valve disorders.

211. What defect will cause a blow at the triple valve exhaust port of a plain triple? Quick action triple valve?

Ans. A leaky slide valve, slide valve cut, or held from its seat by gum or dirt, or a leak around the plug cut-out cock.

With the quick action, the same defects in the slide valve, and others such as a leaky rubber seated valve, a leaky check valve case gasket, a leaky body gasket, or a leak in the B pipe or auxiliary tube.

212. What air pressure is escaping to the atmosphere, when a blow exists at the triple valve exhaust port?

Ans. This depends as to the location of the leak, either brake pipe, or auxiliary reservoir pressure.

213. What are the defects that will cause the leak to come from the auxiliary reservoir?

Ans. A leak by the slide valve, body gasket, or the auxiliary tube.

214. What defect will cause the blow to come from a brake pipe leak?

Ans. The rubber seated valve, or the check valve case gasket.

215. How can these leaks be distinguished, one from the other?

Ans. In some cases by making a reduction, in others by cutting out the triple valve, and watching the action of the brake. If the brake applies, and the blow stops, it indicates a brake pipe leak. If the blow continues, and the brake does not apply, it indicates an auxiliary leak. A leak from the brake pipe causes the brakes to apply harder, and the blow stops during the time the brake is being applied by the engineer, while a leak from the auxiliary will cause the brakes to release, providing it is a leak by the slide valve, it being necessary for the triple to be in release position to determine a leak from the auxiliary tube, or body gasket. A leak by the rubber seated valve or check valve case gasket, tends to set the brake harder than is desired, and the blow stops during the time the brake is applied. A leaky rubber seated valve causes the brake pipe check to chatter, when the triple is in release position.

216. What effect will a leaky graduating valve have on the action of the brake?

Ans. In some cases it will release the brakes, but not in all.

217. What would be the effect of a loose fitting piston packing ring?

Ans. On a long train, with a light reduction it tends to allow the auxiliary pressure to feed by into the brake pipe and does not set the brake. If the brake does apply, it sometimes fails to release, owing to the fact that the air feeds by the loose ring and does not move the parts to release position.

218. What effect has a sticky triple on the operation of the brakes?

Ans. The triple in this condition has lost its sensitiveness, and is very liable to go to emergency during a service reduction.

219. What effect on the operation of the triple would a weak or broken graduating spring cause?

Ans. None whatever on a train of more than 7 cars, but with a train of less would be liable to cause undesired quick action.

220. What effect will a leaky brake pipe check have on the operation of the brakes?

Ans. This would have no effect on the operation of the brakes in service, but after an emergency application (the brake pipe pressure all being gone) the brake on that particular car would release, by reason of its brake cylinder pressure leaking back into the brake pipe and escaping to the atmosphere.

221. What will sometimes stop a blow at the triple valve exhaust?

Ans. By tapping the valve cage lightly, or by applying the brakes in emergency.

222. Could train brakes be operated with triples in the conditions just mentioned?

Ans. Defects of this nature only effect the particular car on which they are found, and should not be cut-out, only in very extreme cases.

NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT.

1. What is meant by ET Equipment?

Ans. ET equipment is a term applied to an equipment for the E, engine, and T, for the tender.

2. What brought about the necessity for this equipment?

Ans. Necessity (being the mother of invention), for many various reasons, made it necessary to produce on equipment that would be satisfactory in all kinds of service, and different kinds of engines. This equipment combines the operative features of the combined automatic and straight air, standard automatic high speed, double pressure control, or schedule U, and several additional features, with much less piping, and devices in connection with these different equipments. The modern locomotive, with its increased weight, calls for a more powerful brake than in the past was necessary. The trains increasing in tonnage, and length, likewise make it absolutely necessary that the locomotive have a positive brake, in order to insure successful handling, in modern railway practice. The increased weight on the drivers, call for large cylinders, until it was no longer possible for a single auxiliary reservoir, and triple valve to maintain an applied brake for any length of time, then too the size of the cylinders, with the large piston packing rings, used almost the entire volume of the auxiliary reservoir before a set brake was obtained, there being so great a leakage by the packing before the presure had forced it against the walls of the cylinder. It was then apparent that the supply of air for these cylinders must be obtained from some other source, as well as some provision made to maintain it there so long as a brake application was desired.

Then again in handling long trains, where a brake application had been made, and for reason it was desired to release, it was always done with an element of danger (there being no holding feature) as the slack action of the train generally outrun the release, with its damaging effect on the load, as well as to the draught rigging of the cars. At times the holding feature was overlooked in haste, or excitement, even when the engine was so equipped, so the damage was done, which in many instances was laid to the brake equipment, instead of being laid to improper brake manipulation. This equipment was designed to overcome as many as possible of these bad practices, as well as to combine the best operative features of all other styles of equipments.

3. This being an engine equipment, is the operation of the train brakes effected?

Ans. The train brakes are operated with this, the same as with other equipments.

4. What is the meaning of the term, train brakes?

Ans. The term, train brakes, means all brakes in the train except those on the locomotive. Locomotive brakes are the brakes on the locomotive, are independent of the train brakes.

5. What are the new operative features obtained with the ET equipment?

Ans. (a) The locomotive brakes may be used independently of the train brakes, they can be operated together, or the train brakes can be operated without the engine brakes, or engine brakes can be operated without the use of the train brakes.

(b) The brake cylinder pressure is the same regardless of the piston travel, or brake cylinder leakage.

(c) The brake cylinder pressure is automatically maintained, regardless of the brake cylinder leakage, providing the pump is in operation, and the main reservoir contains pressure.

(d) The locomotive brakes may be graduated on or off at will of the engineer, with either the automatic or independent brake valve.

(e) The operation of the brakes is greatly improved in service applications, as well as an increased braking power, in emergency applications.

(f) The brakes on the second engine (when double heading) can be applied or released at the will of the engineer, without the assistance of the leading engine, or in so doing without interfering with the operation of the leading locomotive brakes, or the train brakes. The second engine can assist in maintaining a set brake, while a release is being made on the train brakes at a slow speed, thus reducing the liability of trains parting.

6. Why is it that the piston travel has no effect on the cylinder pressure?

Ans. This brake equipment has what is known as a distributing valve, the operation of which causes a port opening to be the same, during either an automatic or independent application. This port opening supplies air to the brake cylinders, and as the piston travel is predetermined in the distributing valve, and is always the same, the cylinders have the same pressure regardless of the piston travel, it taking longer to apply or release with a long travel than with a short travel.

7. What are the necessary operative parts, in order to install this equipment?

Ans. The necessary parts are an air pump, main reservoir, duplex pump governor automatic brake valve, independent brake valve, feed valve, reducing valve, distributing valve, double reservoir, two duplex air gauges, combined air strainer, and check valve, brake cylinders, for engine and tender, and suitable piping connecting one part with another, according to the relation each part bears to the other.

8. Are there any special parts with this equipment, by so installing the operative features of the equipment are changed?

Ans. There is what is known as the quick action cylinder cap, combining the operative features of the quick action triple valve, which when applied to the distributing valve, somewhat increases the efficiency of the valve's operation in emergency applications. There is also what is known as the combined air strainer, and check valve used in connection with the reducing valve, and independent brake pressure, to operate the train air signal system.

9. **Is there any difference in the operation of the air compressor, or governors with this equipment, in comparison with previous equipments?**

Ans. The operation of the compressor is the same with this as with other equipments, but the operation of the governor is somewhat different, this being explained later.

10. **What provision is made for separating the main reservoir from the rest of the brake equipment?**

Ans. A cut-out cock is placed in the pipe connection leading to the automatic brake, and independent brake valves. This cut-out cock cuts out all parts of the equipment from the main reservoir, except the maximum pressure head of the duplex governor.

11. **Why is such an arrangement as this necessary?**

Ans. While not a necessity, this is of great convenience, in cleaning, or repairing any of the parts, without draining the pressure.

12. **Where do the main reservoir pipe connections lead?**

Ans. These pipe connections lead from the main reservoir to the red hand of the duplex air gauge, the pump governors, the automatic brake valve, the feed valve, the reducing valve, the distributing valve, and to the dead engine feature.

13. **Are there any other branches of this pressure?**

Ans. Yes, there is a branch leading to a pressure log, which furnishes air to operate the bell ringer, air sanders, blow off cock, traction increaser, head light extinguisher, pin lifter, water scoop, ditcher, and all such devices, that are operated by this pressure.

14. **For what purpose is the feed valve?**

Ans. The purpose of the feed valve is to automatically carry and control a predetermined pressure in the brake pipe.

15. **To what parts of the equipment does the feed valve connect?**

Ans. The feed valve pipe connects to the automatic brake valve, and to the spring chamber of the excess pressure head of the low pressure governor.

16. **For what purpose is the reducing valve?**

Ans. The reducing valve is for the purpose of reducing, and supplying the proper pressure from the main reservoir, to the independent brake valve, and to the train air signal system.

17. **To what pressure is the feed valve adjusted?**

Ans. The feed valve is adjusted to two positions, 70 pounds for ordinary practice, and 110 pounds for the high speed brake.

18. To what pressure is the reducing valve adjusted?

Ans. Ordinarily 45 pounds, yet under certain circumstances it may be even less.

19. For what purpose is the automatic brake valve used?

Ans. The purpose of the automatic brake valve is to charge up the brake, brake system, to discharge air from the brake system in order to apply the brakes, to prevent a flow of air to, or from the brake pipe when it is desired to hold the brakes applied, to hold the locomotive brakes, applied, and to release the train brakes, if it is so desired, to allow the air from the main reservoir to flow through the brake pipe, into the brake system for the purpose of releasing the brakes, and recharging the system, to control the flow of air pressure to the excess pressure head of the low pressure governor, and to allow main reservoir air to charge up the application cylinder of the distributing valve, in emergency application position.

20. For what purpose is the independent brake valve?

Ans. To operate the engine brakes (as the name implies) independent of the train brakes.

21. For what purpose is the distributing valve?

Ans. The distributing valve takes the place of the auxiliary reservoirs, and triple valves (as used with other styles of brake equipment) and automatically controls the flow of air from the main reservoir to the brake cylinders, in a brake application, to maintain the brake cylinder pressure constant, regardless of brake cylinder, or pipe connection leaks, when the brake is being held applied, to automatically control the flow of air from the engine, and tender, brake cylinders, when it is desired to graduate off, or release the brakes.

22. What is the purpose of the brake cylinders, on engine and tender?

Ans. The brake cylinders are where the expansive force of the confined compressed air is made to perform its work, forcing out a piston which in turn is connected to a suitable set of rods, and levers, forcing against the wheels metal shoes, retarding the motion, or bringing to a stop a vehicle.

23. How many brake cylinders are there on an engine and tender?

Ans. There are two cyinders on the engine, and one on the tender.

24. Why is it that there are two cylinders on the engine, and only one on the tender, or a car?

Ans. There are two cylinders on the engine due to the fact that with its great weight, it would be impossible to develop sufficient power, in a single cylinder without making it excessively large, for the position in which it has to be installed. The tender, or a car furnishes a better place for the cylinder, levers and rods, and the weight to be contended with is not so great.

25. When the brake is applied is there as much pressure exerted on the shoe as there is in the cylinder?

Ans. There is a much greater pressure exerted on the shoe than is developed in the brake cylinder.

26. This being true, how is such a condition brought about?

Ans. This condition is brought about by a system of suitable levers, which are so proportioned in points of construction, that the power of the cylinder is compounded to the proper shoe pressure for each wheel, according to the brake power of the vehicle, and its permissive brake power due to its light weight.

27. What is the braking power percentage?

Ans. Passenger cars are braked to 100 per cent. of their light weight, freight cars 70 per cent., tenders 100 per cent., locomotive driving wheels 75 per cent., engine trucks 75 per cent. The braking of the locomotive is calculated on its loaded weight.

28. How many positions has the ET, H6 automatic brake valve?

Ans. The H6 brake valve has 6 positions. They are full release, running, holding, lap, service, and emergency.

29. What are the names of the pipe connections, to the automatic brake valve, and what is the purpose of each?

Ans. (Main reservoir pipe.) This pipe is to permit air from the main reservoir to flow to the chamber above the rotary valve, and when the rotary valve is in full release position, allows air at its highest pressure to flow into the brake pipe, producing a rapid recharge of brake pipe, and auxiliaries, and a prompt release of brakes, if a brake application has been made.

30. (Feed valve pipe.) This pipe connects the feed valve to the under side of the rotary valve. When the handle of the automatic brake valve is in running position, the pressure in this pipe is free to flow to the brake pipe, maintaining a constant pressure, in the brake pipe equal to the tension of the regulating spring of the feed valve.

31. (Equalizing reservoir pipe.) This pipe connects the chamber above the equalizing piston, and black hand of the air gauge, with the little drum or equalizing reservoir.

32. (Brake pipe.) This pipe connects the distributing valve on the engine, and the triple valve on each car with the underneath side of the equalizing piston or equalizing discharge piston, and the underneath side of the rotary valve.

33. (Governor pipe.) This pipe makes a connection from the rotary valve chamber to the underneath side of the diaphragm, in the excess pressure head of the low pressure governor, when the handle of the automatic brake valve is in either full release, running, or holding positions.

34. (Distributing valve release pipe.) This pipe makes a connection from the application chamber of the distributing valve, through the independent brake valve to the underneath side of the rotary valve in the automatic brake valve. This forms a communication to the atmosphere, when the handles of both the

automatic, and independent brake valves are in running position.

35. (Application cylinder pipe.) This pipe connects the under side of the rotary valve direct with the application cylinder in the distributing valve When the automatic brakes are applied in emergency, this pipe is open to allow the pressure in the rotary chamber (main reservoir), to pass to the application cylinder, through the blow down timing port.

36. When is release position of the automatic brake valve used?

Ans. Release position of the automatic brake valve is used to charge a train at terminals, and to release brakes on long trains.

37. Trace the flow of air through the automatic brake valve in full release.

Ans. With the rotary valve in this position, main reservoir pressure flows through a large port in the rotary valve, direct to the brake pipe, also through suitable ports to the equalizing reservoir, and pump governor. With the rotary in this position feed valve air flows through the warning port to the atmosphere, giving the engineer warning that the valve is in full release, with the danger of overcharging, and destroying excess pressure.

38. Trace the flow of air through the automatic brake valve in running position and when is this position used?

Ans. Running position is used when it is desired to obtain the benefits of the feed valve attachment, with its predetermined pressure below main reservoir pressure. In this position it is possible to obtain and maintain a certain amount of excess pressure, as well as to release the brakes on engine and tender or a short train, the distributing valve release pipe forming a connection in this position allowing the brakes on engine and tender to release. In running position the air from the feed valve flows through a port in the rotary valve direct to the brake pipe, and equalizing reservoir. In this position the main reservoir flows through proper ports, and pipe connections to the diaphragm chamber, of the excess pressure head or the duplex governor. Also proper port, and pipe connections, have been set up to allow the pressure in the distributing valve to escape to the atmosphere, through the independent brake valve, the distributing valve release pipe, the underneath side of the rotary in the automatic brake valve, and then to the atmosphere through the direct application, and emergency exhaust port.

39. Trace the flow of air through the automatic brake valve in holding position and when is this position used?

Ans. The air flows through the rotary of the automatic brake valve, in holding position in the same manner that it does in running position with the exceptions that the port and pipe connections of the distributing valve release pipe is not set up, hence the engine and tender brakes do not release. This position is used when it is desired to release the train brakes, and recharge, without loosening the holding power of the engine and tender brakes.

40. Is there any flow of air through the automatic brake valve in lap position, and when is this position used?

Ans. There is no flow of air through the automatic brake valve in this position. Lap position is used to hold the brakes applied after an automatic application of the brakes. The brake valve should never be carried in this position at any other time.

41. Trace the flow of air through the brake valve in service position, and when is this position used?

Ans. In the automatic brake valve, the equalizing piston forms what is known as the equalizing discharge valve. The brake pipe pressure is always on the underneath side of this piston, and equalizing reservoir, or chamber D pressure on top of it. When it is desired to apply the brakes in service application the rotary in the engineer's brake valve is so moved that the preliminary exhaust sets up proper communication between chamber D (the pressure on top of the equalizing piston) and the exhaust cavity, allowing the chamber D pressure to escape to the atmosphere. The pressure being reduced on top of the piston, the pressure on the underneath side of the piston (brake pipe pressure) causes the equalizing piston to be raised up, unseating the equalizing discharge valve, allowing brake pipe pressure to escape to the atmosphere so long as the reduction in chamber D continues. The reduction in chamber D being stopped, the equalizing piston is forced to the bottom of its bushing seating the equalizing discharge valve. This being accomplished the brake pipe air is gradually stopped, and the reduction in its pressure causes the service application of the engine and train brakes. (The manner in which the distributing valve sets the brake will be explained later.) The service application is used when it is desired to apply the brakes gradually, thus making much more smooth and accurate stops, with the least possible amount of damage to the load, or to the equipment.

42. **What is the purpose of the service exhaust fitting, at the termination of the equalizing discharge valve?**

Ans. The purpose of this fitting is to so proportion the exhaust opening, that the brake pipe pressure will be discharged gradually with all length of trains in a service application.

43. **Under what conditions should the emergency position be used?**

Ans. This position should only be used in actual cases of emergency, or when it becomes necessary to make as short a stop as possible. When using emergency the brake valve should be moved to this position all allowed to remain there until the train comes to a full stop, and under certain conditions until a signal is given to release.

44. **Trace the flow of air through the brake valve in emergency application, position.**

Ans. When the handle of the automatic brake valve is placed in emergency position, a direct opening between the brake pipe, and the atmosphere is formed by the rotary valve, and the direct application emergency exhaust, allowing a sudden, heavy reduction in brake pipe pressure to be made. At the same time the pressure in the equalizing reservoir (chamber D) is allowed to escape to the atmosphere through a suitable port in the rotary valve, and air at main reservoir pressure is fed through a restricted port (blow down timing port) to the pipe connection leading to the application cylinder, of the distributing valve, assisting in building up, and regulating the pressure in the application cylinder during emergency application of the brakes.

45. When should the automatic brake valve not be used?

Ans. The automatic brake valve should not be used when light engine movements are being made as in order to release, the tendency is to over charge, and the brakes creeping on cause trouble. If found necessary to use the automatic under any circumstance, the handle of the brake valve should be placed in running position, in order to release.

S6 INDEPENDENT BRAKE VALVE.

46. For what purpose is the independent brake valve?

Ans. The purpose of the independent brake is to operate the engine brakes, independent of the automatic, or in conjunction with it. The brake cylinder pressure may be increased or decreased at will with the independent brake valve, or in case it for reason becomes necessary, the entire pressure of the engine and tender brake cylinders may be quickly exhausted to the atmosphere, by placing the handle of this brake valve in its full release (or driver brake bleed cock position).

47. **What are the positions of the independent brake valve?**

Ans. There are five positions, and they are release, running, lap, service, slow application, and quick application.

48. **What are the pipe connections for, leading to the independent brake valve?**

Ans. (Reducing valve pipe.) This pipe connects the reducing valve to a chamber above the rotary valve, this being the manner in which air is supplied to the independent brake valve. When the handle of this valve is moved to either of the application positions, this air feeds through a port in the rotary valve, to the application cylinder and chamber, of the distributing valve. When the rotary valve is in release position this air escapes through the warning port.

49. Distributing valve release pipe.) This pipe makes a connection from the application chamber to the underneath side of the rotary in the independent brake valve. When the handle of the independent brake valve is in running position, this pipe is connected to the automatic brake valve (underneath side of the rotary) by means of ports, in the seat, and a cavity in the rotary of the independent brake valve.

Aside from the connection between the distributing valve, there is a pipe connection between the independent and automatic brake valves, with the handles of both these valves in running position, a free passage is set up from the application chamber to the atmosphere.

50. (Application cylinder pipe.) This pipe connects the application cylinder to the underneath side of the rotary valve in the independent brake valve. When the handle of the independent brake valve is placed in either of the application positions, air from the chamber above the rotary flows through proper ports, and this pipe connection to the application cylinder of the distributing valve. When the handle of the independent brake valve is placed in release position, this pipe is connected to the atmosphere, through suitable ports in the rotary valve and its seat.

51. At what time should release position be used?

Ans. This position should be used when the handle of the automatic brake valve is in any other position, other than running, and a release of the brakes is desired, without affecting the features of the automatic brake valve.

52. Trace the flow of air through the independent brake valve in release position.

Ans. The air in the application cylinder of the distributing valve passes direct through the application cylinder pipe to the atmosphere, through the rotary of the independent brake valve. At the same time the air in the rotary valve chamber (reducing valve pressure) flows through the warning port in the rotary to the atmosphere.

53. Trace the flow of air through the independent brake valve in running position, and explain when this position is used?

Ans. The air takes the same course in the independent brake valve in running position that it does in running position of the automatic brake valve. In this position the distributing valve release pipe through its port and pipe connections allows the pressure in the application cylinder, and chamber to escape to the atmosphere. This position is used when running along the road, when standing or when (the automatic brake valve in running position) it is desired to release the brakes after an independent application.

54. Trace the flow of air through the independent brake valve in lap position, and explain when this position is used.

Ans. With the independent brake valve (as with the automatic) on lap, there is no movement of the air, through any port, or pipe connection. Lap position is used when holding the brakes applied after an independent application.

55. When should slow application position be used?

Ans. This position should be used when space and time will permit of a gradual application of the brakes.

56. Trace the flow of air through the independent brake valve in slow application?

Ans. Air from the chamber above the rotary (reducing valve pressure) flows through the service port (slow service port is restricted) and application cylinder pipe, to the application cylinder and chamber of the distributing valve.

57. **Trace the flow of air through the independent brake valve in quick application, and explain when this position should be used.**

Ans. In full service, or quick service application of the brakes, with the independent brake valve, the service port is full open, and the air from the chamber above the rotary (reducing valve pressure) flows through the port in the rotary valve and application cylinder pipe to the application cylinder and chamber of the distributing valve. Quick service application position is used when by accident, or design, it is desired to apply the brakes quickly, with the independent brake valve.

58. **What provision is made to prevent the handle of the independent brake valve from remaining in quick service, or release position?**

Ans. A return spring, which when the hand is removed from the handle of the independent brake valve, returns the rotary to either running, or slow service position.

59. **Why is such a spring necessary?**

Ans. This spring is necessary in order to prevent a quick application, when only a slow, is desired, also to prevent leaving the handle in release position, which would release the engine and tender brakes, in case an automatic application was made.

60. What harm would result, in case the handle of the independent brake valve was left in release position, and a brake application made with the automatic brake valve?

Ans. The greatest possibility of damage being done lies in the fact, that the train is liable to break in two at any time, an air hose is liable to burst, the conductor is liable to open the angle cock, in case a signal cannot be transmitted to the head end, or for any reason were the brakes to apply suddenly without the action (or with the action) of the engineer, the handle of the independent brake valve being in release position, the engine and tender would not have a brake. The brake would apply but owing to the position of the handle of the independent brake valve, would quickly release. The engine working, or running away from the train, would in all probabilities, either pull out a draw bar, or do serious damage to draught rigging, shift the load, and etc.

61. Why is it necessary that the handle of the independent brake valve be moved by this spring?

Ans. This is necessary as in case it becomes necessary to leave the engine standing with the brakes applied, the flow of air to the application cylinder is limited.

DISTRIBUTING VALVE.

Plain Cylinder Cap.

62. What is a distributing valve?

Ans. The distributing valve (as its name implies) distributes the supply of air in the engine and tender brake cylinders, in a brake application with the ET Equipment, No. 6. The distributing valve is a clever mechanical appliance, the construction of which will be taken up later, combining all the features of the triple valve and auxiliary reservoir, and several additional ones, explained later.

63. How does this valve control the flow of air to the brake cylinder on the engine and tender?

Ans. The distributing valve permits air from the main reservoir to flow to the brake cylinders, when applying the brake, and from the brake cylinders to the atmosphere, when it is desired to release the brakes. This valve automatically maintains this pressure constant regardless of brake cylinder, and pipe connection leaks, so long as there remains a pressure in the main reservoir, or the ability of the pump is not exceeded to supply the leak.

64. What is the performance of the distributing valve similar to?

Ans. The distributing valve performs its work much the same as the reducing valve (combined automatic and straight air) supplying the air to the brake cylinders.

65. If when standing facing the distributing valve (the side with two pipe connections) you were asked what these two pipes were for, and to what do they connect, what would you say?

Ans. The upper pipe on this side is called the cylinder pipe, and connects the distributing valve to the brake cylinders, on the engine and tender. This pipe allows the air from the distributing valve to flow to, and from, the brake cylinders, when the brakes on the engine and tender are applied or released. The lower of these two pipes is called the branch of the brake pipe, and connects the distributing valve to the brake pipe. This pipe supplies a compartment in the distributing valve (pressure chamber) with air at brake pipe pressure.

66. What are the names of the three pipes on the left, or opposite side, and to what do they connect?

Ans. The upper pipe is called the supply pipe, and connects the distributing valve to a pipe leading from the main reservoir.

The middle, or intermediate pipe is the application cylinder pipe, and it connects the distributing valve to both the independent and automatic brake valves.

The lower pipe is called the distributing valve release pipe, and it connects the distributing valve to the independent brake valve, through the independent brake valve, to the under side of the rotary in the automatic brake valve.

67. How many chambers, or compartments, are there in the distributing valve reservoir, and what is their names?

Ans. There are two compartments, or chambers, in the distributing valve, the names of which are pressure chamber, and application chamber, sometimes called dummy auxiliary, and dummy brake cylinder.

These two compartments are separated by a metal partition in the reservoir, and are at times connected by port, and pipe connections, set up by either of the brake valves, in their different positions, through the medium of slide and graduating valves.

68. How many pistons are there in the distributing valve?

Ans. There are two pistons the names of which are equalizing piston, and application piston.

69. How many slide valves are there in the distributing valve?

Ans. There are four slide valves in the distributing valve, the names of which are application valve, exhaust valve, equalizing valve, and graduating valve.

70. Which of these four valves is operated by the equalizing piston?

Ans. The equalizing and graduating valves are operated by the equalizing piston.

71. Which ones are operated by the application piston?

Ans. The application and exhaust valves are operated by the application piston.

72. With both the automatic, and the independent brake valves in running position (with the brakes released) what pressure is present in the distributing valve?

Ans. When these valves are in this position, and the brakes are released, there are three different pressures present in the distributing valve. They are main reservoir, brake pipe, and atmospheric pressure.

73. **Where in the distributing valve is each of these pressures found?**

Ans. Main reservoir pressure is found in the chamber above the application valve. Brake pipe pressure is found in the pressure chamber (dummy auxiliary) and in the chamber around the equalizing, and graduating valves. Atmospheric pressure is found in the chamber above the exhaust valve, and in all ports and cavities, on the left hand side of the application piston, and on the right hand side, or application cylinder side of the application piston.

74. **How is the chamber around the application valve charged?**

Ans. This chamber is charged to main reservoir pressure by a branch pipe leading from the main reservoir to the distributing valve.

75. **Describe and trace the flow of air through the distributing valve, when an application of the brakes is made with the independent brake valve.**

Ans. When the handle of the independent brake valve is placed in either slow, or quick service position, reducing valve pressure flows through suitable port in the rotary of the independent brake valve, to the application cylinder, and application chamber of the distributing valve. This causes the application piston to move closing the exhaust valves, and opening the application slide valve. Main reservoir pressure feeds to the brake cylinders, until such time as their pressure is slightly greater than application cylinder pressure, when the greater pressure, and the graduating spring, forces the application piston back to the left, closing the application slide valve, but does not move the exhaust valve owing to the lost motion on the piston stem. At the same time air is flowing to the brake cylinders, it is also flowing to the safety valve, through a cavity in the equalizing slide valve, and a port in its seat, from the application cylinder. This limits the brake cylinder to permissive amount of pressure in case there might be a defect in the reducing valve, which would allow it to become too great. In an independent application of the brakes the equalizing piston, slide, and graduating valves, do not move. The amount of brake cylinder pressure is limited by the amount for which the reducing valve is set, there always being the same pressure in the brake cylinders, that there is in the application cylinder. When the pressure on either side of the application piston is the same, the application piston moves to independent lap.

76. **In what manner are the brakes released, after they have been applied with the independent brake valve?**

Ans. When the handle of the independent brake valve is placed in release position, the air that is in the application cylinder, and chamber, is allowed to exhaust to the atmosphere, through the distributing valve release pipe, the rotary of the independent brake valve, the U pipe connection, between the independent, and automatic brake valves, and through a cavity in the rotary of the automatic brake valve, and then to the atmosphere, through the direct application emergency exhaust port. The pressure being exhausted from behind the application valve, piston in the application cylinder, the brake cylinder pressure, and graduating spring return the application piston to its normal running, or release position. The exhaust valve then uncovers the exhaust port, and the brake cylinder pressure is exhausted to the atmosphere. There is no movement of the equalizing piston, or its slide, and graduating valve, in independent release.

77. **In what manner is the pressure chamber charged?**

Ans. The pressure chamber (dummy auxiliary) is charged with air at brake pipe pressure, through a branch of the brake pipe, connecting at the distributing valve on the outer end of the equalizing piston. The air then feeds through a groove in the equalizing piston bushing (called the feed groove), around the equalizing piston into the equalizing valve chamber, then through proper ports into the pressure chamber, charging it up to the same pressure there is in the brake pipe. The pressure on either side of the equalizing piston is the same when fully charged up.

78. **From where do the application cylinder and chamber receive their supply of air during an independent or automatic application of the brakes?**

Ans. When the brakes are applied with the independent brake valve, the pressure in the application cylinder and chamber comes from the reducing valve.

When the brakes are applied with the automatic brake valve, the pressure in the application cylinder and chamber comes from the pressure chamber (dummy auxiliary).

79. **Describe the manner in which the distributing valve parts operate during an automatic application of the brakes. (Service application).**

Ans. When the automatic brake valve is placed in service application position a reduction is made (through proper ports in the rotary) in the equalizing reservoir pressure (chamber D). This reduction causes a like amount of pressure in the brake pipe to be reduced, and exhausted to the atmosphere, through the equalizing discharge valve fitting (brake pipe exhausts). This reduction in brake pipe pressure is likewise felt on the outer end of the equalizing piston in the distributing valve. The first movement of this piston (it moves by reason of a greater pressure being on the inside of the piston) to the right closes the feed groove in the equalizing piston bushing, and at the same time opens the graduating valve. This movement of the graduating valve sets up port connections leading to the safety valve, and as the piston continues its movement to the right, the fitting on the end of the piston stem engages the slide valve causing it to be moved to a position to set up port connections to the application chamber, and cylinder. The safety valve is in communication with the application chamber, and cylinder through proper ports in the equalizing slide valve. The pressure in the pressure chamber (dummy auxiliary) is now allowed to feed into the application chamber (dummy brake cylinder) and application cylinder. The amount of pressure obtained in the application chamber and cylinder depends upon the reduction made in brake pipe pressure.

The pressure in the application chamber and cylinder expands behind the application piston and forces it to the right against the tension of the graduating spring. This movement of the piston causes the exhaust valves to cover their seats, and the slide valve to open the port leading to the brake cylinders. When the pressure chamber (dummy auxiliary) pressure is reduced slightly below the brake pipe pressure, the brake pipe pressure being the greater, causes the equalizing piston to move to the left, and as it moves it closes the graduating valve, stopping the reduction in pressure chamber pressure. This movement of the equalizing piston does not move the equalizing slide valve, and the air that is now trapped between the graduating valve (in the application chamber, and cylinder), and the back of the application piston, causes the application piston to remain to the right, until such time as the pressure on the brake cylinder side is greater than the pressure in the application cylinder. The application piston then moves to the left, closing the application port to the brake cylinders with the application slide valve. The position of the parts in the distributing valve is now spoken of as being in service lap.

80. Describe the manner in which the brakes are released after an automatic application of the brakes. (With the automatic brake valve).

Ans. When brake pipe pressure is supplied to outer side of the equalizing piston, it moves to the left, against the lesser pressure in the pressure chamber, and as it moves, it takes with it the slide and graduating valves, opening the feed groove in the bushing and recharging the pressure chamber. In this position a port in the slide valve (equalizing slide valve) registers, with the distributing valve release pipe, leading to and through the rotary of the independent brake valve (when in running position) the U pipe connection between the independent, and automatic, brake valves, a cavity in the rotary of the automatic brake valve, and through the direct application emergency exhaust port to the atmosphere. The pressure in the application cylinder and chamber is quickly exhausted to the atmosphere, which allows the greater pressure, and graduating spring to return the application piston to its normal running, or release position. This movement of the application piston causes the exhaust valves to uncover their seats, and the pressure in the brake cylinders is quickly exhausted to the atmosphere through the exhaust elbow on the distributing valve.

81. Describe the manner in which the brakes are

released with the independent brake valve after an automatic application.

Ans. When the brakes are to be released, with the independent brake valve, after an automatic application (the automatic brake valve being on any position except running) the handle of the independent brake should be placed in release position. This allows the pressure in the application cylinder and chamber to flow direct to the atmosphere through the application cylinder pipe, and the central exhaust cavity in the rotary of the independent brake valve. As soon as the air in the application cylinder is exhausted to the atmosphere, the application piston is forced to its normal running, or release position, allowing the pressure in the brake cylinders to be exhausted to the atmosphere, through the exhaust elbow on the distributing valve. When the brakes are released in this manner, the equalizing piston does not move, in other words it remains in service lap. Should there be a slight leak in the brake pipe, the brakes will reapply, and the release in the manner described will be necessary.

82. Describe the manner in which the distributing valve operates in an emergency application of the brakes). Not equipped with quick action cylinder cap).

Ans. A heavy brake pipe reduction in brake pipe pressure causes the pressure on the plain side of the equalizing piston in the distributing valve to be quickly exhausted to the atmosphere. This heavy sudden reduction allows the greater pressure in the pressure chamber to force the equalizing piston, its full travel to the right against the graduating spring, compressing it. In this position the pressure chamber pressure is free to flow to the application cylinder, through suitable ports in the seat of the equalizing piston, slide valve, the application chamber does not receive any air due to the fact that the port leading to it is blanked. The safety valve is connected by a restricted port from the application cylinder, this limiting the brake cylinder pressure to permissive amount. The air admitted behind the application piston quickly expands in the application cylinder, forcing the application piston, and with it the slide valve to the right. This allows the exhaust valves to cover their seats, and main reservoir pressure to be admitted to the brake cylinders, until such time as the distributing valve parts move to emergency lap position.

83. About what cylinder pressure is obtained from 70 pounds brake pipe pressure, in service application of the brakes?

Ans. There will be a pressure of 50 pounds in the brake cylinders after a full service application of the brakes under these conditions.

84. What cylinder pressure will be obtained with a 70 pound brake pipe pressure when an emergency application of the brakes is used?

Ans. There will be a pressure of about 70 pounds in the brake cylinders at first, but the safety valve set at 68 pounds reduces the pressure to this amount.

85. Why is it that a greater pressure is obtained in emergency than in service applications of the brakes?

Ans. When the brakes are applied in service application, the pressure chamber is connected to both the application chamber, and application cylinder, the size of which is such that, the combined volumes of both the application cylinder and chamber will equalize with the pressure chamber at about 50 pounds pressure during a full service application of the automatic brake. When the brakes are applied in emergency, the pressure chamber pressure does not flow to the application chamber, but direct to the application cylinder, the size of which is comparatively small, causing the pressure chamber and application cylinder pressures to equalize at about 65 pounds. Also during emergency applications, air from the main reservoir is admitted through a small restricted port, called the blow down timing port, through the application cylinder pipe to the application cylinder. This port is so proportioned in size to compare with port in the equalizing valve leading to the safety valve, that the pressure in the brake cylinder has time to reduce, to the tension of the safety valve spring.

86. Does brake cylinder leakage, or unequal piston travel effect the brake cylinder pressure? Why?

Ans. These things do not effect the cylinder pressure, as the main reservoir furnishes the air that fills the brake cylinders, and this supply is practically unlimited. The piston travel may effect the brake leverage to a certain extent, but the brake cylinders receive the same pressure so far as equalization is concerned. The pressure chamber, application chamber, and application cylinder volumes is practically constant. A leak in the application cylinder would allow the brakes to release, while a leak in the brake cylinders would cause the pressure in the application cylinder to keep the application piston to the right, which when in this position allows the slide valve to remain open supplying air from the main reservoir to the leak.

87. Is there any great advantage gained from the use of the quick action cylinder cap?

Ans. This quick action cap acts much the same as the quick action triple, in that it causes serial application of the brakes, when double heading, and it is desired to use emergency application. The operation of the quick action cylinder cap will be taken up later.

SAFETY VALVE.

88. What is the safety valve?

Ans. The safety valve, is a mechanical appliance, consisting of a suitable brass body in which are found a valve, stem, and a regulating or tension spring.

89. For what purpose was the safety valve designed?

Ans. The safety valve, as its name implies, was designed to prevent excessive brake cylinder pressure, and to perform the functions of the high speed reducing valve, when high speed brake pressures, were being used.

90. To what part of the equipment is the safety valve connected with the ET equipment?

Ans. The safety valve is connected to the application cylinder of the distributing valve, and is in communication with this pressure at all times except during automatic service lap.

91. To what pressure is the safety valve adjusted?

Ans. The safety valve is adjusted to 68 pounds, but should be re-adjusted to from 35 to 40 pounds when an engine is being hauled dead in the train (dead engine feature cut in), there being no water in the boiler.

QUICK ACTION CYLINDER CAP.

92. What is the quick action cylinder cap?

Ans. The quick action cylinder cap is a mechanical contrivance, consisting of a suitable cast body, in which are operated a series of check valves, in connection with tension springs. This device is made to bolt to the outer head of the equalizing piston bushing, in the distributing valve, and its purpose is to assist the triple valves produce serial action of emergency application of the brakes when it is so desired.

93. Does this device operate an any other time except in emergency.

Ans. This device does not operate at any other time except in emergency.

94. Why is it necessary that this device be used?

Ans. It is necessary to use this device to assist in obtaining emergency applications of the brakes, when two or more engines are coupled together.

95. In what manner does this device assist in this performance?

Ans. By actuating quick action in the same manner that a quick action triple valve does.

96. Does the operation of this device increase the brake cylinder pressure, as in the case of the quick action triple valve?

Ans. No, as the brake cylinder pressure (with the ET equipment) is governed by the application cylinder pressure in the distributing valve.

97. Is there any advantage in the use of this device, over the quick action triple valve?

Ans. The only advantage in its use lies in the fact that it is less sensitive, and consequently not so liable to cause undesired quick action.

98. How is it then that results are obtained, if this device be less sensitive?

Ans. The quick action cylinder cap is much closer to the brake valve, and is of course effected by a heavy brake pipe reduction, much easier than the triple valve would be (as installed in the ordinary brake equipment). This reduction being felt produces the results for which it was designed, without the sensitive features of the quick action triple valve.

99. When the distributing valve is so equipped, is there, or should there be, a different method followed in handling?

Ans. The equipment should be handled in the same manner as though the distributing valve was not so equipped. The quick action cylinder performs no function in the brake application, only in emergency, and requires no special brake valve manipulation, in order to produce the desired results.

100. **Describe the manner in which the quick action cylinder cap operates?**

Ans. When the handle of the automatic brake valve is placed in emergency application position, the heavy brake pipe reduction is felt in the chamber around the plain side of the equalizing piston in the distributing valve. This allows the equalizing piston to move to the right, and as it does so it strikes the stem of the slide valve in the quick action cylinder cap, compressing the graduating spring in connection with this valve. The fact that this spring is compressed allows a movement to the slide valve which uncovers the port in its seat, and allows brake pipe pressure to flow to the check valve, in the lower part of the cap. This pressure unseats the check valve, and allows the brake pipe pressure to flow to the brake cylinders through a port in the distributing valve body. The local brake pipe reduction in turn causes serial application of all triples throughout the train.

101. **What takes place when the brakes are released so far as the quick action cylinder cap is concerned?**

Ans. The graduating valve returns the slide valve to its normal position, covering the port in its seat, and the spring under the check valve returns the check valve to its normal position.

102. **Is it absolutely necessary that the ET**

equipment be equipped with this device, in order to insure emergency?

Ans. So long as a single engine is used on a train it would not be necessary, but in case of double heading, emergency application of the brakes on the train might not be obtained, owing to the length of crooked piping, and the frictional resistance offered to the air in its travel through the two engines might prevent emergency.

B 6 FEED VALVE.

103. **What is a feed valve, as spoken of in connection with air brake equipment?**

Ans. A feed valve is a mechanical appliance, consisting of a suitable cast body in which are found, several different parts, namely: Regulating spring diaphragm, pin valve, supply valve, and piston. The feed valve, is a form of brake pipe control, or brake pipe governor, limiting the brake pipe pressure to a predetermined standard.

104. **How does the B6 feed valve differ from other styles of feed valves?**

Ans. The B6 feed valve aside from several points in construction is the same as other styles of feed valves. The main feature in this valve's construction is, a ready means of changing the adjustment of the valve from high to low, or from low to high pressure as is desired.

105. **Explain this feature of adjustment.**

Ans. The adjusting nut is provided with a hand wheel, the adjusting nut operating in a quick thread.

The case of the adjusting nut has two lugs, or fins, so placed on its body that by turning the adjusting screw to one, gives a high brake pipe pressure, to the other gives a low brake-pipe pressure.

106. Is there any particular point to which the feed valve is attached?

Ans. The feed valve is fastened to a bracket in the pipe connection between the main reservoir and the engineer's brake valve.

107. Why is it necessary to fasten the feed valve to a bracket, and not directly to the engineer's brake valve as is done with other styles of equipment?

Ans. The feed valve is so fastened in order that it may be easily removed, and being in the pipe connection is out of the way of the man on the seat.

108. What two operative parts are there in the feed valve?

Ans. The feed valve consists of a supply portion, and a regulating portion.

109. What are the duties of the regulating parts of the valve?

Ans. The regulating parts control the movement of the supply valve piston, and the supply valve, when the port in the seat of the supply valve is either open or closed.

110. Trace the flow of air through the feed valve in its open position.

Ans. Air from the main reservoir flows into a chamber, in which is found the supply valve piston, causing this piston to move to the left, compressing a spring behind his piston. As the piston moves it carries with it a slide valve, uncovering a port in its seat, that allows main reservoir pressure to feed through to the regulating parts. At the same time the air is feeding through this port in the slide valve seat it is also passing around the piston (which is not an airtight fit), through a port leading to the pin valve in the regulating part. The air admitted in these two ways flows through a port in the case, leading to the brake pipe connections (known as the feed valve pipe).

111. **What causes the flow of air from the main reservoir to stop?**

Ans. When the pressure in the feed valve pipe, and on the diaphragm in the regulating part, exceeds the tension of the regulating spring, this spring becomes slightly compressed, and in doing so alows the pin valve to seat.

The main reservoir air continues to leak by the supply valve piston, and it finding the pin valve closed quickly equalizes with the pressure on the opposite side of the piston. The spring behind the piston then forces the piston to the left, carrying with it the slide valve, which covers the port in its seat, stopping the flow of air from the main reservoir to the feed valve pipe.

112. **What causes the feed valve to again open, and supply air to the feed valve pipe?**

Ans. The diaphragm chamber, always being in communication with the feed valve pipe, feels any reduction in the feed valve pipe pressure, and as soon as there is a noticeable reduction in this pressure the regulating spring being compressed, is then allowed to return to its normal condition. This action of the spring straightening out causes the pin valve to be forced open against the slight tension of its spring. The balance of pressures on either side of the supply valve piston being destroyed, the greater main reservoir pressure forces the piston to the left again and with it the slide valve opening the port in its seat, supplying air to the feed valve pipe as before explained.

113. **Is there any advantage in this style of feed valve over a style called the Poppet valve?**

Ans. The main advantage lies in the fact, that with the slide valve type a wide open charging port is maintained longer with the slide valve type, owing to the regulating features of the two valves. With the Poppet valve the supply port began to close as soon as there was tension put on the regulating spring, while with the slide valve type the pressure for which the tension spring is set must be reached before the slide valve closed the port.

C6 REDUCING VALVE.

114. **Is there any difference between the reducing valve, and the feed valve?**

Ans. The only difference lies in the manner of adjustment. The operation of one is identical with the other. The reducing valve is used in connection with the independent brake valve, while the feed valve is used in connection with brake pipe control, in the automatic brake valve.

115. **If these valves be much the same why are they not called the same?**

Ans. The reducing valve is so called in order to distinguish it from the feed valve, when reporting work.

116. **In case for reason it became necessary to change the reducing valve to feed valve bracket, would the operation of the reducing valve answer the purpose of the feed valve?**

Ans. The reducing valve would fill the wants of the feed valve, all that would be necessary in making this change would be to adjust the reducing valve to the desired brake pipe pressure, put a blind gasket in the reducing valve bracket, to prevent a waste of main reservoir air, and proceed.

117. **This change being made what effect would it have on the operation of the independent brake?**

Ans. It would be impossible to apply the brakes on the engine and tender with the independent brake valve, all other features of the independent brake would remain the same.

118. **Suppose by accident or design the feed valve was placed on the reducing valve bracket, and the reducing valve was placed on the feed valve bracket, what effect would this change have on the operation of the brakes? (Feed valve adjusted to 70** pounds, and reducing valve adjusted to 45 pounds.)

Ans. The reducing valve set at 45 pounds would limit the brake pipe pressure to that amount, an automatic application of the brakes could be made, the cylinder pressure corresponding to equalization of this pressure in the distributing valve parts. The feed valve being set at 70 pounds, would in a quick service application of the brakes with the independent brake valve, give too great a cylinder pressure. The safety valve adjusted to 68 pounds could not reduce cylinder pressure below this amount, and the results would be slid flat wheels.

119. **In case this condition should exist, what should be done?**

Ans. Each valve should be adjusted to its proper pressure, regardless of the change made in the location.

SF-4 PUMP GOVERNOR.

120. **What is a pump governor?**

Ans. A pump governor is a mechanical appliance, consisting of a suitable brass body, in which are found following operative parts; a regulating spring, diaphragm, pin valve, governor piston, and steam valve.

121. **For what purpose is a pump governor?**

Ans. A pump governor is for the purpose of giving the pump automatic control.

122. **Where is the pump governor generally located?**

Ans. The pump governor is generally located outside of the cab, in the steam pipe between the boiler and the pump.

123. Explain the general arrangement of the SF-4 pump governor.

Ans. This governor is of the duplex type, having two regulating tops, connected to a Siamese fitting having one stem valve portion.

124. Are the diaphragm portions, or regulating portions, designed any different from the ordinary duplex governor?

Ans. Yes, the low pressure portion, or low pressure head, is what is known as the excess pressure head of the governor. This portion of the governor has two pipe connections leading to it, one a main reservoir pipe connection, the other a feed valve pipe connection. The maximum pressure, or high pressure head, is identical with the ordinary governor, it having but one connection, and that being a main reservoir pressure connection.

125. What is meant by the term (excess pressure) head of the governor?

Ans. This term has reference to the excess pressure spring, on top of the diaphragm, in the governor. Through the medium of this spring, and the feed valve pipe connection, it is possible to maintain an excess pressure equal to the tension of this spring (generally 20 pounds), regardless of the fact that the brake pipe pressure is above normal, or standard (in which case excess pressure was destroyed with the ordinary duplex governor).

126. In what positions of the automatic brake

valve does the excess pressure head of the governor have control of the pump?

Ans. This head of the governor has control of the pump, when the handle of the automatic brake valve is in full release, running, or holding positions.

127. **In what positions of the automatic brake valve does this head of the governor loose control of the pump?**

Ans. The excess pressure head of the governor looses control of the pump, when the handle of the automatic brake valve is in either lap, service, or emergency positions.

128. **If this be the case, what has control of the pump in these positions of the automatic brake valve?**

Ans. When the handle of the automatic brake valve is in either lap, service, or emergency positions, the maximum pressure, or high pressure head of the governor has control of the pump.

129. **When the handle of the automatic brake valve is in either full release, running, or holding position, what pressure is exerted on the diaphragm of the excess pressure head of the governor?**

Ans. When the automatic brake valve is in either of these positions, air from the main reservoir flows through the automatic brake valve, and a pipe connection leading to the underneath side of the diaphragm, also air from the feed valve pipe flows through a pipe connection leading to its connection at the top of the governor, in addition to the air pressures exerted on the diaphragm. The excess pressure spring exerts itself on the top of the diaphragm.

130. **What is the adjustment of the spring?**

Ans. The excess pressure spring in the low pressure governor is adjusted to 20 pounds. This pressure sometimes varies, but in case the spring is light, a greater tension can be put on it by screwing down on the regulating nut.

131. **What two pressures are there acting on top of the diaphragm, in the excess pressure head of the governor?**

Ans. The pressure of the feed valve pipe (brake pipe) plus the tension of the excess pressure spring.

132. **What pressure overcomes this spoken of pressure, and how great a pressure does it require to raise the diaphragm, in order that the governor can stop the pump?**

Ans. It requires a greater pressure than the combined pressure of the feed valve, and excess pressure spring pressure underneath the diaphragm to overcome these spoken of pressures, as for example, with 70 pounds pressure from the feed valve pipe plus the 20 pound spring, acting on top of the diaphragm it would require a little over 90 pounds of main reservoir pressure to raise the diaphragm against this combined pressure, and thus allow the governor to stop the pump.

133. **In what way does the feed valve variation of pressure effect the operation of the excess pressure head of the governor?**

Ans. When the adjustment of the feed valve is changed from one pressure to another, such as when using the high or low pressures, the added feed valve pressure (or subtracted), on top of the excess pressure spring, and diaphragm, causes the governor to automatically adjust itself to the required pressure, in order to maintain 20 pounds of excess in running position.

134. **In what way is this an advantage?**

Ans. This is a decided advantage in that it always insures a main reservoir pressure sufficient to maintain the 20 pounds of excess pressure. Its operation being automatic makes less trouble when changing from one standard to the other as well as possible troubles arising from a failure to cut out the high main reservoir pressure when reducing the pressures to the lowest standard.

135. **To what pressure is the maximum pressure head of the governor connected?**

Ans. This governor is connected to main reservoir pressure at some convenient point back of the main reservoir cut-out cock.

136. **Is there any difference in the operation of this governor to the excess pressure governor?**

Ans. There is practically no difference in as far as shutting off the supply of steam to the pump is concerned, but this governor has not the excess pressure spring, or any of its features, as just spoken of.

137. **When does this governor stop the pump?**

Ans. This governor takes control of the pump at such times as when the low pressure head is cut-out, by the position of the engineer's brake valve, or at times when the tension spring, through accident or design, was adjusted lower than the regulating features of the low pressure, or (excess pressure head).

138. **Is the maximum pressure head controlled in any way by the engineer's brake valve?**

Ans. No, as this governor is in no way connected to, or through, the engineer's brake valve.

139. **Why is it necessary to have two main reservoir controls?**

Ans. This is necessary in modern train service as when running along the road (the handle of the engineer's brake valve in running position) 20 pounds of excess is sufficient to supply brake pipe leaks, should any exist, and to operate all air operated devices without interfering with the brake pipe pressure. But when the brakes have been applied, the 20 pounds, plus the 20 pounds gained by reason of the brake application is in some cases not sufficient to get a prompt release of brakes on an exceptionally long train, hence the necessity for a greater main reservoir pressure, and the double control. It is not advisable to have the pump working at all times against high main reservoir pressure, so the double control makes it possible to obtain these pressures as they are desired.

140. **How is it that the low pressure governor automatically cuts out of service when the brake valve is moved to any position beyond holding position?**

Ans. The rotary in the engineer's brake valve breaks the port and pipe connection, when the valve is moved to any position beyond holding, hence as there is no air in the diaphragm chamber, the governor becomes inoperative.

DEAD ENGINE FEATURE.

141. What is the dead engine feature?

Ans. The dead engine feature is a form of mechanical appliance, consisting of the following operative parts, a suitable cast body, in which are found a compartment containing curled hair that acts as a strainer, a check valve, and a regulating spring. The spring has but a light tension and is for the purpose of holding the check valve to its seat. The hair strainer and restricted passage in the body of this device causes a very gradual flow of air from the brake pipe to the main reservoir.

142. For what purpose is the dead engine feature used?

Ans. This device is used (when cut-in) to enable the pump on the live engine to charge up the main reservoir, so that the brakes on the dead engine may be operated in conjunction with other brakes on the train.

143. Why is this necessary?

Ans. This is necessary due to the fact that the air for the brake cylinders, with the ET equipment comes from the main reservoir. The engine being dead or otherwise unable to supply its own air, when being hauled in a train would have no brake were it not for this feature.

144. About what pressure is in the main reservoir, when the dead engine feature is cut-in?

Ans. The pressure varies with the tension of the spring on top of the check valve, being considerable less than the brake pipe pressure.

145. Suppose the boiler contained no water, what would be advisable, when using this feature, and no one was riding the engine?

Ans. It would be advisable to reduce the tension on the regulating spring of the safety valve, so that it would allow but about 30 or 35 pounds brake cylinder pressure.

146. Why would this be necessary?

Ans. The boiler containing no water would be considerable lighter, and this would in a certain sense increase the braking power, which would be liable to cause the drivers to lock and slide (flat wheels the result).

147. For what purpose is the one-inch cut-out cock in the brake pipe, underneath the engineer's brake valve?

Ans. The cut-out cock is for the purpose of cutting out the automatic brake valve, when double heading, or for any other reason such as when cleaning certain parts of the equipment, when hauling the engine dead in a train, the dead engine feature cut-in, or at a time when the engine was broken away from the tender, and it was wished to operate the brakes. This cut-out cock either cuts out, or cuts in the brake pipe as is desired.

148. For what purpose is the strainer in the brake pipe underneath the brake valve?

Ans. This strainer is to prevent foreign matter from working back into the distributing valve, thus seriously effecting the operation of the distributing valve.

AIR SIGNAL SYSTEM.

149. What is the air signal system?

Ans. This is a system, consisting of certain operative parts, by means of which signals from an air operated whistle are transmitted from trainmen to enginemen, on the engine, through the medium of signal line pressure reductions.

150. From what source does the signal line receive its supply of air?

Ans. The signal line pressure is received from the reducing valve used in connection with the independent brake valve, through a special fitting known as a combined check valve and strainer. This pressure like all other pressures, has its real source, or fountain head in the main reservoir, but when speaking of the beginning, we take it at its nearest pipe connection to the main reservoir.

151. In what manner does the reducing valve govern the two pressures, signal line, and independent brake pressure?

Ans. The reducing valve being set for 45 pounds allows a pressure of 45 pounds to feed to the combined strainer, and check valve. The independent brake not having such a device, gets its air direct from the reducing valve. Thus the reducing valve answers two purposes, with the ET equipment.

152. **For what purposes are the strainer and check valve?**

Ans. The strainer is for the purpose of preventing any foreign substance working back into the signal line system, thus destroying the action of some of the operative parts. The check valve is to prevent a back flow of air, from the signal line, to the reducing valve pipe.

153. **Is there any difference in the construction of this combined check valve, and strainer, to the one used with the dead engine feature?**

Ans. The two devices operate identically the same, the only difference in construction being that the tension of the check valve spring is greater in the one used in connection with the signal line than the dead engine feature.

154. **In regards to defects in the operation of the signal system is there any difference between the signal system of the ET equipment and the system used in connection with other styles of brake equipment?**

Ans. The defects of one system are the same with all with the exceptions of a possible defect in the combined check valve and strainer, the rest of the signal system being the same so far as operative parts are concerned.

155. **In what part of this book is there further information in regards to signal line defects?**

Ans. In the third years' air brake examination.

DEFECTS, BROKEN PIPES.

156. Are there defects in connection with broken pipes that can be in a measure repaired, while on the road?

Ans. Yes, there are many defects in connection with the operation of the different parts, and pipe connections, that can be so repaired that the engine can complete the trip.

157. Would it be sufficient grounds to cause an engine failure, by reason of the fact that certain operative features of the equipment had been destroyed due to broken pipes?

Ans. There would of course be exceptional cases, but ordinarily the defects spoken of can be so repaired that the engine will be able to continue the trip, even though certain operative features have been destroyed.

158. What would be the effect if the brake pipe branch to the distributing valve broke off?

Ans. This would of course cause the locomotive and train brakes to apply, by reason of a reduction in brake pipe pressure.

159. What would be done in case this should happen?

Ans. The broken pipe could be plugged, towards the pressure. If it could not be otherwise repaired, the locomotive brakes could be released by placing the handle of the independent brake valve in release position. The engine would then be ready to proceed.

160. What effect would this defect have on the operation of the distributing valve?

Ans. In case the brake pipe branch to the distributing valve were broken off, it would be impossible to obtain an automatic application of the engine and tender brakes, with the automatic brake valve, but this would in no way interfere with the operation of train brakes, with the automatic brake valve.

161. **How then could engine and tender brakes be applied and released?**

Ans. The engine and tender brakes could be applied and released with the independent brake valve, always using release position to release the brakes.

162. **What would be the results if the pipe connections between the distributing valve and the brake cylinders, broke off?**

Ans. This would first result in the loss of brake cylinder pressure, that would in turn cause an entire loss of main reservoir pressure, if the handle of either brake valve be left in application, or lap position.

163. **What could and should be done?**

Ans. If this should happen while running on the road, the main reservoir pressure can be saved by placing the handle of the independent brake valve in release position, which will allow the pressure in the application cylinder to be exhausted to the atmosphere, thus allowing the application valve to return to its normal running, or release position, closing the application slide valve, and preventing any further loss of main reservoir pressure. If possible the cut-out cock in the cylinder pipe should be closed, or else plugged. If the break be close to the distributing valve, the cut-out cock in the supply pipe should be closed, in which case there will be no engine or tender brakes, but the train brakes can still be operated with the automatic brake valve.

164. What would be the result if the supply pipe to the distributing valve should break off?

Ans. There would be an entire loss of main reservoir pressure, and it would be impossible to obtain a brake application (with either valve) on the engine, or tender.

165. What should be done?

Ans. The cut-out cock in the supply pipe should either be closed, or the pipe plugged to prevent a loss of main reservoir pressure.

166. What would be the results if the application pipe to the distributing valve broke off?

Ans. In case the application cylinder pipe breaks, it would be impossible to apply the locomotive brakes.

167. What can and should be done in this case?

Ans. The broken pipe should be plugged at the distributing valve, the locomotive brakes could then only be applied with the automatic brake valve.

168. In case the brakes had been applied with the automatic brake valve, would it be possible to release them with the independent brake valve?

Ans. No, it would only be possible to release the brakes by placing the handle of the automatic brake valve in running position.

169. Why would this be impossible?

Ans. When the handle of the automatic brake valve is in any other position, except running, the distributing valve release pipe, and port connections are blanked by the rotary in the automatic brake valve, it then being only possible to rid the application cylinder of its pressure (that is holding the brakes applied) through the medium of the application cylinder pipe, and the rotary of the independent brake valve, when the independent brake valve is in release position. This pipe being broken and plugged prevents this port and pipe connection being made.

170. If the distributing valve release pipe, leading to the under side of the rotary in the independent brake valve, should break off, what would be the effect?

Ans. The holding feature of the automatic brake valve would be lost, and it would be impossible to apply the brakes with the independent brake valve, in case the equalizing parts of the distributing valve were in their normal, running, or release position. The brakes would apply, but as soon as the handle of the independent brake valve was returned to lap position, the brakes would release.

171. With the brakes applied by the automatic brake valve, could they be released with the independent brake valve? How?

Ans. Yes, they could be released by placing the handle of the independent brake valve in release position, in which case the application cylinder pressure would be allowed to escape to the atmosphere by way of the application cylinder pipe, the rotary in the independent brake valve, and the central exhaust port in the independent brake valve.

172. **What should be done in case this should happen while on the road?**

Ans. With the distributing valve release pipe broken off it is not necessary to do any plugging, care should be exercised, and not attempt to depend on the holding feature of the automatic brake valve. The brake valve should be handled as was good practice with the older styles of equipment.

173. **What effect would it have on the operation of the air pump, if the pipe leading to the spring chamber (top pipe) of the excess pressure governor should break off?**

Ans. As soon as a pressure sufficient to seat the governor piston against boiler pressure was obtained (25 to 40 pounds) the pump would stop.

174. **Would the position of the automatic brake valve have any effect on this defect?**

Ans. As long as the brake valve was in full release, running, or holding position, the pump would remain idle, but as soon as the brake valve was moved to lap, service, or emergency the pump would resume operation.

175. **What can and should be done in a case of this kind?**

Ans. Either put in a plug, or flatten the broken pipe, then put in a blind gasket in the lower, or pipe connecting below the diaphragm. The lower pipe can be connected to the top of the spring chamber, which in some cases would be the quicker and better method. The excess pressure head of the governor is then out of service, and the engine should proceed, depending upon the maximum pressure head. If the train be short, the maximum pressure head should be adjusted to 100 pounds, main reservoir pressure (as with the single governor). If in heavy freight service, the main reservoir pressure should be 120 pounds, even though it is detrimental to the pump to work against such a high pressure.

176. **What can and should be done if the pipe connecting below the diaphragm should become broken, what effect would it have on the operation of the pump?**

Ans. With this pipe broken there would be no pressure under the diaphragm, to raise it, and the feed valve pipe pressure, with the tension of the excess pressure spring, would hold the diaphragm down, until such time as the maximum pressure head took control of the pump. With this pipe broken it is only necessary to put in a blind gasket to prevent a waste of air, and proceed depending upon the maximum pressure head of the governor for pump control.

177. **In case the pipe connection to the maximum pressure head of the governor should break off what would be the effect, and what should be done?**

Ans. In case this pipe should break off, there would be no pressure under the diaphragm to control the maximum pressure head, and this governor would lose control of the pump, when the handle of the automatic brake valve, was in service, emergency, or lap positions. The low pressure head would control the pump in all other positions of the engineer's brake valve. The broken pipe should be plugged, to prevent a waste of air, and when the handle of the engineer's brake valve is moved to lap, service, or emergency position, the pump would have to be throttled to prevent too high a main reservoir pressure, as the pump having no governor control, would pump to boiler pressure.

178. What can and should be done, in case the equalizing reservoir pipe should break off, or the reservoir should spring a leak?

Ans. The pipe connection at the engineer's brake valve should be plugged if it be impossible to make repairs, and service applications, of the brakes, made by moving the handle slowly to partial emergency position, being very careful when returning the valve to lap position, to not do so quickly, as the stoppage of the flow of air would cause head brakes to release. The equalizing discharge fitting should also be plugged in this case (brake pipe exhaust elbow).

179. In case the brake pipe should break under the tender, is there any way by which the train can be gotten to the terminal, with all brakes in operation?

Ans. Yes, plug the broken brake pipe, then connect the brake pipe hose to the signal line hose on the front, or pilot of the engine, open all signal line hose angle cocks, and carry the brake pipe pressure to the rear of the train through the signal line, where the brake pipe hose, and signal line hose should again be cross coupled. The angle cock in the brake pipe between the tender and first car should then be coupled. Charge up the train, and after a terminal test of brakes had been made the train is ready to proceed, with a brake on the engine, tender, and the entire train.

180. **In this case could the air signal system be operated?**

Ans. No, as the signal line is acting as a pipe line to carry the brake pipe pressure, to the rear of the train.

181. **Could an emergency application of the brakes be obtained with the air so coupled?**

Ans. An emergency application of the brakes could not be obtained, as the frictional flow of the air, through this pipe line would be too slow to operate the emergency features of the quick action triple valves.

182. **Would it be advisable to use this method to get in?**

Ans. Only in cases of actual emergency, as a passenger train should not be operated, without the emergency feature of the brakes, as it is not known at what time an actual emergency will arise. The brakes otherwise could be operated according to recommended practice.

183. **What should be done in case a pipe leading to the air gauge should break off?**

Ans. Plug the pipe, and proceed, without that feature of the gauge.

184. What would be the results if the feed valve became so inoperative that it could not be repaired? What could be done?

Ans. The feed valve becoming inoperative, would prevent carrying the proper brake pipe pressure. The reducing valve could be adjusted to the feed valve pressure, and substituted for the feed valve.

ROUND HOUSE TEST OF THE ET EQUIPMENT PARTS.

185. What are the parts of the ET equipment that should receive a test before the engine leaves the house for a trip?

Ans. The following parts should be known to be in good working order before the engine leaves the house: The automatic brake valve, independent brake valve, distributing valve, feed valve, reducing valve, combined check valve and strainer (used in connection with air signal system, and dead engine feature) safety valve, and duplex pump governor.

186. Why should these parts be tested before leaving the house?

Ans. They should be tested in order to determine that each part of the equipment is doing the work for which it was intended, that all valves properly maintain and separate their pressures, and that all parts of the equipment are reasonable free from leaks that would seriously effect the operation of the brakes in any manner. The proper place to locate defects is in the round house.

187. **What should be the engineer's first duty before attempting to make a round house inspection of the different parts of the equipment?**

Ans. After the air pump has been in operation a certain length of time, the drain cocks on drums and in pipe wells, should be closed, the angle cocks on both signal line and brake pipe hose should be opened, and blown out, to remove any collection of water, or scales that would otherwise work back into the system and cause trouble.

188. **What pressures should the air brake equipment contain before a test is attempted?**

Ans. Each part should have its standard pressure, the air gauge should be the first part tested, to see that it is reasonably correct.

189. **How would you test the air gauge, without the use of a test gauge?**

Ans. By placing the handle of the automatic brake valve in full release position, if both the red and black hand come well together, the gauge is said to be correct. If the two hands stand more than three pounds apart, the gauge should be repaired, or changed.

190. **What parts should next be tested?**

Ans. The pump governors.

191. **How would you test the pump governor?**

Ans. The handle of the automatic brake valve should be placed in running position, in which position the excess pressure head of the pump governor should stop the pump when 20 pounds of excess had been obtained, or the red and black hands of the air gauge should stand 20 pounds apart when the pump stops.

192. **If the brake pipe pressuure is standard, but the main reservoir does not contain an excess pressure of 20 pounds, what, and where should an adjustment be made?**

Ans. The excess pressure head should be adjusted by removing the cap nut, and by screwing down on the adjusting screw, obtain the desired 20 pounds. If the gauge shows a greater excess pressure than 20 pounds, the tension on the excess pressure spring should be relieved until the pump stops at the desired pressure.

193. **How can the maximum pressure head be adjusted?**

Ans. By placing the handle of the automatic brake valve on lap, then either increase or decrease the tension on the regulating spring, until the red hand of the air gauge (Duplex gauge) shows the desired main reservoir pressure.

194. **After satisfying yourself that the air gauge, pump governor, and pump are doing their work as is desired what should then be tested?**

Ans. The automatic brake valve should then be tested.

TESTS FOR DEFECTS IN THE AUTOMATIC BRAKE VALVE.

195. Of what should the first test in connection with the automatic brake valve consist?

Ans. The engineer should examine with a lighted torch all pipe connections to and from the automatic brake valve, to ascertain that there are no leaks. He should then satisfy himself that the rotary valve handles easily in the automatic brake valve.

196. If the rotary handles hard, what might be the cause, and what should be done?

Ans. The rotary valve might be cut or dry, the handle key gasket dry, or the handle latch dry. The cut-out cock in the brake pipe underneath the brake valve, and the main reservoir cut-out cock should be closed, the plug from the body casting of the engineer's brake valve removed, and a sufficient amount of clean valve oil introduced to properly lubricate these parts. The rotary valve should then be moved so as to allow the oil to work down on the rotary seat, and the plug returned. Put a small quantity of oil on the handle latch to lubricate it, and a small amount down by the rotary stem to lubricate the handle key gasket.

197. If after a reduction in chamber D has been made, the equalizing discharge valve continues to discharge air, what might be the probable cause, and what should be done to stop it?

Ans. If the equalizing discharge valve continues to discharge air with the automatic brake valve on lap, it may be due to some foreign substance on the face of the valve, or its seat, or possibly a leak in chamber D, or the equalizing reservoir or its pipe connections. By closing the cut-out cock in the brake pipe underneath the engineer's brake valve, and making a heavy service reduction, the obstruction can usually be removed. Leaks must be located, and repaired.

198. How long should it take to reduce chamber D 20 pounds, in service application?

Ans. It should take from 5 to 7 seconds.

199. In case the reduction from chamber D is faster than this, what might be probable cause?

Ans. It may be due to too large a preliminary exhaust port, a leak by the rotary in the brake valve, or a leak in the equalizing reservoir or its pipe connections.

200. If the reduction is too slow what might be the probable cause?

Ans. The reduction being slow might be caused by too small preliminary port, or a leak into the equalizing reservoir (or chamber D).

201. How should a test for a leaky rotary be made?

Ans. The pressure in chamber D should all be reduced, by allowing the handle of the automatic brake valve to remain in service application position, the cut-out cock underneath the engineer's brake valve should then be closed. If a blow starts at the equalizing discharge fitting (brake pipe exhaust) it indicates a leak into the brake pipe due to leaky rotary. If the black hand of the air gauge moves up, noticibly, it indicates that pressure is leaking into chamber D, either by a leaky rotary, or by a leak in the body gasket.

202. What does an increase in brake cylinder pressure, and a blow from the safety valve indicate while the automatic brake valve is in lap position?

Ans. It indicates that there is a leak from a leaky rotary valve into the application cylinder, of the distributing valve.

203. If the brake releases with the handle of the automatic brake valve on lap position, what does it indicate?

Ans. It indicates that there is either a broken distributing valve release pipe, a leak in the U pipe connection, a leak in the application cylinder, or the adjustment on the safety valve is too low, or a broken regulating spring or the return spring in the handle of the independent brake valve (broken), and the handle in release position, or a broken application cylinder pipe.

204. If the brakes would not apply either with the automatic, or independent brake valve, what might be the trouble?

Ans. In this case, there might be a stoppage in the cylinder pipes, the cut-out cock in the pipe might be closed, the supply pipe leading to the distributing valve may either be stopped up, or the cut-out cock closed, the supply port in the seat of the application slide valve stopped up, or possibly the cylinder pipe might be leaking bad or the pipe might be broken off entirely, which action could be told by the performance of the pump. The application cylinder might be leaking bad, causing an entire loss of pressure behind the application piston, the safety valve spring might be broken, the equalizing slide valve may be leaking the pressure away, the pressure chamber may not be charged due to a dirty feed groove in the equalizing valve bushing, or possibly there is a leak from the drain plug in the distributing valve reservoir.

205. When the handle of the automatic brake valve is on lap position, after a service application of the brakes, and there is a continuous waste of air at the brake pipe exhaust, what does it indicate?

Ans. It indicates a leak in chamber D, or the equalizing reservoir, and its pipe connections.

TESTS FOR DEFECTS IN THE INDEPENDENT BRAKE VALVE.

206. What is the most important thing to observe in connection with the independent brake valve?

Ans. To know that there is no leak in the rotary, or the valve pipes, to and from the brake valve, and that the valve handles reasonably easy, and that the return spring is not broken, and will do the work for which it was intended.

207. In case the independent brake valve handles hard, what might be the cause, and how can the defect be remedied?

Ans. The valve may be handling hard due to improper lubrication, or possibly the return spring or its housing, or the same defects that affect the operation of the automatic brake valve. The independent brake valve should receive a sufficient amount of lubrication, in the same manner as the automatic brake valve.

208. In case it was thought there was a leaky rotary in the independent brake valve, how could a test to determine, be made?

Ans. By making a very light independent brake application of the brakes, and then allow the handle of the brake valve to remain on lap position. If the brake cylinder pressure increases to the limit of the adjustment of the safety valve spring it indicates a leaky rotary. If while the handle of the independent brake valve is in running position, there is a continuous blow at the direct application emergency exhaust port, it also indicates a leak by the rotary valve in the independent brake valve.

209. In case the handle of the independent brake valve failed to return to slow application, or running position, when this valve is being used, what might be the cause, and should the engineer take the engine out, without having repairs made?

Ans. This may be caused by a broken return spring, or by the resistance offered to frictional parts, due to a very dry condition of the valve, or seat. The engineer should insist on repairs being made providing it was a broken spring at fault. The spring being broken is liable to be the cause of the handle being left in release position, which would surely cause trouble in case the train should break in two.

DISTRIBUTING VALVE TESTS.

210. If when the brake system is fully charged, a five pound reduction fails to cause the brakes to apply on the engine and tender, what is the probable defect?

Ans. Dirty, sticky parts, causing excessive friction in the operation of the operative parts. The frictional resistance offered by the sticky parts is so great that a five pound reduction is not sufficient to overcome the resistance offered.

211. How could it be determined which of the operative parts is at fault?

Ans. If after charging the system a slow application of the brakes be made with the independent brake valve, the brake sets promptly it indicates that the trouble is in the equalizing portion of the distributing valve. If the brake is very slow in applying or responding to the application, it indicates that the trouble is in the application portion.

212. In case these parts be found defective in the manner described, what should be done?

Ans. The distributing valve should be dismantled, cleaned and oiled.

213. How often should such work as cleaning and oiling the operative parts of distributing valve be done, and should it ever be done by the engineer?

Ans. This work should be done as often as necessary to keep the parts in a sensitive working condition, and if considered necessary by the engineer he should clean and oil the parts. Ordinarily the distributing valve parts do not require cleaning and oiling oftener than once in each six months, this of course depending upon the condition of the service, and the manner in which the main reservoir be drained, as well as some points in the construction of the drum, and its pipe connections.

214. **In case it be found necessary to clean and oil parts of the distributing valve in route, how should the parts be removed?**

Ans. After all pressure had been drained from the system, the equalizing piston, slide and graduating valve can be removed by taking off the equalizing cylinder cap. Then carefully remove the parts, being careful not to injure them, the parts should then be cleaned (with kerosene) and laid to one side until other parts have been cleaned. In order to remove the application piston, application valve and exhaust valve, the application valve cover must first be removed, and the application valve and pin carefully taken out, the application piston and exhaust valve can then be removed. After all parts have been removed and cleaned, the compressor should be allowed to work, and all ports in the distributing valve blown out, in order to remove any obstruction there may be in them, the parts should then be well oiled, and returned to their respective places. While the distributing valve was dismantled, the feed groove in the equalizing portion should be cleaned out, care being taken to prevent scratching the bushing, in case it is being cleaned with any thing hard. A pointed piece of hard wood is better than a piece of metal for this purpose.

215. After a reduction of ten pounds had been made, what should the red hand of the brake cylinder gauge show?

Ans. This hand should show 25 pounds pressure in the brake cylinder.

216. Explain why a ten pound reduction from 70 pounds, brake pipe pressure, results in a 25 pound brake cylinder pressure?

Ans. The size of the application cylinder, and chamber, is such in comparison to the size of the pressure chamber, that a pound of air from the pressure chamber is equal to two and one-half pounds in the application chamber and cylinder. The brake cylinder pressure corresponds to the application cylinder pressure, for each pound reduction made in the brake pipe.

217. After a partial service application of the brakes had been made, with the automatic brake valve, the cylinder pressure was noticed to be increasing, what might be the cause?

Ans. The most probable cause is that it was due to brake pipe leakage, although it may be caused by a leaky rotary valve, in either brake valve, a leak by the equalizing or graduating valve in the distributing valve.

218. Why should a brake pipe pressure of 70 pounds be used, when testing for defects in the distributing valve?

Ans. With a brake pipe pressure of 70 pounds, the point of equalization is below the adjustment of the safety valve, while with 110 pounds brake pipe pressure, the point of equalization is considerably above the adjustment of the safety valve, and this being the condition, leaks could not so easily be discovered.

219. When it is desired to test for leaks, how can their source be determined?

Ans. By making a partial service application, with the automatic brake valve, then by watching the brake cylinder air gauge. If the cylinder pressure reaches 50 pounds, and remains at this point, it indicates a leak in the brake pipe.

If the cylinder pressure reaches the adjustment of the safety valve it indicates that there is a leaky rotary valve in the automatic brake valve. (The safety valve will discharge air in this case.) If the brake cylinder pressure increases to 45 pounds, it indicates a leak by the rotary in the independent brake valve. In case the safety valve be removed, and there be a continuous leak at the safety valve connection (after a partial service application) it indicates a leak by the equalizing, or graduating valve. If there is a constant leak of air from the exhaust port of the automatic brake valve, it indicates a leak in the equalizing slide valve. (The handles of both brake valves must be in running position in this case.)

If after a service application there is an intermittent blow at the distributing valve exhaust elbow, it indicates an application slide valve leak, that is if the application cylinder, and application cylinder pipe be found free from leaks. If there is a continuous leak of air from this exhaust port, it (with the brake applied) indicates that the exhaust valve is leaking. If after a service application of the brakes have been made, the brakes release (the equalizing piston, slide and graduating valve move to release position) it indicates that there is a leaky graduating valve in the distributing valve. The brake in this case will not release on the engine from which they are applied, but will on the second engine when double heading (that is when the double heading cock is closed in the brake pipe of the second engine, and the engineer's brake valve carried in running position. The brakes do not release on the engine from which they are applied, due to the fact that the rotary in the automatic brake valve has the port connection in the distributing valve release pipe blocked. The second engine can get the hold feature of the brake application by also lapping his brake valve (automatic brake valve). If the brakes release, when the handle of the automatic brake valve be placed in either full release or holding position, it indicates a leak in the distributing valve release pipe between the two brake valves. The brakes will not release with this defect, if the brake be applied with the independent brake valve.

If the brakes release after either an automatic or independent brake application, it indicates a leak from the application cylinder, cylinder gasket, or pipe connection. In order to determine whether the distributing valve release pipe is leaking, make a service application of the brakes. If the brakes remain applied with the handle of the brake valve on lap position (automatic brake) the distributing valve release pipe is not leaking, but if when the brake valve is returned to holding position, the brakes release it is then an indication of a distributing valve release pipe. In order to determine whether the application cylinder application cylinder cap gasket, or pipe connection is leaking, make a service reduction of at least 15 pounds, lap the brake valve, if the brake releases it indicates a leak from some of these sources.

If the brake cylinder fails to remain at the point at which it was applied, it indicates a leak from the application cylinder, cylinder gasket, or the application cylinder pipe connections. The amount of leakage from the brake cylinder can readily be determined by noting the number of strokes the compressor makes in a given length of time. Apply the brake with the independent brake valve, and then note the number of strokes the pump makes. The difference in the number of strokes mdae by the pump, indicates the brake cylinder leakage. Another way in which to determine brake cylinder leakage is to apply the brake, and close the cut-out cock in the cylinder pipe. The red hand of the brake cylinder gauge will show the rate at which the cylinder is leaking the pressure away. In order to determine which of the cylinders (engine or tender) close the cut-out cock in the cylinder pipe, and note in which case the pump works the harde , this will indicate which of the cylinders is leaking. Testing with a lighted torch will indicate the leak, but the above method is given in cases where cylinders are so located, that it is hard to get to them in order to make the test.

220. In what manner can the amount of signal line pressure be told?

Ans. The signal line pressure should correspond to the reducing valve pressure but in case the reducing valve becomes inoperative, and the signal line becomes over charged, the amount of pressure can either be told with a test gauge, or by charging up the signal system, stop the pump, and then drain the main reservoir, the red hand of the air gauge will tell the amount of signal line pressure when the whistle sounds.

221. What harm would an overcharged signal line do?

Ans. The signal line being overcharged, might be the cause of burst signal line hose, and when the independent brake was applied, or the automatic brakes released, the signal whistle would blow, thus destroying the purpose for which the signal was intended.

222. What else will cause the whistle to blow when the car discharge valve has not been opened?

Ans. A leak in the signal line from any cause, or a back leakage from the combined check valve and strainer.

223. What defects will interfere with the correct operation of the signal whistle?

Ans. The same defects that are common to the standard equipment, as used with the ordinary brake equipment, are found in the equipment used in connection with the ET equipment.

224. What is the only difference in the signal system used with the ET equipment?

Ans. The only difference lies in the signal line reducing valve.

225. In case it becomes necessary to cut out the signal system, how can it be done?

Ans. By closing the cut-out cock in the combined check valve and strainer pipe connection.

226. If the signal line charged too slow· where would you look for the trouble?

Ans. In the signal line reducing valve, or the combined check valve, and strainer.

227. With the signal system fully charged, the signal whistle continues to blow after a signal line reduction, what might be the cause?

Ans. Leaks in the signal system, or a sluggish working reducing valve.

TRAIN HANDLING.

Brake manipulation, like any other thing about the engine and train, requires good judgment. The engineer who is lacking in this qualification never makes a success of the business he is trying to follow. An education on the working principle of a device may help a man in the successful handling of it but no book will ever be able to impart to a man the greatest acquirement in modern railway practice, good judgment.

228. When the engine is hauling the train, what

position should the engineer's brake valve be in? (Independent and automatic.)

Ans. Both brake valves should be carried in running position.

229. **In what position should the automatic brake valve be while charging a train?**

Ans. The automatic brake valve should be in release position while charging a train before a test of brakes is made.

230. **Why is this?**

Ans. This position should be used as there is a more direct opening between the main reservoir and the brake pipe, and the air that is being compressed by the pump is being delivered direct to the brake pipe, thereby making a much more free working pump.

231. **How long should the brake valve be allowed to remain in this position?**

Ans. Until such time as the black hand of the duplex air gauge registers 70 pounds, or whatever pressure it is desired to carry. (The feed valve being taken into consideration.)

232. **When fully charged, how should a test be made?**

Ans. A full service application of the brakes should be made. (The amount of brake pipe pressure being taken into consideration.)

233. **Of any given pressure, how much of it should be reduced to get all power obtainable in a service application?**

Ans. All things being standard, a 2-7 reduction of a given pressure will produce equalization, and this is all the power obtainable in a service application.

234. Why should the engineer insist on a test of brakes before leaving the terminal?

Ans. Without this knowledge, he would be unable to successfully attempt to handle the train over the road, he would not know the condition of the brakes in regards to piston travel, or leaks that effect the operation of the same, or would it be possible to locate defective triple valves, that in some cases effect the operation of the train brakes as a whole. (Undesired emergency.)

235. In case after a test of brakes had been made, while running along the road the brakes should apply in emergency application without the action of the engineer, what should be done, and why?

Ans. The engineer should move the automatic brake valve to emergency position, and leave it there until the train is brought to a stop. This is done to insure the locomotive brakes remaining applied, and to prevent a loss of main reservoir pressure.

236. In case a stop has been made, how should the brake valve be handled to release all brakes?

Ans. The brake valve should be placed in full release position (it being understood that a proper reduction has been made, and the main reservoir contains a sufficient amount of excess pressure) and left there a sufficient length of time (different roads have different rules in this regard) to release all brakes.

On trains of any considerable length a second release, or kick off, should be used. This is done to get the equalizing valve off service lap position, and to release brakes on the train that may have re-applied due to the resultant overcharge on the head end of the train.

237. In case the driver brakes should cause the wheels to slide, during a stop, how can they be released?

Ans. By moving the independent brake valve to release position, making a direct opening between the application cylinder and the atmosphere, through the application cylinder pipe, and the rotary of the independent brake valve.

238. After releasing train brakes, why is it necessary to move the handle of the automatic brake valve to running position to release the locomotive brake?

Ans. Due to the construction of the rotary, and the port and pipe connection of the combined rotary and distributing valve, this is the only position in which there is an opening between the distributing valve, and the atmosphere.

239. Should the independent brake valve be used in completing a stop?

Ans. Yes on trains of all loads or empties, it should be used as follows: On a train of all empties, build up the engine brake cylinder pressure, with the independent brake valve. On a train of all loads reduce the engine brake cylinder pressure with the independent brake valve.

240. Should the independent brake be used before the automatic?

Ans. No, as by bunching slack with this valve, great damage to laden, and draught rigging is sometimes done.

241. What is the greatest advantage in connection with the use of the ET equipment?

Ans. The ability to release engine, and train brakes alternately, or both at a time, if conditions will so permit.

242. Why is some set standard not attempted (Brake Manipulation) in this volume?

Ans. All roads have air brake instructors, whose recommended practices sometimes differ with ours, and others' ideas of brake manipulation, hence it is hoped that whatever information it is possible for us to impart to you, will be of use in a better understanding of the instructions, which your air brake instructor may give.

LOCOMOTIVE BREAKDOWNS.

Perhaps the most vital question, in the operation of railroads of the present day is (so far as the motive power is concerned), how to prevent, or reduce to a minimum the number of locomotive breakdowns. In the construction of the present day locomotive many of the mechanical weaknesses of the earlier locomotive have been entirely eliminated. Motive power men have improved the locomotive in parts, until many of the weak points in construction of the earlier types of locomotive have become only a remembrance of the early days of the now great railroads of the country. The Walschaert valve gear has taken the place of the old clumsy eccentrics, the piston valve, and many other styles of an almost perfectly balanced valve have replaced the slide valve. Engine frames are built more strongly year after year, points in construction mechanically show their improvements each year. The injector has entirely replaced the pump as a boiler feed. Front end, or smoke box arrangement has become a science until at present a poor steaming engine is almost a thing of the past.

Still so long as man is not infallable, the works of man will likewise not be perfect. Mechanical weaknesses may in a great measure be overcome but breakdowns will be sure to happen. The one thing that most strongly appeals to the operating departments of railroads is to educate the man in charge of the engine until he is able to cope with any and all breakdowns that may happen. Good judgment is a great factor in the successful handling of the engine from any standpoint. Experience is a wonderful teacher, and no education is complete without it, yet in the science it applies in the making of a locomotive engineer, has in many cases proven to be a very expensive acquirement. Book knowledge has never made a thoroughly practical engineer. But the education gained from books has been of great assistance in enabling the engineer to successfully handle the engine from all standpoints. Thorough inspection of the engine parts and an intelligent work report will in a great measure help to prevent a large percentage of breakdowns. The old adage (an ounce of preventive is worth a pound of cure) applies most strongly in the operation of the locomotive. So as long as the earnings of a railroad depend almost entirely on the ability of the engine to handle a train, will this question be one of importance and prominence, in the minds of motive power men.

Trains are heavy, time is fast, and a breakdown means a delay which is at times unavoidable, but might, and can in many cases be avoided by a more careful system of engine inspection. Let us then in the discharge of our duties, have it said of us (rather than say, I did all I could do). He did all there was to do to prevent an engine failure or breakdown. To the man who has done this, he alone is worthy of the name of a successful engineer.

MECHANICAL.

1. **What is heat?**

Ans. Heat is one form of energy, and by students of chemistry is said to depend upon the molecular motion of the particles within a body. Since it is energy, it is capable of doing work. The energy confined may be able to drive a piston, it may cause expansion and contraction of solids, or it may change the cell-like formation of solids as when fused, or liquids when vaporized.

Heat does not in a sense act the same as matter, because a heated body does not gain in weight by reason of the fact that it is heated, while matter, such as rubbing two pieces of ice together, the quantity of heat entirely disappears and is lost.

Heat being a form of energy has many sources from which it is derived, because energy can be transformed, or changed into heat. Friction, or any process by which motion is arrested, causes a certain degree of heat. The two forms of energy which produce heat are spoken of as kinetic, and potential.

Kinetic energy is illustrated by moving currents of air, or by ocean currents, while potential energy is stored in coal, or water, and requires a certain degree of heat to produce a working energy. Carbon being a quality of coal, when burned gives off 14,500 heat units. Hydrogen when burned gives off 62,000 heat units, the combination of carbon and hydrogen forms the basis for all commercial fuels, such as oil, gas or coal. The general form in which heat is produced, is by some form of combustion.

2. **What is combustion?**

Ans. Combustion is a chemical combination of any burnable substance (fuel), with oxygen. (One of the universal gases.)

3. **What is meant by a degree of heat?**

Ans. The amount of heat contained in a body. By degree is meant a unit of measure.

4. **What is meant by a unit of heat?**

Ans. The unit of heat is defined as meaning the amount of heat necessary to raise one pound of water one degree, and is called a British thermal unit.

5. **What kind of an instrument is used in measuring heat?**

Ans. The thermometer, for ordinary temperatures, and the pyrometer for high temperatures.

6. **What is meant by latent heat of fusion?**

Ans. During the time a piece of metal is melting, or a liquid is freezing no change in temperature takes place, by adding to or subtracting from the body heat. Consequently as it follows that there is a certain degree of heat stored in the body (potential energy) it is called the latent heat of fusion.

7. **What is meant by vaporization?**

Ans. Vaporization is the process of converting (changiing), a liquid into a vapor.

8. **What causes or brings about vaporization?**

Ans. The act of introducing heat, or boiling (changing a liquid into a vapor.

9. **What is meant by boiling?**

Ans. By boiling is meant the act of separating vapors, or gases, from fluids by the action of heat.

10. **Upon what does the degree of heat necessary to boil fluids depend?**

Ans. The degree of heat necessary to boil a fluid depends upon the pressure, on the fluid at the time it is being boiled. That is if the pressure be increased, the boiling point is raised, while if the pressure be decreased the boiling point is lowered.

11. **What is meant by mechanical energy, and heat?**

Ans. Heat may be made to perform work. The principle of producing these results is quite simple The steam when admitted to the cylinder of an engine carries with it the heat energy of the fuel, and by reason of the construction of the cylinder of the engine is able to expand, and do a work equal to the degrees of heat that it contains. By experiments it is found that one British thermal unit has a capacity for work equal to 778 foot pounds. A pound of coal is said to give out 14,000 heat units, which when multiplied by 778, in case all the heat could be utilized, would give an equivalent equal to 10,892,000 foot pounds of work.

12. **What is meant by generating steam?**

Ans. By generating steam is meant the act of raising the temperature of water to such a point that the chemical composition of the water is separated, or caused to be separated by the action of heat.

13. **What is the chemical composition of water?**

Ans. Water is said to contain two parts of hydrogen and one part oxygen, and may exist in any one of three different states, ice, water, or steam.

14. **What is the boiling or separating point of water when in its true state?**

Ans. When water is in a liquid state, under atmospheric pressure, it will boil at 212 degrees Fahn.

TEMPERATURE OF STEAM AT VARIOUS PRESSURES.

Gauge Pressure lbs. per sq. in.	Temper Degree Fahrenheit	Heat of Vaporization. Heat, Units
	101.99	1,043.0
	126.27	1,026.0
	141.62	1,015.3
	153.09	1,007.2
	162.34	1,000.8
	170.14	995.2
	176.90	990.5
	182.92	986.2
	188.33	982.5
	193.25	979.0
0	212.00	965.7
0.3	213.03	965.1
5	227.95	954.6
10	240.04	946.0
15	250.27	938.9
20	259.19	932.6
25	267.13	927.0
30	274.29	922.0
35	280.85	917.4
40	286.89	913.1
45	292.51	909.3
50	297.77	905.5
55	302.71	902.1
60	307.38	898.8
65	311.80	895.6

Gauge Pressure lbs. per. sq. in.	Temper. Degree Fahrenheit	Heat of Vaporization. Heat, Units
70	316.02	892.5
75	320.04	889.6
80	323.89	886.7
85	327.58	884.0
90	331.13	881.3
95	334.56	878.8
100	337.86	876.3
105	341.05	874.0
110	344.13	871.7
115	347.12	869.4
125	352.85	865.1
135	358.26	861.2
145	363.40	857.4
155	368.29	853.8
165	372.97	850.3
175	377.44	847.0
185	381.73	843.8
210	391.79	836.3
235	400.99	829.5
260	409.50	823.2
285	417.42	817.4
310	424.82	811.9
335	431.90	806.8
360	438.40	801.5
385	445.15	796.3
485	466.57	779.9

These figures are taken from steam in its saturated state.

15. What is saturated steam?

Ans. Saturated steam is steam containing particles of water. It may be either wet or dry, depending upon the particles of water suspended in it. Its temperature is due to the pressure under which it is generated. Saturated steam is always given off from boiling water, and so remains in a greater or lesser degree unless superheated.

16. What is superheated steam?

Ans. Superheated steam is steam containing a greater degree of temperature than saturated steam does at the same pressure. Superheated steam is produced by increasing the temperature of the steam, over that temperature at which it was generated, and must be done at some point away from the place at which it is generated into saturated steam.

17. What are the advantages of superheated steam over saturated steam?

Ans. The greatest factor in the use of superheated steam over saturated is that there is less loss due to radiation or condensation. Superheated steam containing a greater degree of heat is consequently able to perform more work in the cylinders of an engine, less the amount lost due to condensation, it still arrives at the cylinders, dry, and has a capacity for work greater than saturated steam would under the same pressure.

18. Are there any disadvantages in connection with its use?

Ans. There are disadvantages, such as being hard to lubricate, due to excessive heat, and by some authorities, the extra expense in connection with its manufacture, seems to offset any economical results obtained from its use.

19. What is the method used in superheating steam in locomotives?

Ans. The steam is superheated by some system of return flues, the steam being admitted to these pipes and exposed to the firebox gases before reaching the cylinders of the engine. The boiler contains the saturated steam and (when the engine throttle valve is open) the superheater pipes contain the superheated steam.

COAL.

The best authorities on the origin of coal claim that in pre-historic time, long before the history of man, the earth was supplied with dense vegetation. Due to the action of water this vegetation was collected, and buried in veins and banks. By reason of air being excluded from these deposits of vegetation, they underwent a change during the ages, until the earth now yields to man for his use a substance called coal. Although the earth has been giving this product to man for his use for many years, soundings and borings show us that the earth is still supplied with enough of this substance to last for several generations.

20. What is the composition of bituminous coal?

Ans. The composition of bituminous coal is Hydrogen, Nitrogen, Oxygen, Carbon, Sulphur and Ash.

CRUDE OIL.

Liquid Fuel.

The scientists claim, after years of investigation, that petroleum found in the rocks below the surface of the earth is not a mineral product. Rock oil, as it is sometimes called, is probably the results of the decomposition of vegetable remains. Oil is found in abundant quantities, in different parts of the earth, and is now being used as fuel, in many of the branches of commerce. Oil, unlike coal, has no structural formation, but when subjected to process of distillation, any vegetable substance, organic matter, coal, wood, and- etc., yields a fluid of an oily nature. Hence it is more than probable that the oil deposits of this earth come from or have their origin in the early vegetation, of which the earth was supposed to flourish before the time of man.

21. Are there any advantages in the use of oil as a fuel in modern railroad practice?

Ans. By some it is claimed that by using oil fuel economy is effected, in that there is considerable saving per ton, over coal. While again the cost of transportation of oil from one section of the country, to another, would offset any economy, in its use. Then again if all railroads were to use oil as a fuel, the earth's supply would soon be exhausted?

22. What is the difference between pounds of coal as per pounds of oil?

Ans. It is claimed that a pound of oil will go as far, as or is equal to, one and one-half pounds of coal.

23. Does the use of oil effect the firebox of an engine?

Ans. It is claimed by some that oil is much more severe than coal, when used as fuel in the firebox of an engine.

24. What are some of the advantages, other than those mentioned in the use of oil as a fuel?

Ans. The use of the entire heating surface of the firebox, due to a clean condition of the flues, even expansion and contraction, by reason of an even temperature, in the box, no dirty fires to be contended with on long runs, less cost in connection with the handling of fuel at terminals, no cleaning, or dumping of a fire at the terminal, engine is much easier and more quickly dispatched, which on large roads of today is an important item, less liable to cause fires along the right ofway due to cinders being emitted from the stack, oil over coal as a fuel takes up less space on the tender, thereby increasing the water capacity of the tender, a very important item on fast passenger runs or heavy freight traffic, less labor on the fireman, thereby enabling him to be of more service to his company and the engineer by a closer watch on his side of the engine.

THE LOCOMOTIVE BOILER.

The locomotive boiler is one of the parts of an engine, the study of which is very often neglected. Regardless of the nicety of valve motion, the precision of mechanical construction, the power which the locomotive is capable of developing depends upon the steam generating capacity of the boiler. Let every other thing about the locomotive be perfect, and the boiler be incapable of generating sufficient steam, no engineer would care to spend his time and effort on such an imperfect machine. Motive power men having taken this into consideration, have designed boilers so that there is but little doubt left as to their capacity in this regard. The question often arises that the boiler is at present too large for the work it is called upon to perform, the expansion and contraction in these large boilers being of vital importance in their satisfactory performance. While many things concerning boiler construction are really of no relative value to the man running the engine (such as tensile strength of metals, or the pitch of a rivet), yet there are many things which the engineer should have a full understanding of, in order that he can safely cope with conditions as they arise. Boiler designing is in itself a science that of course the engineer would not be expected to go into details over, yet after a boiler is turned out a perfect piece of work, the engineer in order to safely handle it should know if or not there are any perculiar points in its construction, which would require his careful consideration. A boiler, like a chain, is no stronger than the weakest link, and with the greatest of care, in selecting material, and with the most expert labor, in its construction, faulty material, and unworkman-like labor will pass the eye of the inspector, so it behoves the engineer to treat the boiler in his care with the utmost consideration, familiarize himself with the things that tend to decrease the life and strength of the parts, and at all times be observant of anything that would tend to cause a rupture in any of the parts, possibly causing a loss of life to himself as well as others, and in many cases a great loss to the company.

25. What are the requirements in the construction of a boiler?

Ans. One of the first things taken into consideration is that it be amply strong in all parts to withstand the strain and stresses to which it is subjected. Another is that the steam generating capacity is sufficiently large for the cylinders it is to supply. Another thing taken into consideration is that it be so designed and built, that it will be easy to repair, in case it becomes necessary to make such repairs. Another is to so construct, with the element of safety taken into consideration, that the greatest amount of work can be expected, with the least expenditure of fuel, as well as make it possible to keep the boiler clean, free from scales and sediment.

26. What are the principal parts of a boiler?

Ans. The principal parts are the firebox, flues, barrel, or cylindrical portion, mud ring and smoke box. There are of course such boiler fittings as throttle valve, dry pipe, and steam pipes taken into consideration, yet the boiler could be spoken of as properly designed, without these things being taken into consideration. The firebox being the point at which the combustion of fuel gives to the water its degree of heat and consequently is the medium through which the energy of heat is transferred, will first be taken up.

27. Describe the firebox.

Ans. The locomotive firebox being the point at which aside from stresses and strains, the greatest degree of temperature is exerted, must naturally be made of the very best material. According to specifications, but usually firebox steel is desired to withstand a pressure per square inch of 57,000 pounds.

The chemical composition of this steel is usually as follows: Carbon 0.15 per cent. of 1 per cent. Phosphorus and sulphur about 0.04 of one per cent., and manganese varying from 0.3 to 0.5 per cent. Another feature in connection with firebox steel is that with a special piece from any part of the firebox it be possible to bend it double, either hot or cold, without it showing any signs of cracking after being heated to a cherry red, and then cooled in water between 80 or 90 degrees Fahn.

Fire boxes are built in several different shapes and styles, but regardless of either, they are usually rectangular in shape, consisting of side, flue and a crown sheet. The crown sheet being the roof, the side sheets, the sides, the flue sheet, the front and the back or door sheet the back. The crown sheet is supported in several different ways, but the side and back sheets are always supported by stay bolts. The side sheets are in later day boiler design most always corrugated, while crown sheets are made of the flat metal, generally so constructed as to form an arch in the roof of the box. The flues are of steel, seamless and lap welded, so that there is scarcely ever any danger in connection with a burst flue.

The boiler shell is by far the easiest part of the boiler to construct, all owing a suitable factor for safety, the material and workmanship is then all that is taken into consideration. The firebox being the point at which the greatest strain and heat is exerted, naturally requires the greatest attention in design and workmanship. The pressure of steam is said to be practically equal on all parts of the inside surface of the boiler, and the outside of the tubes, or flues, so it is not necessary to have any further provision in staying the shell or barrel of the boiler. The strength of boiler plat is supposed to be about 60,000 pounds to the square inch and the bursting strain after the boiler is completed is said to be 90,000 pounds to the square inch. Stay bolts are used to hold the sheets together, and they are supposed to resist a pressure of about 14,000 pounds per bolt. There are many kinds of stay bolts, such as the straight round bolt, and the flexible type. All bolts are subjected to a very uneven expansion and contraction, hence are quite liable to break. The flexible type are so mechanically constructed, as to avoid this to a certain extent. The straight bolt is provided with a tell tale hole that allows steam and water to escape in case the bolt does become broken. The flexible bolt is so constructed that the uneven expansion and contraction is accommodated by a ball joint working in a socket. This in certain localities has done away with stay bolt breakage in a great measure, while in others the limy ingredients in the water soon render the bolt useless so far as the ball joint feature is concerned. So, so far as safety is concerned, the ordinary bolt is considered of as great strength and of an equal factor in safety to any of the so-called flexible type.

Breakage of stay bolts is generally brought about by the action of the expansion and contraction in the side sheet metal, low water, and hot crown sheets. When any great number becomes broken in one particular part of the boiler it becomes so weakened that an explosion generally occurs. The fact these bolts break is of constant re-occuring trouble to the boiler inspector and the length of time necessary to renew, as well as the length of time the engine is out of service is an item of great expense to a railroad company.

CROWN SHEETS.

The crown sheet is the roof of the firebox, and is the point of greatest danger in the operation of the steam boiler. The crown sheet being the highest point is most liable to become dry, and if subjected to any great degree of heat will become burned. The crown sheet is supported in several different ways, some of the systems are crown bars, radial stays, and the Belpaire.

28. What is the most common manner of staying the crown sheet?

Ans. The most common method of supporting the crown sheets is with crown bars. These bars are practically beams placed across the sheet, and supported or held in place with crown bolts, or crown stays. These bars are made with a foot that extends to the edge of the side sheet on either side, and are so placed in the firebox as to be in pairs. The crown bolt is then screwed through the sheet, and passed up through the pair of bars and held in place by a rivet, when the bolt is riveted over, as well as drawn tight by the threads, the crown bars support the weight of steam on the crown sheet. In order to increase the holding power of the crown sheet, a stay known as the sling stay is used, this stay fastens to the crown bar and then to the shell of the boiler. By so doing the crown sheet is very strongly supported, and very little if any trouble ever was caused by the crown bars giving out, thus causing a boiler explosion. In a boiler that is designed to carry low pressure, and working in reasonable good water districts, there is still a doubt in the minds of boiler designers, if there is any better method to be used.

29. What were the disadvantages in the use of the crown bars?

Ans. The greatest disadvantage in the use of crown bars is that in bad water districts the bars become coated with lime, and in case the sheets and bars were not rid of it in a reasonable time there was great danger of mud burning the parts. Another feature was that the crown sheet so supported was very hard to wash, as well as expensive in case it became necessary to renew any of the parts. On the large power, the crown bars are not considered strong enough to support the great weight, without the use of a great number of sling stays. When this is done the outer shell of the boiler is sometimes very much weakened.

RADIAL STAYS.

The most general method in modern boiler construction is to stay the crown sheet with a bolt screwed through the crown sheet and through the shell of the boiler. The bolt is riveted over on either end, and is called a radial stay.

30. What if any are the advantages of the radial stay over the crown bars?

Ans. The radial stays are much easier to renew, as well as to keep clean, the water has a better circulation and the factor of safety is greatly increased in large power.

31. In regards to the factor of safety, is there any advantage?

Ans. The radial stayed crown sheet is considered in many cases the stronger, due to the fact that the scale, and incrustating matter is less liable to collect, hence the life of the stay bolts, crown bolts, and the boiler sheet is increased.

32. **Is there any provision made for protection to the heads of the crown bolts, exposed to the firebox heat?**

Ans. When a boiler has radial stays, the center four or five rows are usually riveted over with button heads, which in a great measure increase the strength of the bolt.

THE BELPAIRE METHOD.

This method of crown sheet support is many instances the same as staying the side sheets, the bolts screw through the sheets of the firebox, and all parts are equally stayed. The crown sheet is flat, and the firebox is generally square. When properly designed and constructed, this method is said to be the best in boiler construction, from both the point of safety and the ease with which it is kept clean. The staying is positive, and all parts of the sheets receive nearly the same strains due to expansion and contraction.

33. **What takes place in the boiler and firebox when the fire is started?**

Ans. When a fire is started in the boiler (the boiler being filled with cold water), the inside sheets become very hot before the outer sheets show any noticeable degree of heat. This action causes the side, back and flue sheets to expand in an upward direction. This is caused by reason of the sheets all being riveted to the mud, or foundation ring. The tendency then of all stay bolts is to break, but the elasticity of the metal used in their construction is called into play, and they stand the strain depending upon the material, and the workman-like manner in which they are placed in the boiler.

After the water begins to boil the outer sheets gain about the same degree of temperature contained in the water, and so remains as long as the watei remains the same. The expansion and contraction of a boiler has much to do with its life and this condition can be greatly benefited by close attention on the part of the engine crew.

34. What are corrugated firebox sheets?

Ans. Corrugated firebox sheets consist of sheets having vertical corrugations, or a form of ridge in the sheet. By some authorities it is claimed that this style of firebox lasts from one to three years longer, due to the corrugations, which give the sheet increased flexibility. Another advantage lies in the fact that the stay bolts are fastened in the groove of these corrugations, and are somewhat protected from the intense heat of the firebox. The flexibility of the sheets helps in a great measure to lessen the bursting strain on the sheets as well as to give greater elasticity to the stay bolt.

35. What is a wagon top boiler?

Ans. A wagon top boiler is one whose firebox end is larger than the cylindrical portion. There are several types of wagon top boiler, some of which will be explained.

36. **What is the Wooten Boiler?**

Ans. This type of boiler was designed in the year 1877, and first used in that year. With it it is necessary to place the engine cab ahead of the firebox, the steam dome being placed either ahead of the cab or in some cases in the cab over the crown sheet. The Wooten firebox is very wide and shallow, this being deemed necessary in districts where they are most used, on account of the grade of coal used. When fine anthracite coal is used, a much wider box is used than when burning bituminous coal. This type of boiler has undergone several mechanical changes since its introduction, but the general features are the same. In its original form the top sheets were made to slope down over the crown sheet, giving to the back end of the boiler the sloping appearance that caused the nick name (Fan Tailed). The fact that only a small amount of water is carried over the crown sheet has both advantages, and also disadvantages. In some cases this point in their construction prevented their coming into general use, and was the cause of changing to a certain extent the design.

37. **What is a prairie type of boiler?**

Ans. The prairie type of boiler is also a wide firebox type, the firebox extending as far as possible over the wheels, giving the greatest possible heating surface. When this form of boiler is used on engine with large driving wheels, the back end of the boiler is generally carried on a trailer.

Another point in the construction of this type of boiler is that the firebox is much wider at the bottom than at the top, or crown sheet. This is now considered the general form of boiler for both passenger and freight locomotives.

38. **What is a Vanderbilt Boiler?**

Ans. This type of boiler differs in points of construction from those already described. The firebox in this style of boiler is also cylindrical, there being no stay bolts as in the usual type of boiler. The fire box is suspended by the Morrison type of suspension, and the walls of the box consist of slight corrugations. This type of firebox has what is known as a combustion chamber and a brick arch. The combustion chamber retains the gases for a short period of time before they are allowed to pass into the flues. The back end of the box is brick lined, to combustion chamber has a man hole plate provided to remove the ashes that collect, and the outlet to the atmosphere forms a chute for dumping the ash. There are no stay bolts used in the construction of this type of boiler.

39. **What is an Atlantic type of boiler?**

Ans. This is also a wide firebox type of boiler, but is somewhat differently constructed to other types in that it contains no wagon top. The sheet of the boiler are straight and about the only advantage lies in the point of construction, it being easier to put up as well as the fact that the steam dome is more centrally located, which by some is considered a great advantage. The reason for this is that the surging of the water does not collect in the dome and is less liable to be carried over to the valves and cylinders.

40. What are some of the different requirements of all styles of boilers?

Ans. The requirements of the boiler are that they generate the greatest amount of steam with the least expenditure of fuel. They are required to be sufficiently strong to stand the enormous strain imposed upon them. They should be kept clean, free from corrosion and limy deposits, have a good circulation, and be sufficiently large to supply steam to the cylinders of the engine (size being taken into consideration).

41. How is the heating surface of the boiler calculated?

Ans. The total grate area, plus the area in square inch of flue surface, gives the total heating surface. The heating surface is the internal area of the firebox exposed to the action of heat. The heating surface is found by finding the number of squares in grate surface, side, back and flue sheet, plus the square inch in the flue, multiplied by the number of flues.

42. In what way does this effect the power of the engine?

Ans. As the source of power is heat, naturally the greater the heating surface the more power can be generated in the cylinders of the engine.

43. About how many pounds of coal should be burned per hour, per square foot of heating surface?

Ans. The amount of fuel consumed per hour, per square foot of heating surface, depends upon the conditions under which the locomotive is being worked. As one pound of coal can and will under favorable conditions raise one pound of water one degree in temperature, the amount of water exposed to the surface as well as the conditions in firebox combustion must be taken into consideration before any set amount per hour could be figured upon. We will leave this question for those better versed in such studies to figure out.

44. **How is the heat of combustion found, as it applies in locomotive practice?**

Ans. The degrees of heat in furnace combustion are found by an instrument consisting of a bomb-like cylindrical body, in which a certain amount of water is exposed to the temperature to the fire for a given length of time, and the degrees of temperature in the water after careful calculations for loss are registered on a thermometer. This in a way registers the temperature of the fire and gives the heat value of the fuels being burned.

45. **What is a water table, used in connection with the locomotive boiler?**

Ans. This is a form of metal arch, taking the place of the common brick arch, placed in the firebox in much the same manner as the brick arch and for the same purpose, to retain firebox gases, longer, and keep the temperature of the box high as well as offer protection to the flues when the fire door is opened.

46. Describe the construction of grates used in connection with coal burning locomotives.

Ans. There are many different kinds of grate used in connection with coal burning engines, the general type being known as the finger type. The kind of coal as well as the service the engine is in has much to do with the style of grate used. When hard coal is being burned a form of water grate is used; when soft coal is used many kinds of grates are used, such as stub, finger, and rocker grate, each grate being composed of a set of fingers that interlock with the other section on either side, thus forming a grate that permits of a great air space as well as allows the ashes of the fire to be easily shaken into the pan when it is so desired.

47. Describe the different kinds of stack used in connection with the locomotive boiler.

Ans. Different front arrangements call for a different kind of stack. The first stack was known as the diamond stack, and due to its construction the draught on the fire was created. The old diamond stack is now a thing of the past with the extension front ends. With the extension front ends there are several kinds of stack used such as the large straight, short, and a stack with a choke bore or a flare that has much the same effect on the gases as the choke bore does to the barrel of a gun. The most usual are the straight short stack, the size depending upon the size of the front end and in many cases the road over which the engine is to be operated. On roads that operate through tunnels the stack sometimes is equipped with a hood, to cause the gases and smoke to trail the engine rather than strike the roof of the tunnel.

48. What is meant by the exhaust nozzle?

Ans. The exhaust nozzle is a ring-like arrangement, placed on top of the exhaust stand, to cause the exhaust steam to escape with a greater velocity than it otherwise would. These nozzles are sometimes two in number in each engine, but the usual practice is to have but the one. Upon the size of the nozzle much of the draft regulation of the firebox depends, as the nozzle has the greatest amount of work in regard to the force draft of the boiler. It is not considered necessary to go into detail in regard to the effect of a large or small nozzle on the fire.

49. What causes the exhaust nozzle to become gummed up?

Ans. This condition is brought about by the use of a large amount of cylinder oil, it in time collecting on the nozzle decreasing its size. When this condition arises the nozzle should be bored out, thus increasing it to the proper size for the draft of the engine. Small nozzles cause considerably more coal to be burned than is necessary.

50. What is meant by boiler fittings?

Ans. These are the different mechanical appliances that are fastened to the boiler, in order to enable the engineer to have full control of the boiler, and the engines as well to which the boiler is attached.

51. What are some of the boiler fittings or attachments.

Ans. The boiler attachments consist of dry pipe, steam pipes, extension from end, and the different draft arrangements parts, the safety valve, injectors, check valves, blow off valves, whistle, bell, gauge cocks, water glass, and steam gauge to register the pressure per square inch inside the boiler.

52. Could the boiler be operated without a steam gauge?

Ans. Yes, depending upon the pops, there being always two or more.

53. Could the boiler be operated without a water glass?

Ans. Yes, by using the gauge cocks, there being three on all boilers, and on some more.

54. Why is it necessary to place the throttle valve in the boiler?

Ans. This is done in order to draw the steam from the boiler with its greatest degree of heat, thus giving to the cylinders of the engine all the power that it is possible for the boiler to generate, there being no loss due to condensation, as the case would be were the throttle valve placed on the outside of the boiler.

55. What is the most important fitting used in connection with the locomotive boiler?

Ans. The most important fitting is considered to be the safety valve.

56. Why is this the case?

Ans. Because upon the safety valve depends the safe working pressure, which the boiler is designed to carry. The boiler might be able to carry a greater pressure than allowed to by the safety valve, but under no circumstances should this valve be so adjusted to carry more than the working pressure generally shown on the sheel of the boiler. The company has men whose duty it is to see that these valves are properly adjusted.

57. Why is more than one safety valve used?

Ans. This is done as an extra precaution in case for any reason the valve should become inoperative. The valves are so set that there is a difference of two and one-half pounds between them.

58. Is there any other precaution made for the safety of the boiler other than safety valves?

Ans. Yes, there is placed in the crown sheet what is known as a fusible plug consisting of composition metal easily effected by heat, when not subjected to emersion in water.

59. What is the composition of a fusible plug?

Ans. The composition of these plugs are brass body, in which is found a soft center, consisting of alloy of tin, lead and bismuth. In case the sheet becomes bare these plugs melt allowing the steam to escape and relieve the boiler of its pressure as well as put out the fire.

60. What sort of an arrangement is a gauge cock?

Ans. The gauge cock is an outward opening valve, from the boiler, and consists of a stem screwing into a body that enters the sheet of the boiler. It tells the water level by allowing water to escape when opened, and is considered the only safe manner in which the water level of the boiler can be told under all circumstances.

61. How many gauge cocks are there on any boiler?

Ans. There are always three, and in some cases six.

62. What is meant by the hydraulic test used in connection with a steam boiler?

Ans. This test consists of filling the boiler full of cold water, and then by means of a force pump, try to cause it to hold more water than it is capable. The pressure exerted by the water is what is known as hydraulic pressure, and a boiler is usually considered safe when it will stand one and one-half times the working pressure for which it was designed. This test is given to all boilers, in order to detect faulty material or workmanship, as well as to see that an old boiler has not lost its strength. In some cases the water pressure is five times as great as it is intended the working pressure to be. This should not be done unless the factor of safety is intended to be five.

63. After taking into consideration the factor of safety and the points in boiler construction, what

should next be taken into consideration, in the study of the locomotive?

Ans. After understanding the points in boiler construction, the manner in which the product of the boiler (steam) performs its work should then be taken into consideration.

64. **In what part of the locomotive is the power of steam made to perform a work?**

Ans. The cylinders of the locomotive, or engines. is the point at which we get the power of the steam, it being understood that without cylinders, the rods and levers, we find in connection with the wheel, wheel on the rail could not possible exert any power.

65. **When we speak of an engine what do we mean?**

Ans. An engine is a mechanical device by which the power of stored energy is made to perform a work.

66. **Of what does an engine consist?**

Ans. An engine consists of a cylinder, piston, valve, some form of valve control, a connecting rod and a connection from the storage plant, so as to supply the cylinder when the machine is in operation.

67. **What is a locomotive?**

Ans. A locomotive consists of two separate and distinct machines, coupled to the same operative parts, namely: The driving shaft, the valve events of one engine being the same as the valve events of the other, but of course taking place at different times, or intervals, due to the manner in which they be connected to the driving shaft. The term locomotive applies due to the fact that the power of the engines causes locomotion, or movement of the machine, in which case the power of the operating energy is transmitted to the wheel, wheel to the rail. The ability then of the locomotive to haul a train depends upon the weight of the machine, in connection with the power exerted in the cylinders.

68. How many kinds of locomotives are there in general use?

Ans. There are two, simple and compound.

69. What is a simple engine?

Ans. A simple engine is one whose operating energy is not expected to perform work but once, it then being exhausted to the atmosphere. This action consists of the act of admitting, allowing a work to be performed equal to the expansive influence of the confined medium of energy, the exhaust then taking place allowing the remaining amount of energy to escape to the atmosphere. This action being a simple step in valve study, is called simple engine valve events.

70. What is a compound engine?

Ans. A compound engine is one in which the operating energy is made to do work two or more times. This action is brought about by a double set of cylinders and controlling valve arrangement. The steam after being used in one set of cylinders is exhausted into another set obtaining whatever available energy remains in the confined medium by which power is being obtained.

71. In classifying locomotives, what things are taken into consideration?

Ans. The number of wheels the engine contains gives a system of classification. Beginning with the front engine truck, and counting back, an engine is classed in the following manner: When the engine contains two wheels on the engine truck, it is spoken of as an engine truck. When not it is either a pony, or bógy truck. Thus an engine is spoken of as 4-number of drivers being next, 2 and trailer 1, or 4-2-1 class.

The following is a list of Locomotives classified:

0-4-0/O O	4 Wheel	0-6-4/O O O oo	Forney 6 coupled
0-6-0/O O O	6 Wheel	0-4-6/O O ooo	Forney 4 coupled
0-44-0/OO OO	Articulated	0-6-6/O O O ooo	Forney 6 coupled
0-66-0/OOO OOO	Articulated	2-4-2/o OO o	Columbia
2-44-0/o OO OO	Articulated	2-6-2/o OOO o	Prairie
0-8-0/O O O O	8 Wheel	2-8-2/o OOOO o	8 coupled
2-4-0/o OO	4 Coupled	2-10-2/o OOOO o	10 coupled
2-6-0/o OOO	Mogul	2-4-4/o OO oo	4 coupled
2-8-0/o OOOO	Consolidation	2-6-4/o OOO oo	6 coupled
2-10-0/o OOOOO	Decapod	2-8-4/o OOOO oo	8 coupled
4-4-0/oo OO	8 Wheel	2-4-6/o OO ooo	4 coupled
4-6-0/oo OOO	10 Wheel	2-6-6/o OOO ooo	6 coupled
4-8-0/oo OOOO	12 Wheel	4-4-2/oo OO o	Atlantic
0-4-2/OO o	Four coupled, Trailer	4-6-2/oo OOO o	Pacific
0-6-2/OOO o	Six coupled, Trailer	4-4-4/oo OO oo	4 coupled double end
0-8-2/OOOO o	Eight coupled, Trailer	4-6-4/oo OOO o	6 coupled double end
0-4-4/OO oo	Forney 4 coupled	4-4-6/oo OO ooo	4 coupled double end

In this diagram the numbers represent the class, the dash, or line at an angle the pilot, and the small cypher the engine truck wheel or trailer, while the large cipher represents the drivers.

72. **What is meant by Mallet Articulated Compound locomotives?**

Ans. The word Mallet represents the name of the inventor, or the man who first succeeds in getting two small engines under the one boiler tried out on a small railroad in France. (Anatole Mallet.) The word articulated, associated with the word Mallet, refers to the jointed feature in the frame by which a maximum wheel base is obtained without the rigid wheel base that would accompany such an engine were it not for the articulated feature in the frame. The drivers are arranged in sets, and each set has its own set of cylinders. The joint in the frame allows the engine to take much shorter curves than it would otherwise be possible were there no articulated feature.

73. **What is meant by the term Malley Compound?**

Ans. This term applies to a double engine, compound in the use of its steam consisting of two sets of cylinders placed on a hinged frame, under the one or same boiler.

74. **Does this class of locomotive work compound at all times?**

Ans. On some types of this class of engine the intercepting and reducing valve works automatically while on others the engineer can at will work the engine either simple or compound.

75. How does the intercepting valve operate?

Ans. On locomotives that are equipped with the automatic operating intercepting valve steam from the boiler at reduced pressure is admitted to the low pressure cylinders, while steam at full boiler pressure is being admitted to the high pressure cylinders. This action only takes place for one complete revolution of the driving wheel, when the intercepting valve automatically closes the port and pipe connection from the boiler to the low pressure cylinders, and opens the connection between the high pressure cylinder's exhaust, into the low pressure steam chest. The engine the works compound, the low pressure cylinders receiving their steam direct from the exhaust of the high pressure cylinders.

76. What connection if any is there in the valve gear arrangements on a Malley Compound locomotive?

Ans. Each set of cylinders has its own separate and distinct valve gear parts, there being no connection between the high and low pressure engines so far as the valve gear parts are concerned.

77. What style of valve and valve gear is generally used with this type of engine?

Ans. The high pressure cylinders are generally equipped with the piston valve while the low pressure cylinders are equipped with the ordinary balanced slide valve. The valve motion of both sets of cylinders is usually of the Walschaert type.

78. **What provision is made for flexibility, in the steam pipe connection between the high and low pressure cylinders, on this type of locomotive?**

Ans. This pipe has what is known as a ball joint connection at either end. so as to give the pipe flexibility in case of uneven movement, such as over rough track and around curves.

79. **From whence does the exhaust from this style of locomotive come?**

Ans. If the locomotive be equipped with the automatic intercepting valve and the engine working compound at the time the exhaust comes from the low pressure cylinders. The steam that is exhausted from the high pressure cylinders is stored in the steam chest, and steam pipe connection, between the high and low pressure cylinders.

80. **Is it possible to cause the exhaust to go to the atmosphere, without entering the low pressure cylinders?**

Ans. Yes on some types of this locomotive there is what is known as a direct exhaust caused by reason of the fact that the engineer has control of the intercepting valve. When the engine is being worked simple, the steam from the high pressure cylinders is exhausted directly to the atmosphere.

81. **By what means is the steam supplied to the high pressure engines, with the Malley Compound type of locomotive?**

Ans. The steam pipes that supply the high pressure cylinders are placed on the outside of the boiler. The throttle valve is situated in the steam dome and empties its steam into these pipes which lead to the steam chest of the high pressure cylinders.

82. What provision is made for uneven movement in regards to all pipe connections, with this type of locomotive?

Ans. When pipes extend from one set of cylinders to the other or from one end of the boiler to the other, they have what is known as a flexible joint. This joint consists of a form of the common ball joint.

83. What are the advantages claimed for this type of locomotive?

Ans. (1) It is claimed that about 50 per cent. more load can be hauled with this type of locomotive than can be hauled with a simple engine having the same weight on drivers, that is the same weight per axle.

(2) It is also claimed that a saving of 33 1-3 per cent. is affected in fuel on the basis of ton miles, owing to the fact that 50 per cent. more load can be hauled than could be hauled in heavy grade work with a simple engine.

(3) It is claimed that this increased load is hauled with the same effort on part of the crew, as would be the case with the simple engine, consequently an increased earning for the company.

(4) It is claimed that the entire weight of the locomotive is utilized for tractive effort or purpose.

(5) It is claimed that about 20 per cent. additional power can be developed at will of the engineer, by working the engine simple (working live steam in all the cylinders) when occasion or conditions would require it.

(6) It is claimed that the short rigid wheel base offers less resistance to the flange on the drivers and is therefore easier on the track.

(7) It is claimed that the engine is less liable to slip than is the case with the simple engine, owing to the equal distribution of the weight on each driver, and the perfect balance of pressure in cylinders, when the engine is working hard. The accumulation of a high unbalanced pressure does not occur between the wheel and rail at the point of contact at the same time in both engines, consequently less liability to slip. In case the engine does slip, that is the high pressure engine should slip, it is not necessary to close the throttle in order to stop it as the greater pressure in the steam pipe and chest due to the exhaust from the high pressure causes the low pressure cylinders to gain in tractive power, and the high pressure engine then with a lessened load regains its grip on the rail and the train is kept in motion even though the engine should slip.

(8) It is claimed that the running gear is much easier to make repairs on than is the case with the simple engine of the same or near the same weight.

(9) It is claimed that in certain localities that the Malley is capable of doing the work of as many as

three ordinary engines, hence the saving in connection with the operation of this number of locomotives.

(10) It is claimed that from the earning and economical standpoint, the Malley Compound is fast taking the place of all other heavy power used in freight service.

84. When was this type of locomotive introduced into the United States?

Ans. The first engine of this type was built in 1904 for the Baltimore & Ohio Railroad and was placed on exhibition at the St. Louis Exposition. This tremendous piece of machinery was viewed with suspicion by the leading Motive Power men of the country, but after being placed in service on the mountains in the east proved in every way a complete success. From this experiment the American locomotive builders have since turned out many different types of this great piece of machinery.

85. Where was this engine first designed and placed in service?

Ans. This engine was first designed in France, and placed in service in all parts of Europe, meeting with general favor in all sections of the country.

86. What other type of freight locomotive is in general use in this country?

Ans. The consolidation, or 2-8-0 type, the Mikado, or 2-8-2 type, the Decapod or 2-10-0 type, the ten wheel or 4-6-0 type, the Mogul, or 2-6-0 type, and others such as the Pacific, Prairie types of engine, the Consolidation type meeting with the greatest favor at present. These engines are generally designed to carry 200 pounds of steam, and have in many cases superheaters, so that in most parts of the country they seem to answer the requirements of a heavy freight locomotive.

87. As a rule how are these engines designed?

Ans. They are designed with as much weight as possible on the drivers, so as to increase their tractive force, it being understood that the power of the cylinders of any locomotive must be offset with weight at the point at which the power is delivered. (The Wheel). The boilers of this class of engine are usually of the wagon top type, with large, or wide fire boxes. When the engine is of the simple type, the general practice is to design as large a cylinder as possible, with a longer stroke and smaller wheel than is used on engines with high steam pressure, superheaters, or one in which the use of the steam is compounded.

88. Is there any other advantage in the use of the consolidation type of engine over the larger and heavier class of freight locomotives?

Ans. It has been proven that the consolidation type of freight engine can in cases of emergency be used in passenger service successfully, while with heavier engines this would be impossible. Often the demands of railroads require that a freight locomotive be used in passenger service temporarily, and the use of the consolidation type has greatly benefited this department of railroads. Then again in fast freight service the consolidation fills the wants for an engine that can successfully handle tonnage at a reasonable speed, where any other type of an engine could not be so operated.

The heavy freight locomotive is only designed to haul tonnage, and of course could not be expected to make express train time with a freight train. The weight carried per axle causes the parts to run hot and even when this does not occur a general damage is felt to both the engine and the track, when this class of engine is operated at high rates of speed.

89. **What is the general type of valve gear, and what style of valve set do freight locomotives generally have?**

Ans. The valve gear is usually of the outside connected style, and the valves are generally set with but little lead, and having considerable lap, with no inside clearance.

90. **What is meant by outside connected valve gear?**

Ans. Motion that is connected to the outside of the engine such as the Walschaert, or Baker, Pilliod, valve gear.

91. **What style of valve is generally used in heavy freight locomotives?**

Ans. Both the slide and piston valve are used extensively, while in some cases the Young Rotary Valve, Allfre Hubbel, and several other styles of valves are used, the slide valve being on some of the leading roads, considered the best, while on others the piston valve meets with general favor.

92. **What are the main advantages in connection with outside valve gears?**

Ans. The main advantage lies in the fact that the motion is much lighter, easier to repair, less liable to cause trouble by running hot, and several other advantages, in points of construction, both to the valve gear parts, and the beneficial results obtained in connection with other points of construction of the locomotive. In regards to steam distribution there seems to be but little if any beneficial results obtained, as was first thought, by reason of controlled lead at all points of cut-off. The best authority on the subject claims under certain conditions, and in some classes of service, the older style of motion gives more satisfactory results. The outside connected motion seems to have taken the place of all other styles of valve gears and probably will continue to be the leading motion for all kinds of service for many years to come.

93. **What style of valve set gives the best results on a high speed passenger engine?**

Ans. Leading authorities claim that when an engine is on high speed passenger runs the valves set with a small amount of lead, and a little inside clearance give the best results. The manner in which this is done depends upon the style of valve and the controlling valve gear. With the Stephenson valve gear it is general practice to set the valves blind in full gear, sufficient lead being accomplished, or obtained, when the lever is well hooked up to give the desired results. This is brought about by reason of points in construction, which will be explained later. The Walschaert valve gear offers a more satisfactory method of setting the valves for all kinds of service by reason of its cross-head connection, known as the lap, and lead lever, or combination lever. Valves with this style of motion have the same lead at all points of cut-off, and this feature is what is known as positive lead, or lead control.

94. What beneficial results are obtained by setting valves with lead, and of what use is lead control, or positive lead?

Ans. By giving an engine lead, or preadmission, as it is more commonly spoken of by motive power men, the engine is made smarter, the event in the stroke known as cut-off is caused to be earlier, and a better cushion for the piston in the cylinder is formed, thus helping the engine by its dead centers, and causing the engine to ride better. Predetermined, and positive lead, gives more satisfactory results due to the fact that the lead does not become too great at short points of cut-off, as is the case on engines with the Stephenson motion, they having lead in full gear. When this style of motion is well hooked up or working at a very short point of cut-off the lead often becomes too great for beneficial results in steam distribution.

95. Why are valves given inside clearance or exhaust clearance?

Ans. Valves are given inside clearance in order to hasten the exhaust, thus decreasing back pressure and cushion. The engines that usually have this feature in valve construction are high speed passenger engines, with valves set with considerable lead, or preadmission. The steam is exhausted earlier in the stroke of the piston than it otherwise would be were it not for this feature. When an engine is running fast the steam enters the cylinder, strikes the piston and in reality there is but little expansion of steam, then in order to accommodate the movement of the piston it is necessary to rid the cylinder of the steam, so that the return stroke of the piston will in no way be interfered with. When the valves are constructed with exhaust clearance, the cushion for the piston while passing its dead centers is formed by the lead, or pre-admission of the valve, due to the valve gear, or with piston valves this event is sometimes brought about by decreasing lap, thus increasing lead.

96. What is meant by exhaust lap?

Ans. Exhaust lap is the amount the inside edges of the exhaust arch of the valve overlap the inside edges of the exhaust bridge when the valve is centrally on its seat.

97. Why are valves given exhaust lap?

Ans. Valves are given exhaust lap, in order to delay the exhaust, increasing compression or cushion, without giving the valve any more lead, or pre-admission. Valves so constructed are generally used in connection with heavy freight engines, it being understood that in order to increase the pulling power of an engine the steam must be retained in the cylinder for a longer period of time than on an engine designed for speed. Inside lap does this without causing a drain on the boiler, to accomplish the same results.

98. In the study of valves and valve gears what do we mean by valve, or by valve motion?

Ans. Of all the various parts that comprise the locomotive, when properly assembled, the valve, and its controlling motion, offers the most interesting subject for study. Upon the valve and its controlling motion depends the ability of the engine to perform the work for which it was designed. Unless the events in the stroke, admission, cut-off, release, and compression, take place at the proper time to accommodate the movement of the piston, the locomotive is an inperfect machine, and no satisfactory results can or will be obtained until such time as steam distribution is in accord with the movement of the piston, in the cylinder. The function of the valve or valves is to control the admission to, or the exhaust from, the piston in the cylinder of an engine. The valve acts as a gate in the path of steam or the mechanical energy, by which the machine is being propelled, and upon its movement in one of two directions, the energy used to propel is allowed to leave the boiler, or store house, and enter the cylinder of the engine. The valve in its movement admits, cut-off, releases, and produces compression of steam, or any other controlling energy, each and every time it moves the distance of its stroke. There are many kinds of valve, but the subject will be taken up later.

99. **What is meant by valve motion?**

Ans. By valve motion is meant the act of moving, or causing to be moved, the valve, in connection with the parts of an engine, or locomotive. This motion is automatic, and purely mechanical, producing the four events in the stroke of the piston.

100. **What produces this mechanical motion?**

Ans. Some form of eccentric, or crank, with its connected parts, which transmit motion to the valve, or valves.

101. **To what is the eccentric or crank fastened?**

Ans. The eccentric or crank is fastened to some one of the driving axles, or journals, which when they move due to the transmission of power in the cylinders of the engine (due to the main rod connection), cause the same motion to be transmitted to the valve. This connection can be made to any one of the driving axles but is generally connected to the pair, on which the main rod is connected. This is done for various reasons that will be taken up elsewhere in this volume.

102. **What are the four events in the stroke?**

Ans. The four events in the stroke of the piston, are admission, cut-off, release, and compression.

103. **What is meant by admission?**

Ans. By admission is meant from the time the steam port is opened, until it is closed, during which time steam from the boiler is being supplied to the piston in the cylinder. As the names implies, admission is the act of admitting, or causing to be admitted.

104. **What is meant by cut-off?**

Ans. By cut-off is meant the act of the valve in closing the admission port to the cylinder of the engine. When cut-off takes place the flow of steam to the cylinder is stopped.

105. **What is meant by release or exhaust?**

Ans. By release is meant the act of allowing the steam in the cylinder to escape to the atmosphere, it having performed its work in a greater or lesser degree.

106. **What is meant by compression?**

Ans. By compression is meant the act of squeezing or trying to compress the steam trapped in the cylinder, due to the fact that the exhaust port closed before all steam was able to escape. This event in the stroke is known as compression, and forms the cushion that brings the reciprocating parts to rest, while they are passing their dead centers.

107. **What is meant by the stroke of the piston?**

Ans. The stroke of the piston is the movement of the piston from one end of the cylinder to the opposite end.

108. **What is meant by valve travel?**

Ans. The valve travel is the distance the valve moves in either direction. The total valve travel is equal to twice the distance in inches to the throw of the eccentric. Thus if the eccentric has a five-inch throw, the total valve travel will be ten inches, five inches ahead, and five inches back.

109. **Are there any other movements of the valve, other than the travel derived from the eccentric?**

Ans. Yes, on certain kinds of valve motion, the valve derives a travel from a cross-head connection. This movement can under certain conditions be produced without any travel, from the eccentric. Under these mentioned conditions the valve travel is equal to the lap and lead of the valve, producing or causing a port opening equal to the lead of the valve. This is the condition when an engine is working at a short point of cut-off, with the outside connected motion.

110. **What is meant by overtravel?**

Ans. A valve is spoken of as having overtravel when it travels farther than is necessary to fully open the steam port, to admission. This overtravel may be so great that in some instances the exhaust port is opened to the stack, in which case there is a very hard blow. This overtravel is generally noticeable when the reverse lever is in full gear.

111. **What is meant by the lap of a valve?**

Ans. The lap of a valve is the amount the valve overlaps the bridges, when the valve is centrally on its seat. There are two kinds of lap, steam, or outside lap, and exhaust, or inside lap. Steam lap produces an earlier cut-off, enables the engine to work steam economically, or expansively, and affords an easy means of giving an engine lead, by reducing lap.

Exhaust lap delays or causes the exhaust to take place later in the stroke than it otherwise would were it not for the lap. Exhaust lap increases compression, and causes a greater cushion for the reciprocating parts to come to rest on while the piston is passing its dead center due to the connection of the rods.

112. **What is meant by the angle of advance, or when we speak of the eccentric leading or following the pin, what do we mean?**

Ans. By the angle of advance is meant the amount the eccentric is, or must be advanced to or from the pin, leading or following, in order to produce the proper opening at the beginning of the stroke, or the position in which the eccentric must be placed in order to bring the valve to the center of its travel, when the main crank pin is on the dead center.

113. **Is it necessary in all kinds of valve set, to have this angle of advance?**

Ans. No, when the valve is constructed without lap, and set without lead, there would be no angle of advance as the eccentric in these cases is set at right angles to the crank pin when it is on its dead center. When so set, it is spoken of as being at right angles to the pin, or 90 degrees, of a circle. A circle is supposed to contain 360 degrees, a line drawn through the circle divides it into halves, or 180 degrees, a line drawn through in the opposite center again divides the circle into 180 degrees. The point at which these lines should cross is the true center, and any section of the circle so cut up by these lines represents one-fourth of the circle, and the angle assumed is a right angle to a perpendicular, hence the expression at right angles to the pin, or leading, or following the pin, 90 degrees plus or minus, the angle of advance, which in reality is the amount of the lap and the lead.

114. **What is meant by the eccentricity of the eccentric?**

Ans. The amount of crank-like action the eccentric possesses is spoken of as the amount of eccentricity the eccentric has or possesses. This crank or throw-like action gives the valves their travel, or movement over their seats. The valves on certain styles of valve motion do not depend entirely on this crank-like action for their movement, but derive a certain movement from a cross-head connection, known as the lap and lead lever, or combination lever. This feature is only found on the Walschaert valve gear.

115. **What are the functions of a valve?**

Ans. The valve (in connection with steam distribution of a locomotive) performs five different things. (1) It admits, or allows steam from the boiler to enter the cylinder of an engine. The steam is admitted in but one end of the cylinder at a time, and the valve must accomplish this, or else the piston would be working against itself, and no work could be performed. (2) The valve must cover the opposite steam port so as to prevent this admission of steam to both ports at the same time. (3) The valve must allow the steam to escape from one end of the cylinder before it is admitted to the other. This feature is called the release or exhaust. (4) The valve must not permit live steam from the boiler to enter the exhaust port, and escape to the atmosphere at the same time the steam is being allowed to escape. (5) The valve must close the exhaust port at the proper time, to retain a certain amount of steam in the cylinder to produce sufficient cushion to bring the reciprocating parts to rest. First we have admission, the act of admitting to the cylinder, then we have cut-off, or the act of stopping the flow of steam from the steam chest or boiler to the cylinder, then we obtain release or exhaust, in which event the steam in the cylinder is allowed to escape to the atmosphere, then we have compression, the steam in the cylinder, that is trapped, due to the fact that the valve closes the exhaust port, causes the remaining steam to be compressed in a smaller space than it is wanting to occupy, hence the term compression, which in reality is delayed exhaust, or possibly the same event in the stroke is brought about by pre-admission, or lead. Admission causes the piston in the cylinder to move. Cut-off closes the port, and the confined steam does its work according to its expansive qualities. Release, exhausts or releases the steam from the cylinder, thus permitting of a free return movement of the piston, when admission from the opposite end of the cylinder takes place. Compression forms the cushion necessary for the piston on any reciprocating engine, thus bringing the parts to rest on the centers and preventing the disagreeable thud, or pound, as the connecting rods pass these points. It would be impossible to operate any reciprocating engine without this event in the stroke known as compression, and upon this event in the stroke depends much of the successful performance of the engine. In valve setting this feature in the set is of vital importance, and no engine performs successfully unless the piston receives the proper amount of cushion. In order to understadn the effect of compression, one must go closely into the effect produced by giving valves lead, and exhaust lap.

116. What effect on valve events does changing the dimensions of the valve have?

Ans. Decreasing the lap of a valve, increases the lead, makes admission earlier, and cut-off earlier. Increasing the lap of the valve, after the eccentrics are set, and no according change made in them, would have the effect of decreasing the lead, and make cut-off later. Advancing the eccentric likewise produces early admission and cut-off. If the eccentricity of the eccentric is increased the valves obtain a proportionate increase in travel. This may in some cases cause over travel. Giving the valve exhaust lap, or clearance, can only be accomplished by adding to, or taking from the exhaust edges of the valve, there being no manner by which these features can be obtained with the eccentric.

117. What are balanced valves?

Ans. Balanced valves are those from which steam at boiler pressure is excluded, in a certain ratio to the two surfaces exposed, the steam area, and the exhaust area. Time was when the top surface of a slide valve was exposed to the pressure of live steam from the boiler and figuring the area of the valve in square inches with so many pounds per square inch it can be seen the load the valve placed on the motion to move. As the locomotive increased in size, the valve became larger, and working pressure also became greater, until were it not for the fact that the valves are in a more or less degree balanced, the entire power of the engine would be absorbed, or used up in its own movement. Aside from the friction of the movement of the valve were it not so balanced, it would be impossible for the engineer to attempt to handle the reverse lever while working steam. So some form of free movement to the valve was devised. The subject of valve balance again brought out many different designs of valves, and balancing features, some of which failed in accomplishing the purpose for which they were intended, but offered the foundation for thought, until at present we have on all locomotives a form of valve most beneficial to the class of service the engine is in.

118. What are the names of some of the different kinds of balanced valves?

Ans. There are many, but the ones in most general use are: The American, the Allen, the Richardson, the Wilson, and several forms and kinds of piston and rotary valves.

119. What is the distinguishing feature in any of these so-called balanced valves?

Ans. The distinguishing feature lies in the manner by which the steam is excluded from the top of the valve. The general custom to accomplish this is by using strips fitted in grooves, on the top of the valve, these strips working against a plate, either fastened to or cast on the underneath side of the steam chest cover.

120. In what manner is the piston valve balanced to pressure?

Ans. The piston valve being round, or spool shaped, operates in a bushing of equal diameter, and the pressure of steam is excluded from the outer surface of the valve by packing rings. These rings form both the admission and exhaust edges of the valve as well as upon the number, and size of these rings depends the perfect balanced feature of the valve.

121. In general railroad practice how many rings are there on each end of the valve?

Ans. There never is less than two (unless the valve be of the New American type), and in some cases three or more rings on each end of the valve.

122. What is the New American piston valve?

Ans. The American or semi-plug piston valve with but a single ring on either end of the valve. This ring is quite wide, and acts as both the admission and exhaust edges of the valve.

123. Has this ring any other peculiarities?

Ans. Yes, aside from being a wide ring it has a wedge-like piece underneath it in the groove in which it works. This wedge is set out or raised by the steam pressure, forcing the packing ring out against the walls of the cylinder, or bushing in which it works.

124. How is steam admitted to this wedge to accomplish this action?

Ans. On the inner side of the valve, or the edge from which the valve admits steam, there are several small holes drilled through the end of the spool, and admitting the steam underneath the wedge, producing the action just spoken of.

125. What is the advantage in a valve so constructed?

Ans. The main advantage lies in the fact that the ring forming a more tight joint against the bushing in which the valve moves, causes the valve to be more steam tight, with less liability to blow. This valve is spoken of as a semi-plug valve, due to the fact that it is fitted with snap rings, which are expansible. When the throttle is closed these rings contract, or float in the bushing, but when the throttle is opened they adjust themselves to the walls of the bushing, and form a form of plug. This valve has many of the desirable features of the slide valve, yet retaining all the beneficial ones of the piston valve.

126. What sort of a valve is the Young Rotary Valve?

Ans. This valve is constructed much after the manner of the ordinary Corliss Engine valve. The valve is round, and has some of the features of the slide valve (namely, The Allen Ported Valve), in that it has a double admission port, or that the valve takes steam through a port in the valve at the same time that it is taking steam by the edge of the valve. This under certain conditions has a decided advantage. The balance feature in this style of valve is practically the same as in the piston valve, the ease with which the valve is moved in its bushing being practically the same. The greatest advantage of all lies in the fact that the valve is much more steam tight than a piston valve, hence there is less liability of a valve blow.

127. **What are some of the other advantages?**

Ans. The ease with which the valve is moved in its bushing shows but very little wear on the machinery in parts. The eccentrics, with an engine equipped with this valve, after eighteen months' continuous service, show but very little wear. This is in itself a decided advantage. Aside from this, steam distribution is more uniform, the port opening being largest at the beginning of the stroke, the point at which it is most desirable. The exhaust opening is said to be much larger, with all points of cut-off that it is possible to obtain with other styles of valve. This has the advantage of causing but very little back pressure.

128. **Are there any other advantages in connection with the use of this valve?**

Ans. Yes, there being two valves for each cylinder, when a breakdown does happen, such as knocking out a front cylinder head, or one of the valves or valve gear parts giving out, the engine can be so blocked that it can complete the trip with an engine and one-half working steam. This will be further explained under the head of valve gear breakdowns.

129. Aside from all these advantages, what other distinguishing features does this valve possess?

Ans. The Young Valve, being on the form of a Corliss Valve, is much like the slide valve inasmuch as it is considered more steam-tight than a piston valve, yet it is possible to move it with the same ease as the piston valve is moved. The fact that it operates in a bushing, with a rotary motion, makes it very easy to move, as well as the fact that there is but little or no trouble experienced from valve stem blows. This point in the construction of the Young Valve is a decided advantage, it not being necessary to use valve stem packing. The stem of the valve is in no way exposed to pressure, hence there is no necessity for packing.

130. Has this style of valve any by-pass valves used in connection with its bushing?

Ans. No, as the functions of the valve set are so arranged, along with the construction of the valve, that compression is taken care of by the exhaust opening of the opposite valve. There being two valves to each cylinder, one only at a time is performing the events of the stroke, such as admission, cut-off, release and compression. When one end of the cylinder is taking steam, the valve on the opposite end is taking care of the release, or exhaust. This makes it possible to obtain certain beneficial results not possible to obtain with other valves, namely, the manner in which steam can be worked expansively, without interfering with the actual construction of the valve. On other styles of valve in order to obtain certain beneficial results during the exhaust opening, other functions of the valve are sometimes destroyed.

131. **What style of strip is used with this valve, in order to make it a perfectly balanced valve?**

Ans. The strip used in connection with this valve is much the same as is used with the slide valve. The admission edge of the valve is supplied with a much wider strip than the exhaust edge, hence the manner by which the lap of the valve is given. These strips are held to the valve proper by a groove and are raised to the inner surface of the bushing in which the valve operates by a spring. These springs are much the same as are used with the older form of slide valve. When the engine is working steam the action of the steam sets the strips out against the walls of the bushing, making a steam-tight joint. There is but little trouble experienced from these strips sticking, as was the case with the slide valve.

132. **Do these strips show any great amount of wear?**

Ans. No, the greatest advantage in connection with the use of this valve is the fact that there seldom appears on the work report anything in connection with the valve. These valves, after eighteen months' continuous service, show scarcely any wear. The bushing in which they operate shows well polished, but the strips show but little wear.

133. What style of valve gear is used in connection with the Young Valve?

Ans. This valve has been successfully operated with both the Stephenson and a form of Walschaert Valve gear, invented by Mr. Young and known as the Young Gear. The Young Gear is similar to the Walschaert, being an outside motion and possessing all of the functions of the Walschaert, namely, a pre-determined and positive lead at all points of the stroke. This feature in a valve set is known as positive lead, and has the same beneficial results with the Young Valve that it has with other type of valve.

134. How is this lead control at all points of cut-off accomplished?

Ans. The lap and lead of the valve is controlled by what is known as the combination lever or lap and lead lever. This lever has its connection to the cross-head, also to the radius bar. The angle assumed by the radius bar is the same regardless of the position of the radius block in the link. (Or regardless of the point of cut-off, due to the position of the reverse lever in the quadrant.) The cross-head having at all times the same travel, the combination lever acts as a fulcrum to the motion, as it were, and the valve is moved a certain distance at the beginning of the stroke (depending upon the pre-determined amount of lap and lead) before there is any valve travel derived from the eccentric. It can then be seen that the point of cut-off does not in any way effect the lap and lead, due to the fact that the combination lever at all times takes care of these functions of the valve.

WALSCHAERT VALVE GEAR BREAKDOWNS.

135. What are the names of the different parts of the Walschaert Valve Gear?

Ans. The names of the different parts are: Eccentric crank, eccentric rod; link, radius bar, radius block, valve stem cross-head, valve stem guide, valve stem, combination lever, union link, cross-head arm, reach rod, reverse shaft and its arms, lifting arm, lifting link.

136. How is the link supported with this motion?

Ans. The link is supported in a bracket on what are known as trunion pins.

137. How is the radius bar connected to the valve stem with this style of motion?

Ans. This depends upon the style of valve. With an inside admission valve the radius bar is connected to the combination lever (which is in turn connected to the valve stem or its crosshead) above the valve stem crosshead. With an outside admission valve the radius bar is connected below the valve stem crosshead.

138. How is the radius bar lifting link connected to the radius bar?

Ans. On some motions it is connected ahead of the link, while on others it is connected to the radius bar behind the link.

139. At what point in the link—top or bottom—is the radius block placed for the forward motion?

Ans. This depends upon the style of the motion, as well as the position of lifting link, either ahead or behind the link. On the American style of motion the block is carried in the bottom of the link for the forward motion, while on others it is carried in the top of the link for the forward motion.

140. In what manner is the reverse brought about—both the forward and backward motions—being controlled by a single eccentric?

Ans. The link being stationary has in it a curved slot. The position of the link, then, at all times depends upon the position of the pin or the wheel to which the pin is attached. The eccentric crank being connected to the link by the eccentric arm causes the link to assume a proper position in relation to the pin. The radius bar moves the valve so as to admit steam to the cylinder, in relation to the position of the piston in the cylinder. Now, when it is desired to reverse the motion of the engine, the reverse lever is moved in the desired direction corresponding to the motion, and the radius block moves in the curved slot of the link, the radius rod then causes the valve to be moved so as to admit steam to the piston in the desired direction. This might be better understood by supposing that the engine was standing on the forward dead center (right side), the reverse lever in full forward gear. In this position, with some styles of valve gear, the radius block is in the bottom of the link, and the radius bar has caused the valve to open the front admission port to the cylinder. The engine is the taking stem on one side ahead of the piston (right side), and behind the piston on the other (left side). In this manner the engine is caused to move ahead. Now if with the engine standing in this position it was desired to back up, the reverse lever would of course be moved to the opposite corner of the quadrant, or in full back gear. This would cause the radius block to be moved to the top of the link, in which position the valve would not have moved from its original position, due to the radius of the link and the position of the engine on the right side. The front admission port on the right side would still be open, and the right engine would be taking steam ahead of the piston. The left engine standing on the quarter would, after the reverse lever had been moved, take steam ahead of the piston for a very short period, or just long enough to get the right engine off its dead center, when the right engine doing most of the work causes the engine to back up. The reverse is brought about with the Walschaert Valve Gear by the fact that the link is stationary and has in it a curved slot, controlling the movement of the radius bar and block.

141. **How is a shorter point of cut-off obtained with this motion?**

Ans. The point of cut-off is effected or brought about with this motion in much the same manner that it is with other styles of valve gear, that embody the functions of the link. The closer to the center of the link the block is worked the shorter the point of cut-off. With the Walschaert Gear valve travel is derived from two sources, and as the block is caused to be moved to the center of the link to shorten the cut-off the movement of the valve then most all falls on the combination lever, with its cross-head connection. In fact, when the center of the radius block corresponds with the center of the link trunion pins, all valve movement comes from the combination lever. With the reverse lever in a position to bring about this result the valve has a movement equal to the lap and lead of the valve, and the port opening is then equal to the lead of the valve.

142. How is the lead controlled with this style of motion?

Ans. The lead control with the Walschaert Valve Gear has been explained in connection with the Young Valve and Gear it being the same in connection with this motion. It is not considered necessary to repeat it.

143. What style of motion is the Walschaert?

Ans. The Walschaert is said to be both direct and indirect. When the radius block is carried in the bottom of the link for the forward motion and the engine is being operated in the forward motion the motion is said to be direct, but when the radius block is working in the top of the link, and the engine is backing up the motion is said to be indirect.

144. Are there any decided advantages, so far as breakdowns are concerned, with this motion over others?

Ans. Yes, as the motion being an outside motion, or outside of the frames of the engine, it is much easier to get at in case it becomes necessary to do any blocking. Aside from this there are conditions where it is possible to obtain a valve travel after a breakdown that would not be possible with the other styles of valve gear.

145. What can and should be done in case of a broken eccentric crank, eccentric rod, link foot, lost eccentric rod bolt, or a broken trunion pin?

Ans. With any one of these breakdowns the engine can be run in on both sides, both main rods being left up and both cylinders working steam. There may be conditions under which there might not be any particular results obtained from such a performance as trying to haul a heavy train, yet at the same time, when the engine is able to handle the train on one side, the following method should be used. For a broken eccentric crank, eccentric rod foot of the link, or a broken trunion pin, block the radius boring the center of the link. Place a block top and bottom on each side of the radius block, so that the center of the radius block corresponds to the center of the link trunion pin. Remove all broken parts and proceed. The valve on the defective side has a travel equal to the combined lap and lead of the valve, and the port opening on that side will be equal to the lead of the valve. The good engine should always be stopped on the quarter, as the defective side has no power to help itself off center, but only works steam at a very short point of cut-off. This method should be followed, as there will be a certain amount of power derived from the defective engine, as well as a much easier and more satisfactory method of lubricating the cylinder with the lubricator. The lifting link should be disconnected and tied up so as to allow the engineer full control of the good engine. When the train is well under way the good engine can be hooked up and the two engines' valve events will be the same, that is if the good engine be worked at its shortest point of cut-off.

146. What can be done in case the good engine should stop on center?

Ans. Shift the valve on the disabled side and move the good engine on the quarter, return the blocking and proceed, exercising more care in stopping.

147. What can be done in case of a broken lifting arm or lifting link, reach rod or tumbling shaft and its arm?

Ans. Block in the link at the desired point of cut-off in the desired motion, being certain to block so as to be able to handle the train on all parts of the road. With any of these breakdowns, block both links top and bottom, and do not allow for the slip of the link block or radius block.

148. In case is was necessary to reverse the motion of the engine, how can it be done?

Ans. By changing the blocking in the link, put the short block in the top or bottom of the link, or vice versa, as the case may be, depending upon the position of the radius block as carried in the link for the forward motion.

149. What can and should be done in case of a broken radius bar?

Ans. Remove the broken parts, clamp the valve on the center of its seat, tie up the end of the broken radius bar from the combination lever and tie it up to main rod if not taken down, and proceed with the engine on one side.

150. What can and should be done in case of a broken combination lever, union link, or a cross-head arm?

Ans. Remove the broken parts, disconnect the radius bar from the combination lever and tie it up to the running board. Clamp the valve on the center of its seat, take down the eccentric rod, make provision to oil the cylinder if main rod is left up, and proceed, with the engine on one side.

151. How should the engine be disconnected for a knocked-out cylinder head, broken piston, or other defects that render one side of the engine useless?

Ans. The radius bar should be disconnected from the combination lever and tied up to the running board. The combination lever should be tied to the back cylinder cock (if the main rod is taken down). The eccentric rod should be taken down, and the valve clamped on the center of its seat. The engine is then ready to proceed on one side.

152. Why is it not necessary to disconnect the radius bar from the combination lever with the engine

disconnected as for a broken eccentric crank, eccentric rod, link foot or link trunion pin?

Ans. With any of these breakdowns it is possible to obtain a valve motion on the disabled side, hence the radius bar should not be disconnected.

153. Why is it not necessary to disconnect the union link from the combination lever, in case of disconnecting the engine as for a knocked-out cylinder head, etc.?

Ans. When the engine is connected for any of these breakdowns, the radius bar is disconnected from the combination lever, and the motion of the cross-head only causes the combination lever to swing at its fixed point on the valve stem cross-head. The valve will not be moved, as there is no connection in the motion or movement of the combination lever.

154. When disconnecting for any of these breakdowns, why is it better practice to remove the eccentric rod than to take chances on leaving it up?

Ans. With the eccentric rod removed there is no possible danger of the radius bar dropping down due to the fact that the cord or wire holding it up might become worn out, as might be the case if the eccentric rod be left. When it is taken down there is no motion on that side, consequently no danger of doing further damage. If the engine had but a very short distance to go, say anything under thirty miles, and the radius bar was tied up with wire, it then might not be necessary to take down the eccentric rod. This, of course, must in no way conflict with set rules of Motive Power men on the road by which you are employed.

155. How would you oil the cylinder with the main rod left up, with the engine disconnected as for a broken eccentric crank, eccentric rod, etc.?

Ans. With the cylinder lubricator. The blocking in cases of this kind allows that particular side of the engine to work steam, hence the lubricator can supply sufficient oil.

156. How would you oil the cylinder in case the blocking could not be done as described in question 145?

Ans. If the rod be left up, the cylinder should be oiled as explained in the first part of this volume by removing the indicator plugs or other ways as explained.

157. In case the union link should break on the American style of Walschaert motion (the combination lever being pivoted to the valve stem cross-head), how could the engine be blocked so as to derive motion on both sides?

Ans. The engine should be placed on the quarter on the disabled side and the reverse lever hooked in the center of the quadrant, or the combination lever should stand straight up and down. A block of wood should then be fit in the stirrup under the valve stem cross-head, and securely held in this position by driving nails through each end of the wood close to the valve stem cross-head. It should then be noticed that the main rod wrist pin is going to clear the combination lever; if not, it should be bent out so that it will. The engine is ready to proceed, working steam on both sides, but it would not be advisable to work the engine at a short point of cut-off, as the functions of the lap and lead are destroyed by reason of the broken union link or cross-head arm, as the case may be. The disabled side must in this case derive all its valve travel from the eccentric, hence the reason for working a longer point of cut-off.

158. What is meant by the term American Style, or American practice?

Ans. By this is meant the manner in which American motive power men have made certain changes in the Walschaert Motion. The motion being an old invention, yet not until late years tried out on the locomotive of this country, suggested certain changes in its mechanical construction that have greatly improved it in parts, hence the expression American style or practice.

159. What was the greatest change from the original style of Walschaert gear?

Ans. The manner of connecting the radius bar to the valve stem cross-head is considered by some to be of the greatest importance, while by others the style of valve stem cross-head is more to be considered. On certain styles of this motion the valve stem has a gib much after the manner of the main rod cross-head, while in others the valve stem cross-head is but a slip bearing. The main advantage in the first named over the other lies in the fact that there is a possible chance to do certain blocking with the defects explained under question 157. While this is not considered much of an advantage, the writer thinks that this is the preferred style from this standpoint, and others, namely, in that particular point in discussion is very much strengthened.

160. What brought about the general use of this style of motion in this country?

Ans: The fact that on the large power of today it was almost impossible to get eccentrics, as well as other valve gear parts, to run under the conditions which they were subjected to, caused the Motive Power men of this country to look for some other style of motion. So far as steam distribution is concerned, this motion also offered certain modifications that are considered beneficial. All the motion being outside the frame of the engine also has certain advantages not possessed by the Stephenson Motion. Troubles from hot eccentrics, with the outside motion are almost entirely eliminated. Engine failures due to broken straps are a thing of the past, as the Walschaert has no such thing to contend with. Running repairs are much cheaper; the life of the motion is much longer; the engine makes greater mileage between shoppings; less trouble to the engineer to oil the various machinery parts; a smaller amount of lubricating oil than was necessary with the older motion; cheaper to install; easier to run valves over in case they by some reason or other get out of square; less liability of such a thing happening, and, in fact, many other decided advantages.

161. **How are the eccentric cranks set with this style of motion?**

Ans. They are always set at right angles to the pin (90 degrees), either leading or following the pin. This depends upon the style of motion and the kind of valve (inside or outside admission) used.

162. **How is the angularity of the main rod accommodated with this motion?**

Ans. The angularity of the rod is taken care of by the dip in the link, or the point at which the eccentric rod connects to the link has a decided backset. This acts to the Walschaert the same as the offset of the link saddle pin in the Stephenson, affecting an even valve travel in all positions of the pin in its revolutions with the wheel.

163. **Has the eccentric crank the same eccentricity as would be experienced with the same valve and the same valve set with the Stephenson motion?**

Ans. No, as all valve travel with the Walschaert is not derived from the eccentric, hence the eccentric does not need to possess the same eccentricity or throw.

164. **Is this any particular advantage?**

Ans. The writer does not think that such is of vital importance in valve motion study. The work performed by the eccentric is much less with this motion, yet in so far as moving the valve is concerned the eccentric crank is much more durable than the eccentric strap, and would be capable of performing more work were it necessary.

165. What part of the motion must then be subjected to the greatest strain when the engine is working at a very short point of cut-off?

Ans. The combination lever must be the point at which the greatest strain is exerted, as with the engine hooked at a short point of cut-off all valve travel is derived from the combination lever and its cross-head connection.

166. With the Stephenson Gear working at a short point of cut-off, where is the greatest strain, so far as the motion is concerned?

Ans. On the back-up eccentrics, for with this motion at a short point of cut-off, all the strain of starting the valve falls upon the back-up eccentrics.

This is considered the reason for the back-up eccentric strap running hot or breaking on most engines running at a high rate of speed and a short point of cut-off.

167. What point in the construction of the Walschaert Gear seems to be the one of greatest importance in so far as steam distribution is concerned?

Ans. The controlled lead feature at all points of cut-off. The lead remaining the same at all times, due to the cross-head connection of the lap and lead lever or combination lever

168. What causes the lead to increase on the Stephenson Gear as the engine is hooked to a short point of cut-off?

Ans. When the reverse lever is hooked to a short point of cut-off with the Stephenson motion, the valve motion is thrown back upon the eccentric, which has the same effect on the valve travel as though the eccentric was to be moved ahead through the motion in the manner in which lead may be given to this style of valve gear.

169. How do the two styles of valve gear handle from an engineer's standpoint?

Ans. The motion has but little to do with the handling of the engine. The Walchaert motion being the lighter should handle the easier, but the writer thinks the style of valve used has the greatest bearing on this question. Considering the valve to be the same, the amount of oil supplied the same, the Walschaert would in all probability handle easier, as in the Stephenson two eccentrics are to be contended with, as well as the fact that in this motion there is much more weight in more parts to be contended with.

BAKER PILLIOD VALVE GEAR BREAK-DOWNS.

170. What is the Baker Pilliod Valve Gear?

Ans. This is a form of outside motion without a link. The motion is said to possess all the features of other motions and one additional one not possessed by others, namely, the dwell in the stroke. This feature, by reason of certain points in the construction of the motion, causes the admission port to remain open for a much longer period of time than it otherwise would with other motions, hence the term dwell in the stroke.

171. What are the names of the different parts of this motion?

Ans. Eccentric arm, eccentric rod, eccentric crank, combination lever, cross-head yoke, union link, lifter bar, valve rod, bell crank, reverse yoke, radius arm, frame inside and outside half (two pieces of each), reverse arm and reverse shaft.

172. This being a linkless motion, what is the advantage claimed?

Ans. This motion having no link or block, has not the wedge-like action of the link block of other styles of motion. There are no loose slipping joints, nothing but pins, working in a bushing, making it very easy to repair in case of lost motion due to excessive wear. The cost of maintenance is very light with this motion, due to this fact. The pins and bushings can all be turned up in an ordinary turret lathe.

173. What about the throw of the eccentric?

Ans. The throw of the eccentric is only seven inches for a valve travel up to six inches. The speed of the engine or the manner in which the engine rides its springs does not effect the throw of the eccentric or the valve travel.

174. What are the advantages claimed by the Baker Pilliod in valve movement?

Ans. It is claimed for this motion that the valve and the piston do not at all times move in relation one to the other. When the motion is in full gear the valve moves as fast as the piston. After the piston has moved 5 per cent. of its stroke, the valve seems to dwell or stand still, as it were, while the piston is moving 40 per cent. of its stroke, or to the point at which release takes place.

When the release takes place the motion causes the valve to be moved very rapidly, thus doing away with the excessive amount of compression.

175. What are the advantages claimed so far as the lead of the valve is concerned?

Ans. This motion maintains a constant lead at all points of cut-off. It is possible to run an engine equipped with this motion with but very little lead, as the motion causes a very quick movement of the valve, this taking place at a time that it is considered most advisable, when the piston is passing its dead centers. It is claimed with this motion that a valve set line will give 5-16 port opening at 25 per cent. cut-off. This, of course, would give a very late release, with but little compression. It is claimed that on an engine with 26-inch stroke, working in full gear, it is only necessary for the piston to travel 5 per cent. of its stroke to obtain full port opening. When the piston has traveled 1½ inches, the port opening is said to be 1 inch. This being the case, as much steam is being admitted as would be with other style of valve gear at one-fourth of the stroke. This feature in itself would be of great advantage in pulling heavy trains.

176. What are the advantages claimed during the period of release?

Ans. It is claimed that the release takes place much later in the stroke at all points of cut-off, hence a much higher rate of expansion. The steam being retained in the cylinder longer is made to perform more work, with less strain on the boiler to supply the cylinders, it being possible to get more work out of each admission. It is claimed by reason of the exhaust taking place late that it is exhausted at a very low pressure, and this with the fact that the exhaust is very rapid and allows the engine to be run with a very large nozzle. This is in all cases a decided advantage.

177. **Does the Baker Pilliod valve gear increase the pulling power of the engine?**

Ans. It is claimed that, due to the fact that the power is applied more evenly throughout the stroke, the engine is able to handle greater tonnage.

The fact that the admission port is wider open at the beginning of the stroke greatly benefits the engine from this standpoint.

178. **How can the motion be blocked in case of a broken eccentric crank?**

Ans. In case the eccentric or eccentric rod should become broken, the engine can be blocked so as to complete the trip in the following manner: Remove the broken parts, being sure to replace the pin that connected the eccentric rod to the bell crank. Now block the radius yoke and reverse yoke together.

This will give a valve travel on the disabled side equal to the lap and lead of the valve, and the port opening will be equal to the pre-determined amount of lead the engine is supposed to have. The engine on the disabled side will be able to perform as much work as though the reverse lever was hooked at a very short point of cut-off.

179. **What can be done in case of a broken combination lever?**

Ans. In case of a broken combination lever, remove the broken parts, clamp the valve on the center of its seat and take down the eccentric rod. The engine is then ready to proceed on one side. With the combination lever connection to the cross-head (the cross-head yoke), the engine should be blocked in the same manner.

180. **What can and should be done in case the reverse yoke, bell crank, valve stem, reversing arm or tumbling shaft arm is broken?**

Ans. On account of the construction of this motion the writer thinks the only thing that could be done in any of these cases would be to disconnect the disabled engine and proceed on one side. The manner by which the valve travel is derived and controlled offers but little opportunity to do blocking in case of any of these defects.

181. **What breakdowns are most common to this style of motion?**

Ans. The eccentric, eccentric rod, or combination lever are the most liable to become broken. This is due to the fact that the strain of moving the valve falls upon these parts.

YOUNG VALVE AND GEAR—BREAKDOWNS.

182. What are the different names of the parts of the Young Valve Gear?

Ans. The Young Valve Gear parts are named very similar to the Walschaert Valve Gear parts, namely, the eccentric crank, eccentric rod, link, radius bar, combination lever, union link, cross-head arm, intermediate radius arm, two rocker boxes, wrist plate and bell crank. The valve connection to the wrist plate is sometimes called the union rods. Each side of the locomotive has two valves of a rotary construction, or on the principle of the Corliss engine valve.

183. What can and should be done in case of a broken valve stem, or yoke inside of the steam chest?

Ans. The fact that each side of the locomotive is supplied with two valves for each cylinder enables the engineer to quickly arrive at a conclusion as to what and where this breakage is located. If the valve stem broke inside the chest, and the valve was open to admission the engine would stop, as that end of the cylinder would be constantly filled with steam. If the valve covered the admission port the engine would have but three exhausts. This would be easy to locate by watching the pin and noticing which end of the cylinder received no steam, hence no exhaust. After locating the side on which the defect is located the engine should be blocked in the following manner: Remove the valve chamber head and block the valve so that the admission port is closed and the exhaust port open. Do the blocking by putting pieces of wood on either side of the valve, replace the head, and the engine is ready to proceed, working steam on both sides, in other words there will, after the blocking has been completed, be an engine and one-half working steam. This is, of course, an advantage not possessed on any other type of valve, or valve gear.

184. What could be done in case one of the dowel pins that hold the union rods to the stem of the valve should become lost or broken?

Ans. The pin could either be substituted or else disconnect, as explained in the preceding question.

185. What can be done in case of a broken eccentric, or eccentric crank?

Ans. Remove the broken parts, and disconnect the lifting arm from the radius bar, then block the radius bar in the center of the link. The engine is then ready to proced, working steam on both sides, but the valve travel on the disabled side will only be equal to the lap and lead of the valve, the port opening being equal to the lead. Care should be exercised to prevent the good engine stopping on center.

186. How should the engine be disconnected for any of the following defects?

Ans. For a broken radius rod, radius rod hanger, or lifting arm the engine should be blocked as follows: For the radius rod the entire motion of that side is destroyed, and the broken parts should be removed, the valves clamped on the center of their seats, provision made to oil the cylinder in case the main rod is left up, and the engine is then ready to proceed. For a broken radius rod hanger, or lifting arm, block in the link at the desired point of cut-off, and proceed.

187. What can be done in case of a broken reach rod or the tumbling shaft and its arms?

Ans. Block in the link top and bottom on each side of the radius rod block at a point where the engine can handle the train all over the road. Guard against getting the block too close to the center of the link, as time can be saved by making certain that the engine is blocked at a point of cut-off consistent with the work the engine is required to do.

188. What should be done in case it is necessary to reverse the motion of the engine, where blocking has been done as explained in the preceding question?

Ans. The blocking can be changed in the link reversing the motion, or by so doing the motion can be changed from go-ahead to backup, or vice versa.

189. How would you disconnect for a broken main rod or cross-head?

Ans. For a broken main rod, disconnect the eccentric rod from the link, and the radius bar from its combination lever connection. Tie it up to the running board, block the cross-head back in the guides, disconnect the combination lever from the cross-head and clamp the valves on the center of their seats. The combination lever will be straight up and down when the valves are centrally on their seats. The engine is then ready to proceed working steam on one side. For a broken cross-head, remove all broken parts, and if necessary take the main rod down, block the remaining parts of the cross-head and disnect the valve gear as explained in the preceding question.

190. **How should the engine be disconnected for a broken main pin?**

Ans. The engine should be disconnected as explained in the preceding question, with the exception that in this case all side rods on both sides will have to be taken down, the engine coming in with but one main rod up.

191. **How would you disconnect for a badly sprung piston?**

Ans. If sprung so bad that it was dangerous to run, it would have to be taken out of the cylinder, knock out the cross-head key, and take off the front head, take the piston out and disconnect the valve motion as for an engine disconnected on one side.

192. **How would you disconnect for a knocked out cylinder head?**

Ans. If the head knocked out was the front head, or the back head was not too badly ruptured, that is if the head still supported the guides, the engine should be disconnected as follows: Knock out the pin holding the union arm to the valve stem, and arrange to block that particular valve on the center of its seat. Tie up the union rod, or remove it, so that it will not strike anything, and the engine is ready to proceed working steam on both sides, yet not working steam in the end of the cylinder with the broken or knocked out head.

When speaking of the dowel pin in connection with the union rod, this connection is sometimes made on the order of a binding bolt, and a dowel pin. It of course will be understood that in some cases it would be necessary to loosen up on this bolt.

193. **In case of a broken combination lever, union link, or cross-head arm, how can the engine be disconnected?**

Ans. If it is impossible to connect the radius bar directly to the valve stem, the engine would have to be disconnected as for one side, and so run in. In case this connection can be made, the valve will have a travel equal to the throw of the eccentric. The lap and lead feature, or lead control, would in this case be destroyed. When speaking of connecting the radius bar to the valve stem, it is meant that it be connected to the intermediate radius bar. It is thought by the writer that this cannot always be done, so the best way to do would be disconnect as for one side.

194. **How should this motion be disconnected so engine can be run in on one side?**

Ans. For any valve gear or other breakdown where it is necessary to disconnect so as to come in on one side, the engine should be disconnected as follows: Remove the eccentric rod from its connections between the eccentric and the link, disconnect the radius bar from the combination lever and tie it up to the running board, clamp the valves on the center of the seat, and make provision to oil the cylinder if the main rod be left up. The engine is then ready to be run in on one side. When it is considered advisable the radius bar lifting arm may be disconnected so as to enable the other side of the engine easier to handle, but this is not necessary, as the radius bar on the disabled side will swing in the link, providing it is not tied too short to the running board.

195. **What is meant by the term link foot, or dip in the links, as used in connection with the Young and Walschaert Gears?**

Ans. This term applies to the curved extension on the link, the point to which the eccentric rod connects.

196. **Why is the link so designed and constructed?**

Ans. This feature in the design and construction overcomes the angularity of the main rod and makes it possible to derive sufficient valve travel to obtain port openings while the engine is passing the dead centers. Or in other words to provide for even valve travel at all points during the revolution of the driving wheels.

197. **Aside from the angularity of the main rod, what else effects the travel of the valve?**

Ans. The vibration of the various parts caused a slipping action to the link block that effects valve travel to a certain degree, as well as the motion of the boiler on its springs. These things sometimes destroy the sensitive features of the valve set. The vibration spoken of usually takes place due to the fact that the valve gear parts are too light for the strain imposed upon them. The movement of the boiler on its springs does not affect the valve travel as much as vibration. The practice of properly oiling all parts of the valve gear is of great importance in so far as effecting even travel is concerned, it of course being understood that other parts of the machinery are in first class condition.

198. What part of the machinery of the engine has the greatest bearing on the exactness of valve travel?

Ans. The condition of the driving box wedge has probably the greatest bearing on this question, as upon the wedge depends the proper line of travel in either direction. When the engine is turned out from the works the distance between wheel centers and a fixed point (the valve seat) is so calculated that the valve travels in proper relation to the piston, but as the wedge wears, and is allowed to remain lower than it should, the distance increases, while the valve travel decreases. Hence the effect of causing improper travel in relation to the piston.

199. Is there any other thing in regards to the machinery that effects valve travel?

Ans. The spring carriage of an engine has, to a certain extent, some bearing on the exactness of valve travel. If the pins in equalizers and hangers are not supplied with a sufficient amount of lubrication, the effect of the engine running over rough track is much the same as though the wedge was not properly adjusted. The motion is in a certain sense thrown out by this condition.

200. **What is the greatest factor in maintaining the valve motion as was intended when the engine was designed?**

Ans. This question can be answered by saying that all parts of the machinery that effect the valve motion should be kept in a good condition. There should not be any great amount of lost motion, the wedges should be properly set up, the proper amount of lubrication should be supplied to all parts requiring the same, and little, if any, trouble will be experienced from a lame engine.

201. **What value are questions, with answers, to the man trying to qualify for an engineer?**

Ans. The majority of books covering the subject, Questions and Answers, are of little value to the man seeking promotion, as they seem to contain little information that is of practical value to the individual. The greatest amount of value lies in the list of questions and their relative value to the subject treated. When a man tries to qualify for promotion, he, of course, seeks all the information obtainable, and in so doing often buys a set of expensive books, as well as taking out a course in some correspondence school, all of which costs a greater or lesser amount of hard earned money. Most men that make a success of the business of railroading learn the business from the machine on which they are working, while the others, books, of one nature or another affords them their education. We, as the authors of this book, feel that the questions asked and answered in this volume will be of great value to any one, either the man seeking promotion, or the man qualified to run the locomotive, as they not only treat on examination questions, but give the engineer the latest and best ways to treat with any, and all breakdowns, that are liable to happen to the engine while in his care. It is to be hoped that no man will attempt to qualify as an engineer, on this or any other set of questions and answers, but it is rather hoped that the information contained in this set will give the student a clearer understanding of all subjects treated. It is not considered necessary to put expensive cuts in a book (thereby making it expensive to the man who buys) as the man who makes a success of running the engine learns the names and location of the parts from the machine. The questions and answers contained in this volume are the ones generally used on all roads where the progressive examination is in force, and if closely followed will greatly benefit the student in his effort to promote himself.

FINIS.

In conclusion of this volume, we hope to say that we have done as well as we could do, and not as well as could be done.

THE AUTHORS,

FISHER. WILLIAMS.

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