THE WESTINGHOUSE AIR BRAKE SYSTEM

A complete and strictly up-to-date treatise containing detailed descriptions and explanations of all the various parts of the

WESTINGHOUSE AIR BRAKE

including the $8\frac{1}{2}$ inch cross-compound air pump. No. 6 E T equipment. High pressure control schedule U. The K triple, L triple and L N equipment. Combined Automatic and Straight Air brake, and the $1\frac{1}{4}$ inch pump governor.

Compiled and Edited by the World's Leading Air Brake Experts

The book also contains a complete course of catechetical instruction on all matters pertaining to the construction, care and operation of the modern Air Brake.

Fully Illustrated *Colored Charts*

PUBLISHERS
FREDERICK J. DRAKE & CO.
CHICAGO

INTRODUCTION

The importance of the air brake as a factor in the operation of railway trains may be realized, to some extent at least, when we pause for a moment to consider that it is even more powerful in results obtained than is the locomotive that pulls the train. Although this assertion may appear to be startling, it is nevertheless true, as can be easily proven by reference to the records obtained by the use of the dynamometer car.

These records show that a locomotive ordinarily requires from five to ten minutes time, and several miles distance of travel to bring the speed of the train up to, say sixty miles an hour, from which speed the modern, automatic air brake will bring the same train to a full stop in approximately twenty-five seconds of time, and within a distance of 1,200 feet. With such a comparison as the above in mind, we cannot emphasize too strongly the necessity of enginemen and trainmen being thoroughly familiar with the construction and operation of the air brake equipment, including especially all the new appliances and devices which have recently been adopted, and are now in use by the majority of railroads, and although the art of train control by means of the automatic air brake has been, and is at present up to the highest point of perfection necessary to meet existing conditions, still it is well to remember that the requirements of train service are always subject to change, and that for every advance in the development of power and equipment of any nature, the air brake must also be improved to meet the emergency. This fact accounts for the many changes and additions constantly being made in air brake apparatus, and it also serves to lay greater stress upon the importance of a thorough, practical knowledge of the equipment on the part of those men who daily manipulate it. This knowledge can be obtained by a careful study of the following pages, which will enable the student to familiarize himself with, not only the older forms of the Westinghouse air brake system, but also with all the very latest improvements and appliances connected with it. Not a single detail has been omitted. Another very important characteristic of the book is, that in addition to the purely descriptive matter, indispensable in dealing with mechanical devices, there is a large amount of catechetical instruction in the form of questions and answers covering every detail connected with the manipulation of the modern air brake, and the knowledge gained thereby will fit the student to successfully pass any of the rigid examinations to which he may be subject while in the line of promotion.

The utmost care and diligence have been exercised in the compilation of the book, and the highest authorities on air brake practice have been consulted in an earnest effort to make it complete in every detail. The reason that no references, or names of authors consulted are given in the text or on the Title page of the volume was for the purpose of presenting these names and authorities in a single group, as witness the following list:

Calvin F. Swingle, M. E., President National Institute of Practical Mechanics, Chicago, Ill.

Walter V. Turner, Chief Engineer Westinghouse Air Brake Company.

Frederick J. Prior, M. A. A., Author of "Operation of Trains;" "What Stops a Moving Train."

L. M. Carlton, Special Instructor Westinghouse Air Brake Company

Robert H. Blackall, Air Brake Expert D. & H. C. Company.

W. W. Wood, Air Brake Expert (Monon Route) C. I. & L. Ry.

Frank H. Dukesmith, Director Dukesmith School of Air Brakes.

W. G. Wallace, M. E., Former President Traveling Engineers' Association.

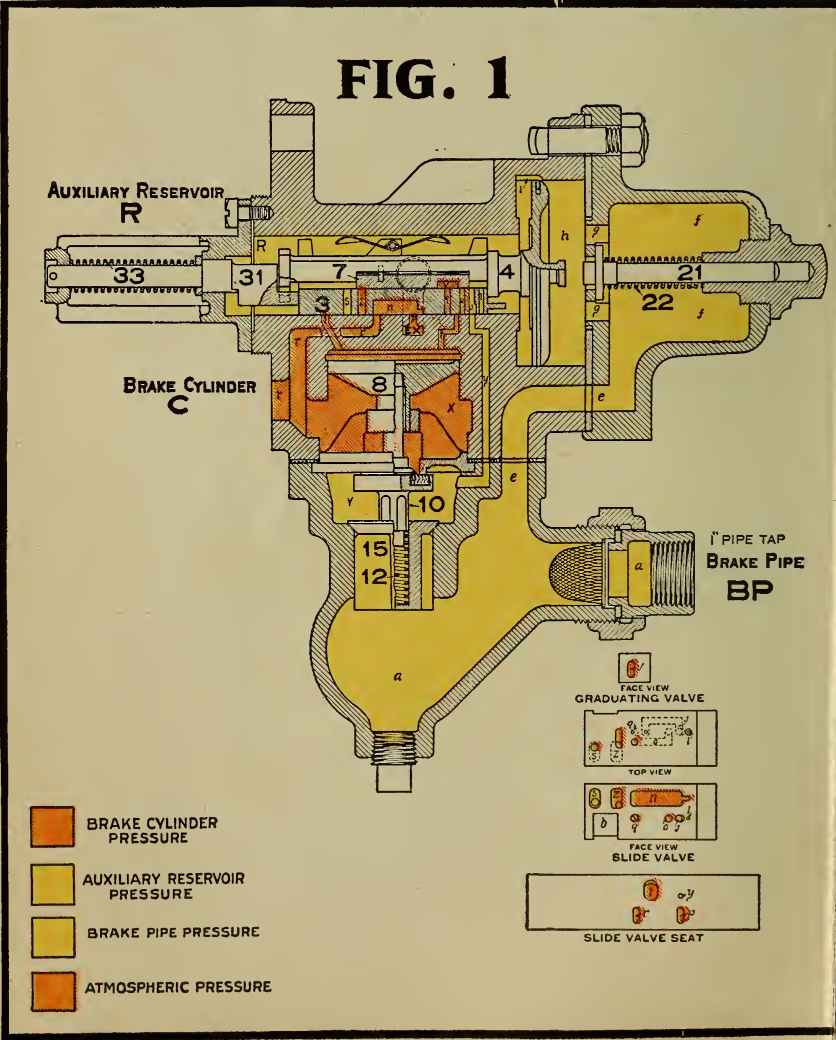
C. B. Conger, Air Brake Expert, and Author.

The Locomotive Firemen and Enginemen's Magazine.

* The Editors and Compilers gratefully acknowledge their indebtedness to the Air Brake Association for a portion of the text contained in the following pages; particularly that pertaining to the examination Questions and Answers.

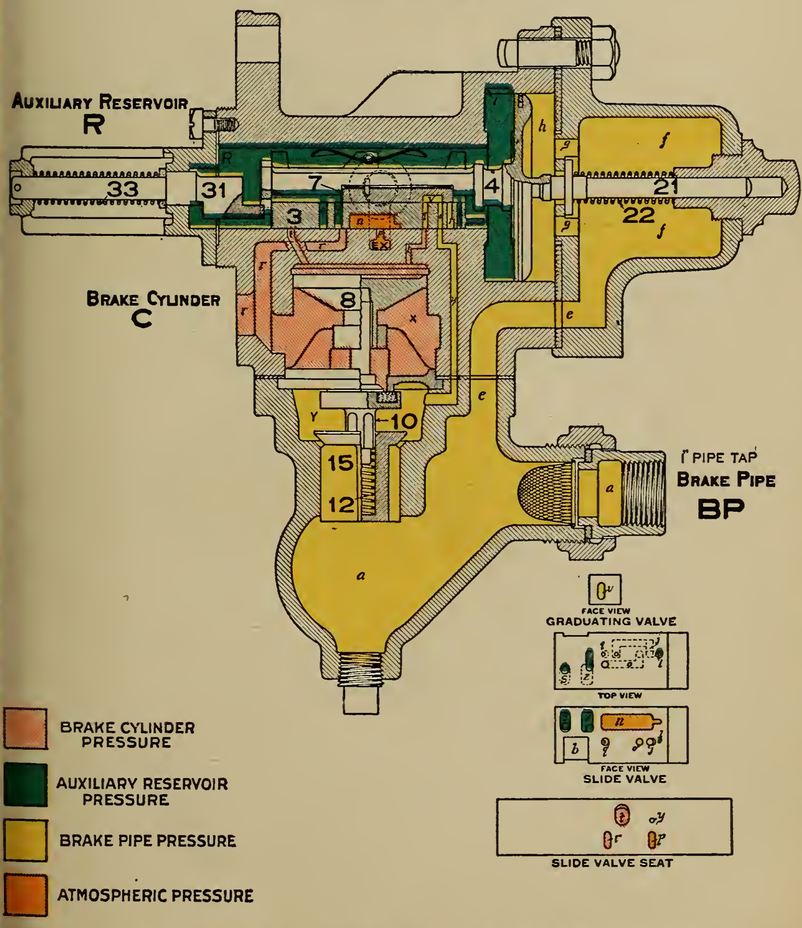
FULL RELEASE AND CHARGING POSITION

FIG. 1



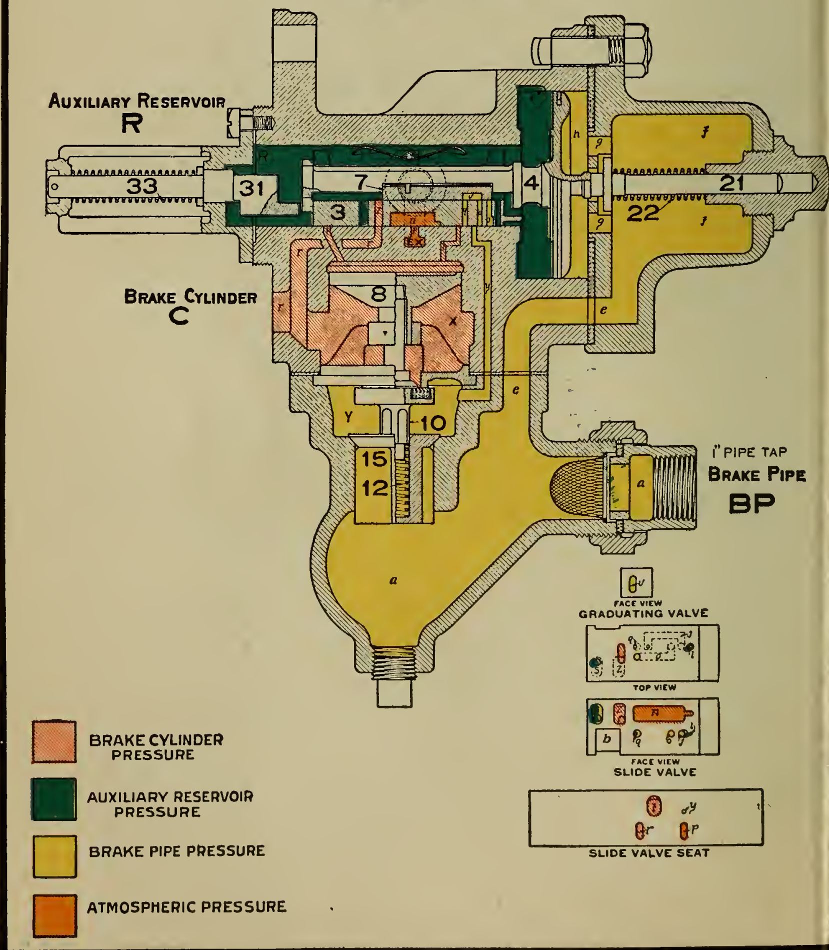
QUICK SERVICE POSITION

FIG. 2



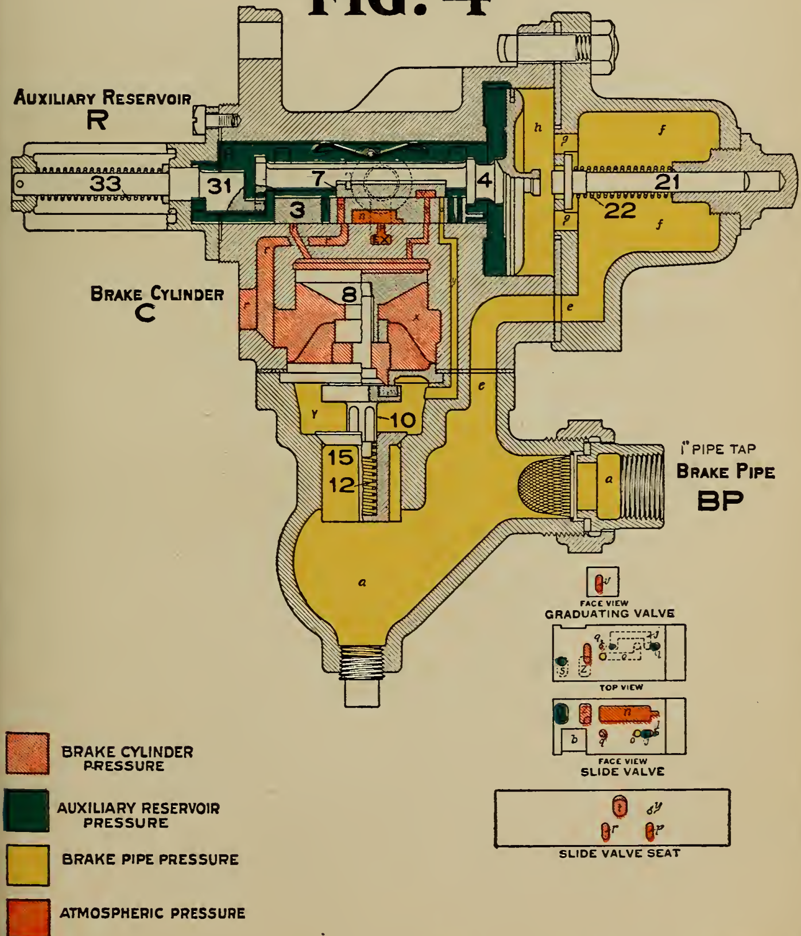
FULL SERVICE POSITION

FIG. 3

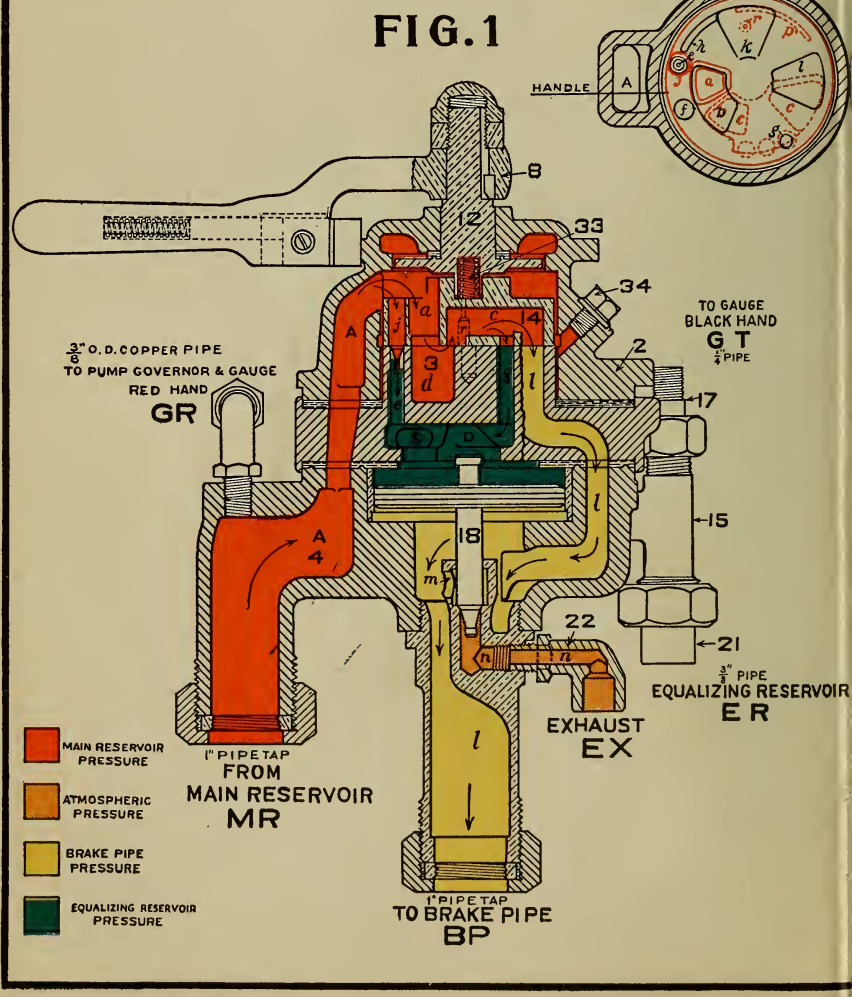


LAP POSITION.

FIG. 4

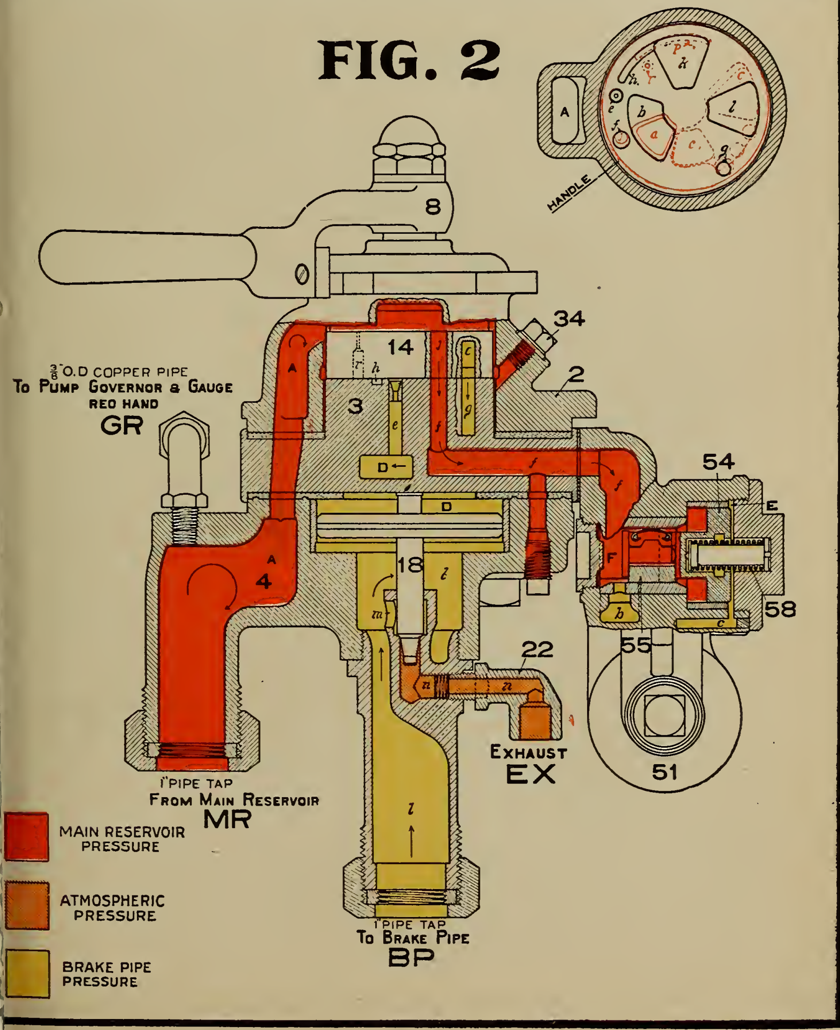


RELEASE POSITION.



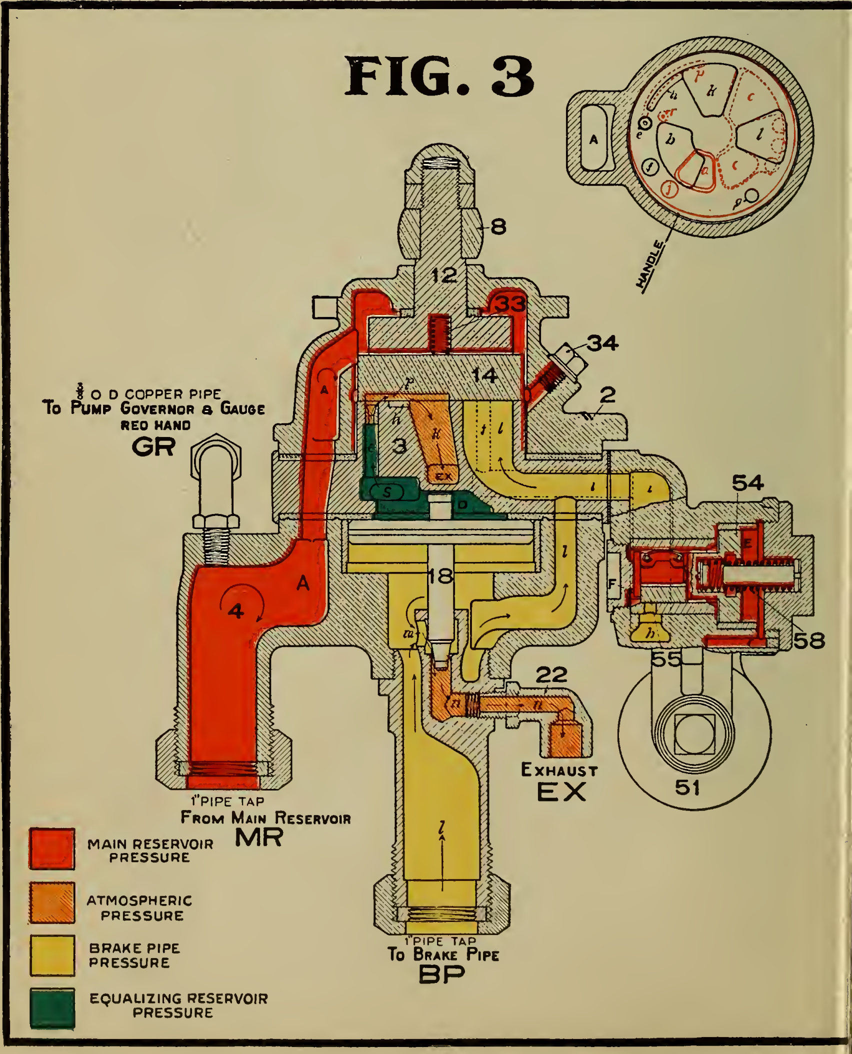
RUNNING POSITION.

FIG. 2

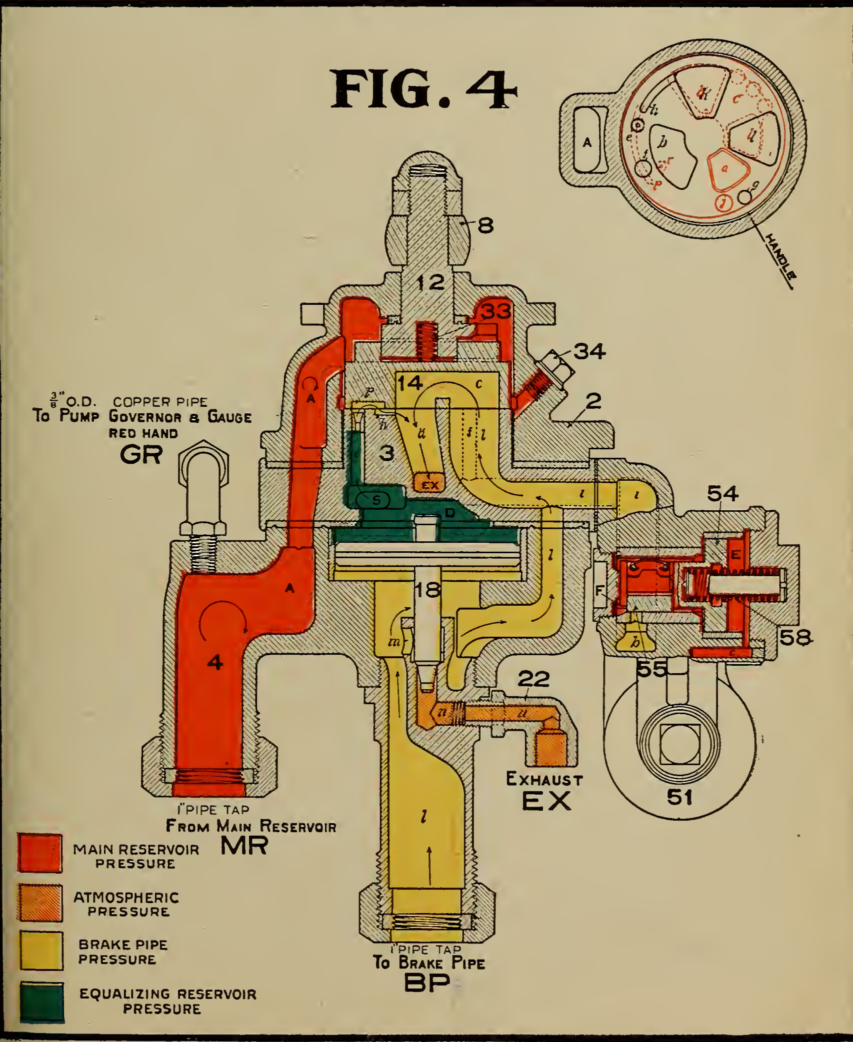


SERVICE APPLICATION POSITION

FIG. 3



EMERGENCY POSITION



PLAN OF PORTS

FIG. 5

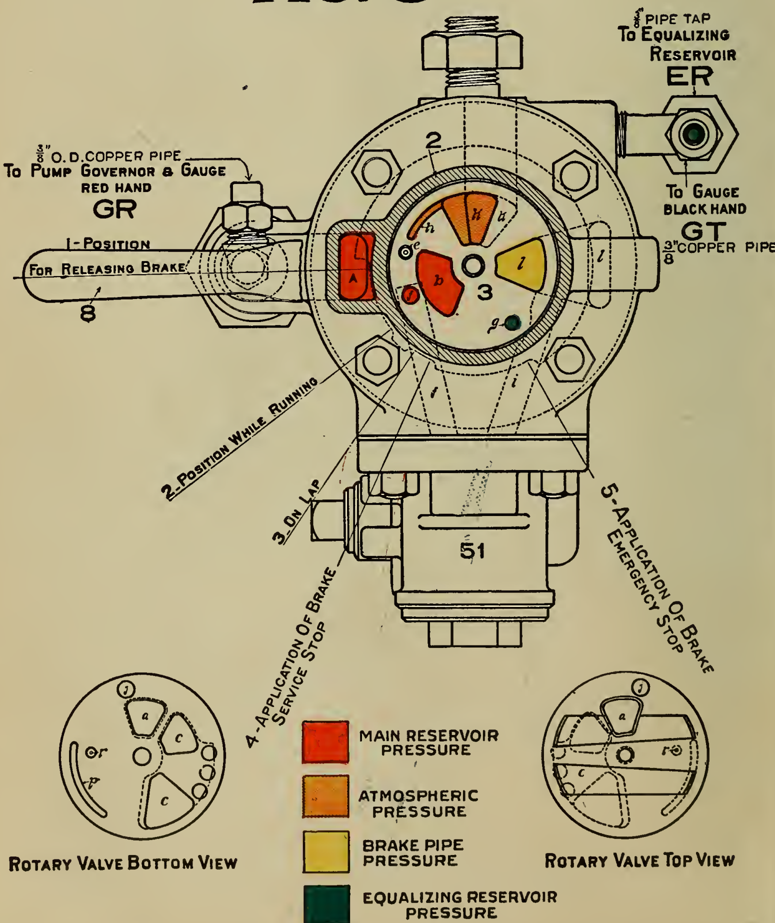
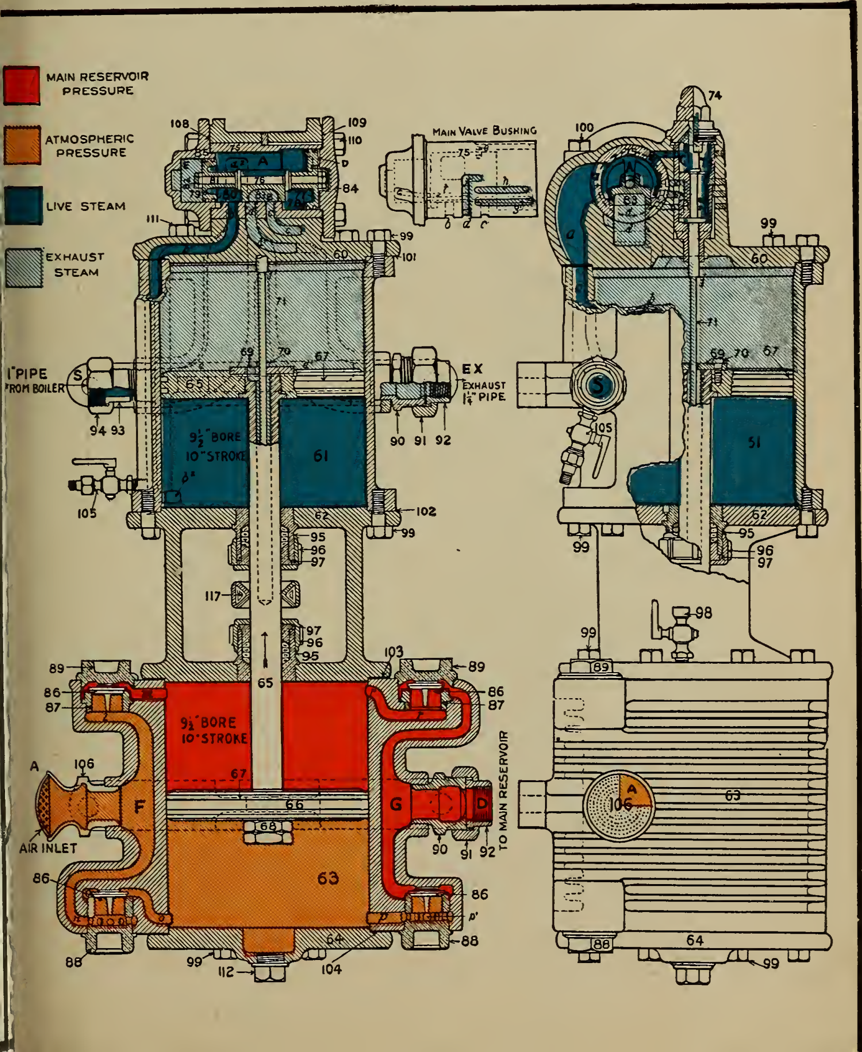


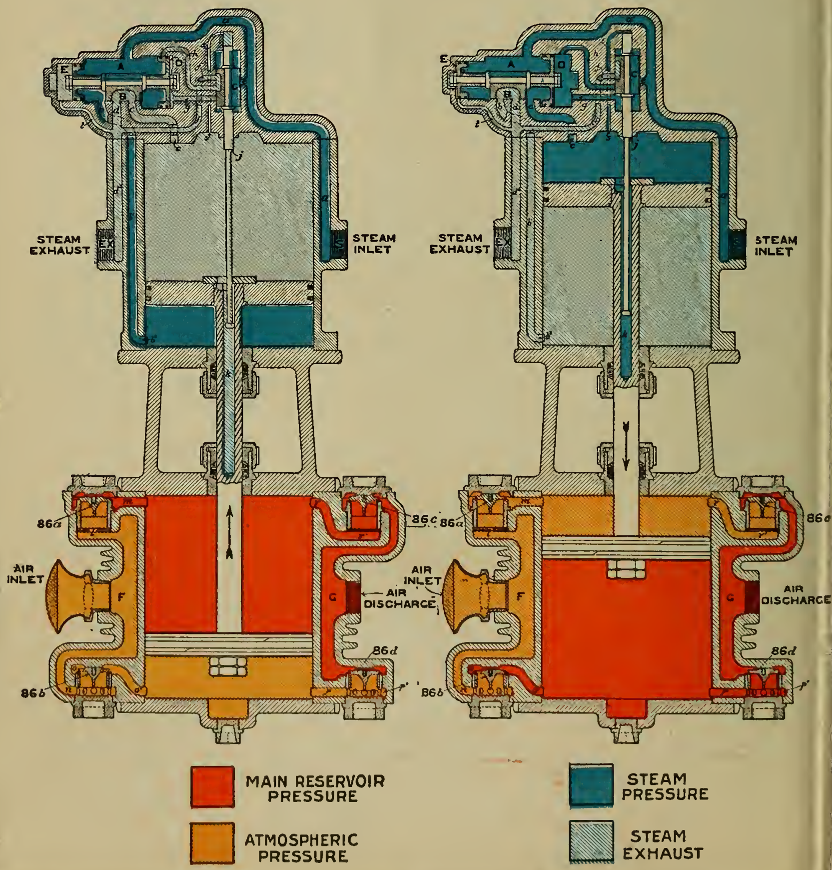
FIG. 1 GENERAL ARRANGEMENT



THE WESTINGHOUSE AIR BRAKE CO. 9½ INCH AIR PUMP

DIAGRAMS

FIG. 2 UP STROKE — **FIG. 3** DOWN STROKE



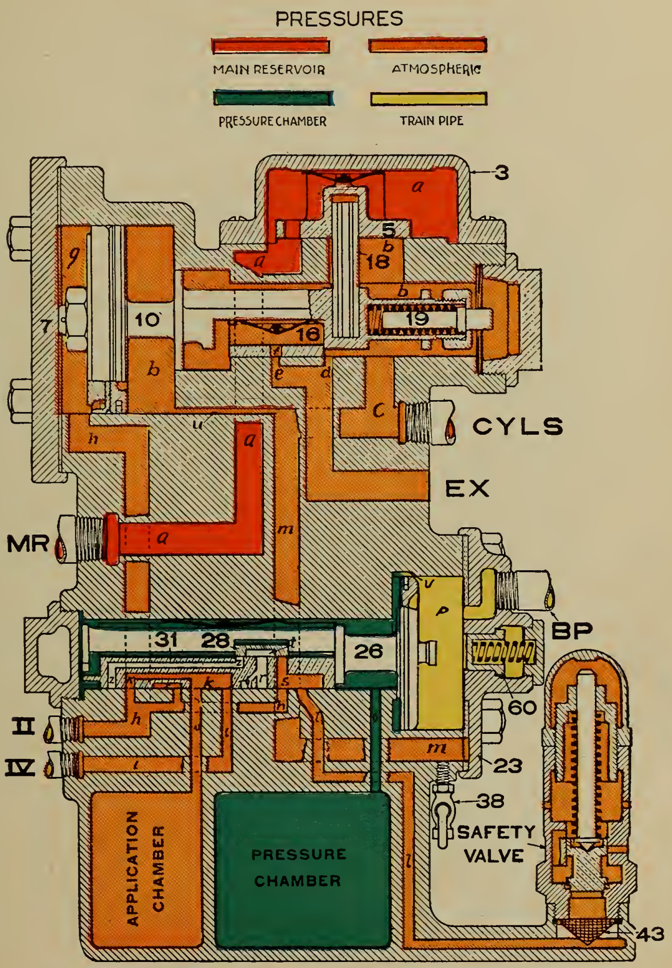


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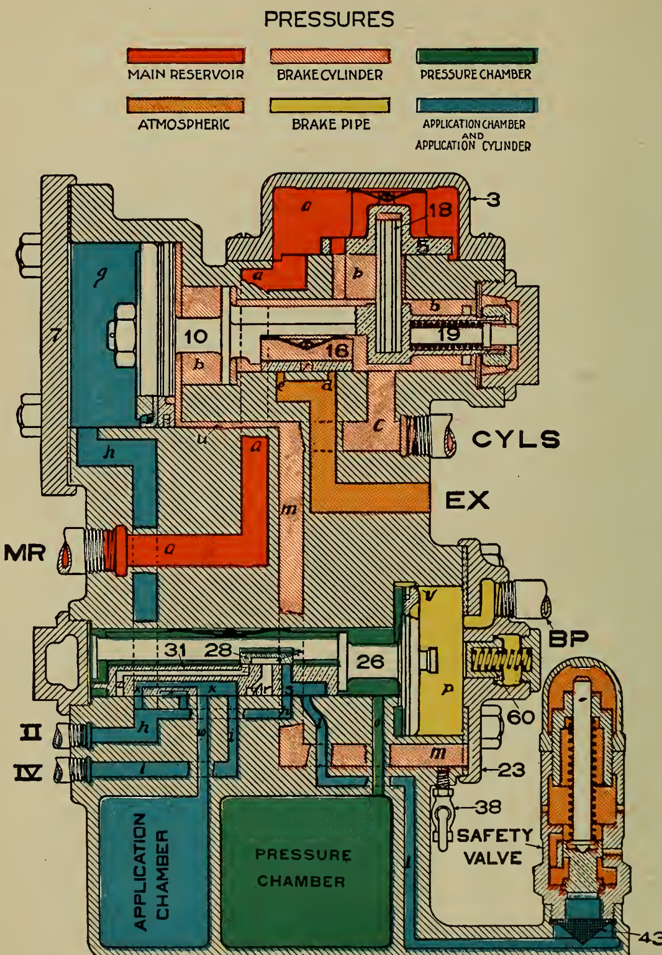
PLATE XXXV—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

(Release Position—Automatic or Independent)



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WESTINGHOUSE AIR BRAKE SERIES

PLATE XXXVI—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Independent Application Position)

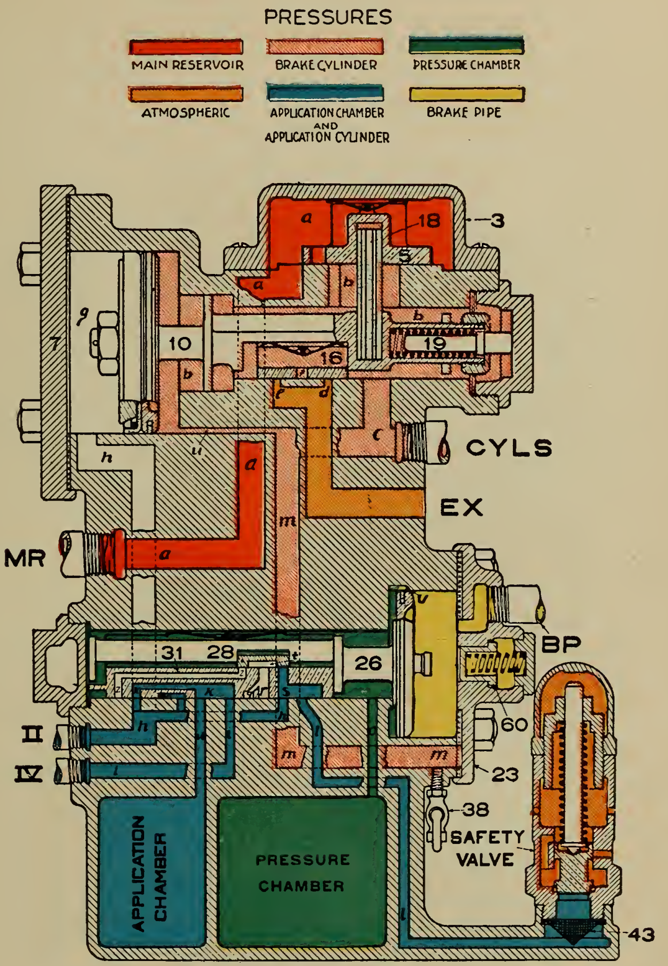

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PLATE XXXVII—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

(Independent Lap Position)

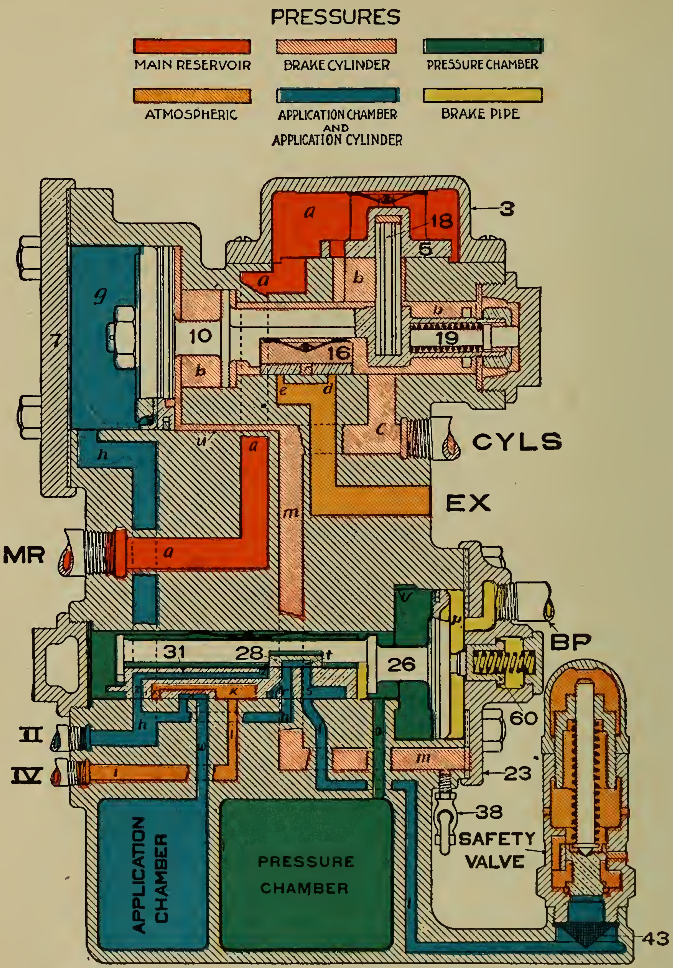

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PLATE XXXVIII—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Automatic Service Position)

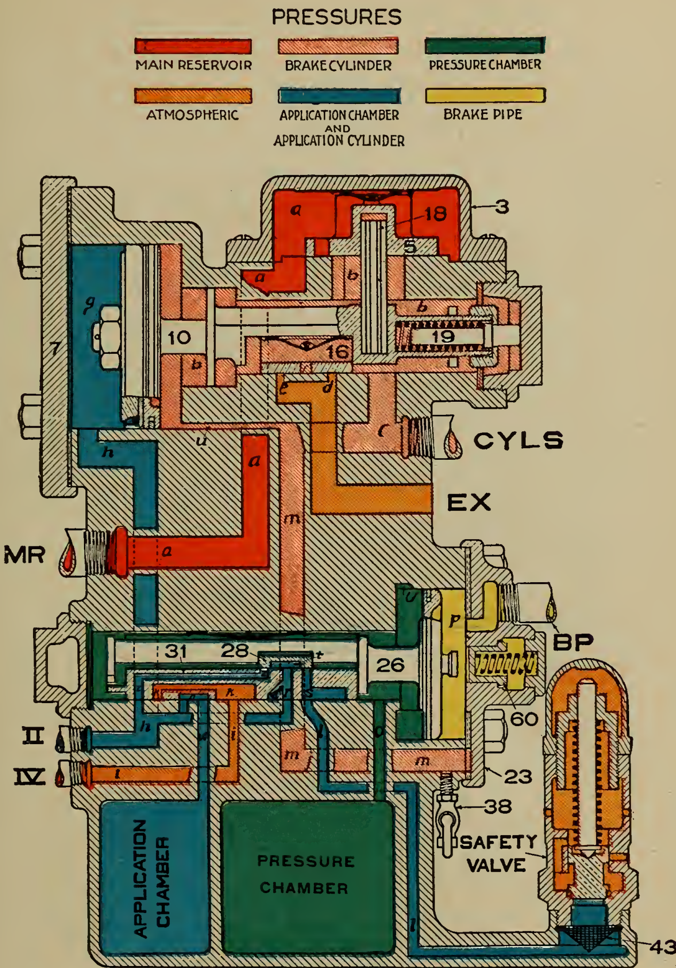

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PLATE XXXIX—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Service Lap Position)

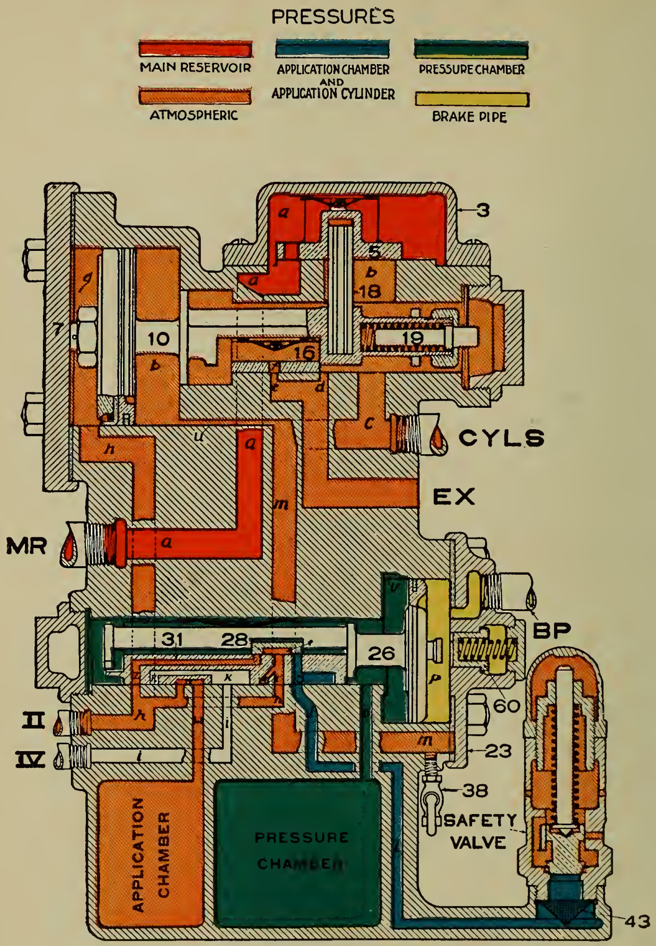

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PLATE XL—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Release Position—Independent Release After Automatic Application)

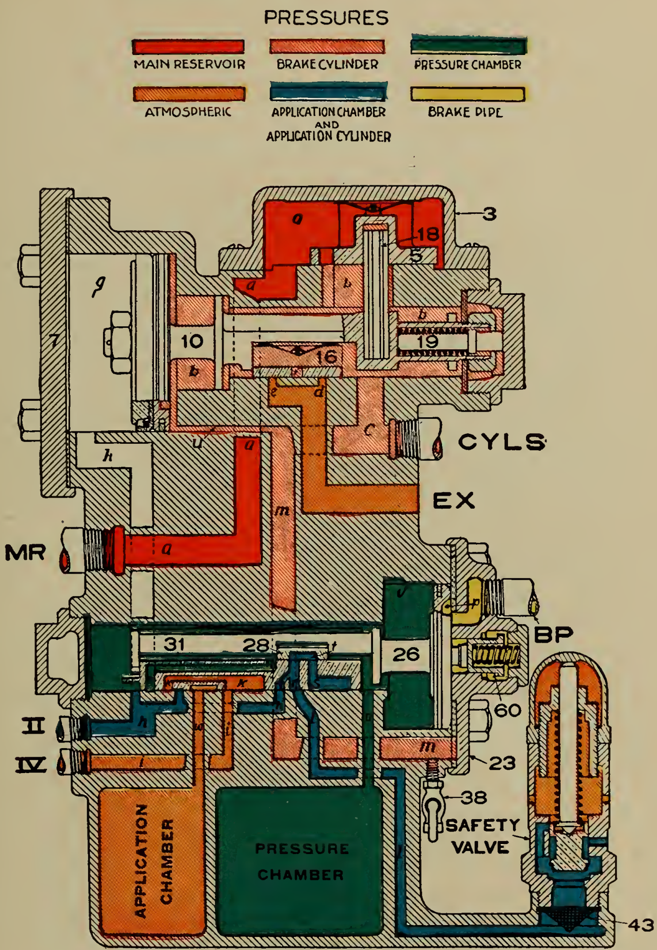

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PLATE XLI—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Emergency Position)

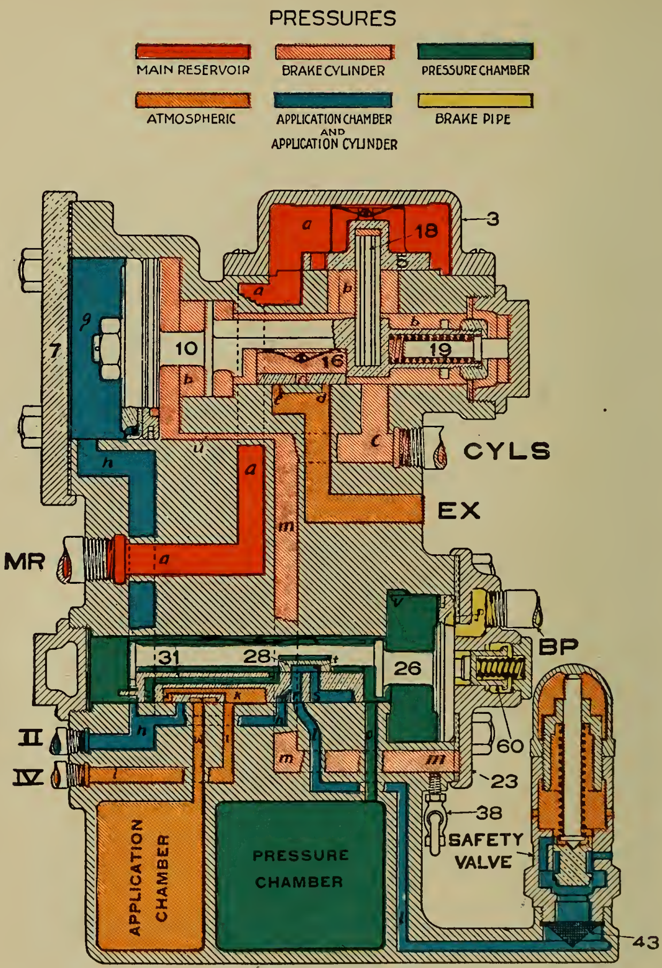

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PLATE XLII—DISTRIBUTING VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Emergency Lap Position)

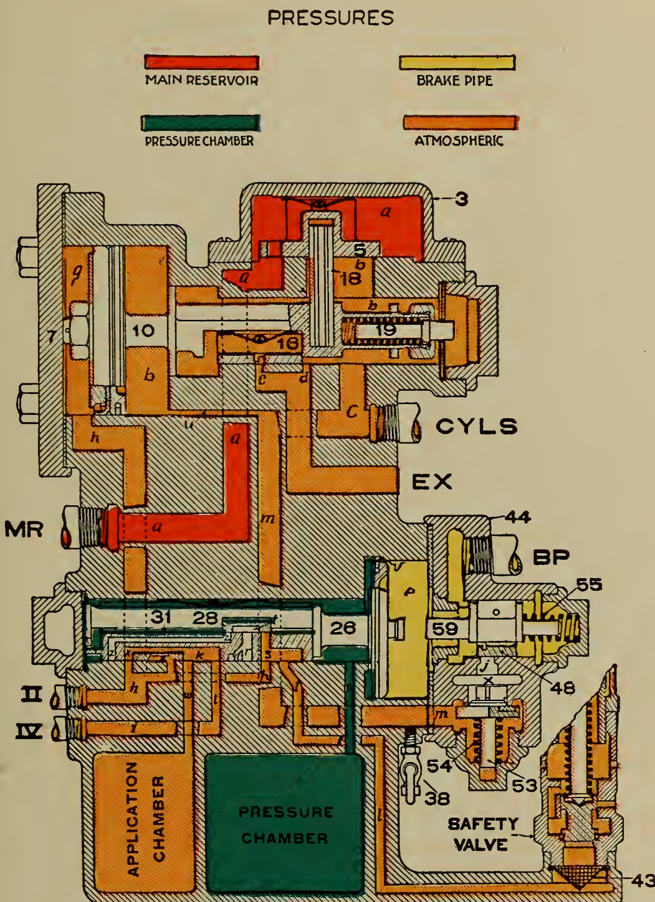

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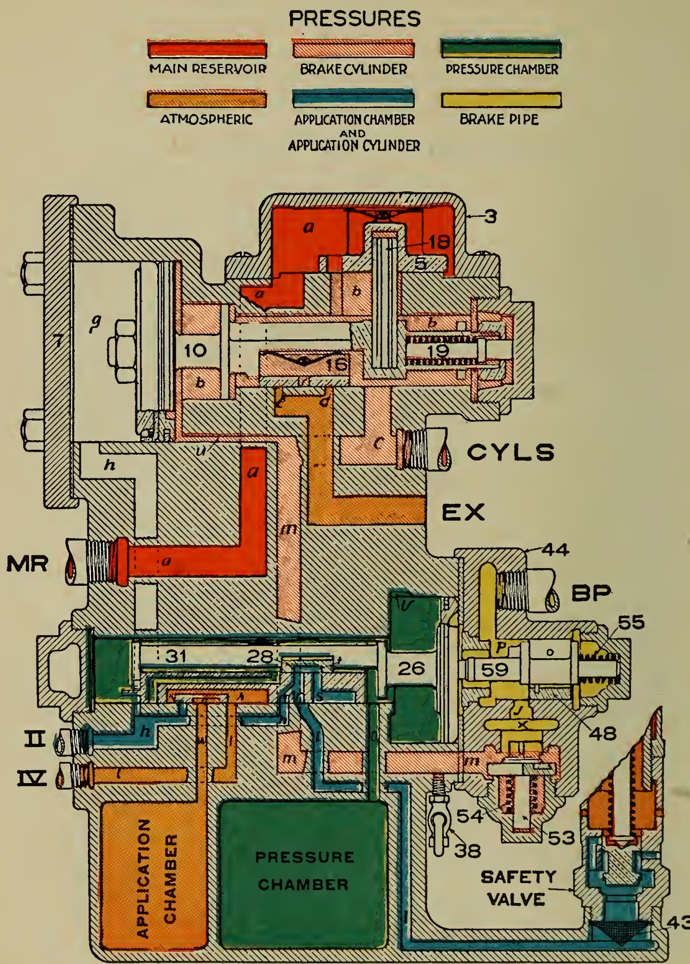
PLATE XLIII—DISTRIBUTING VALVE, WITH QUICK ACTION CYLINDER CAP, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Release Position)



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WESTINGHOUSE AIR BRAKE SERIES

PLATE XLIV—DISTRIBUTING VALVE, WITH QUICK ACTION CYLINDER CAP, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT (Emergency Position)

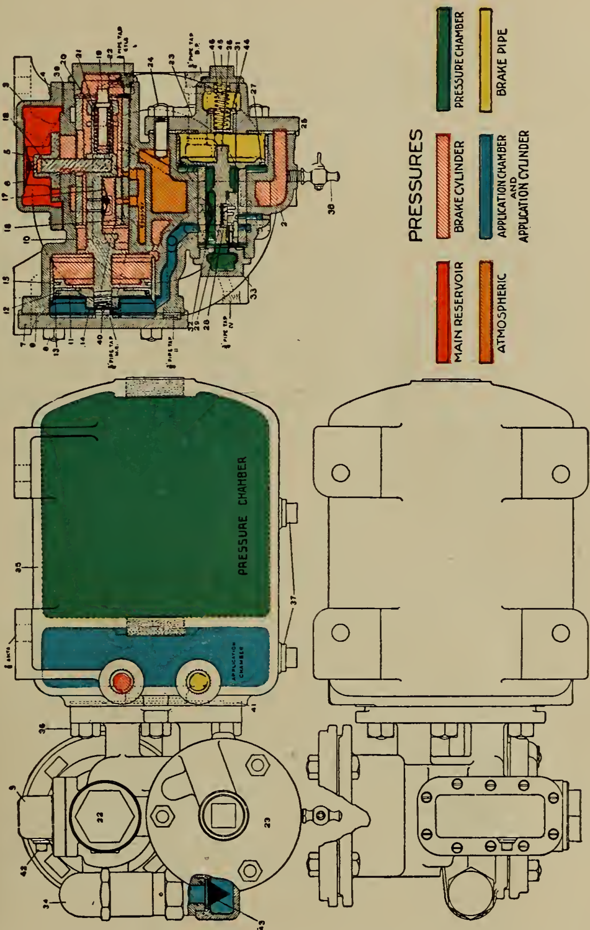

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PLATE XLV—DISTRIBUTING VALVE AND DOUBLE-CHAMBER RESERVOIR, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

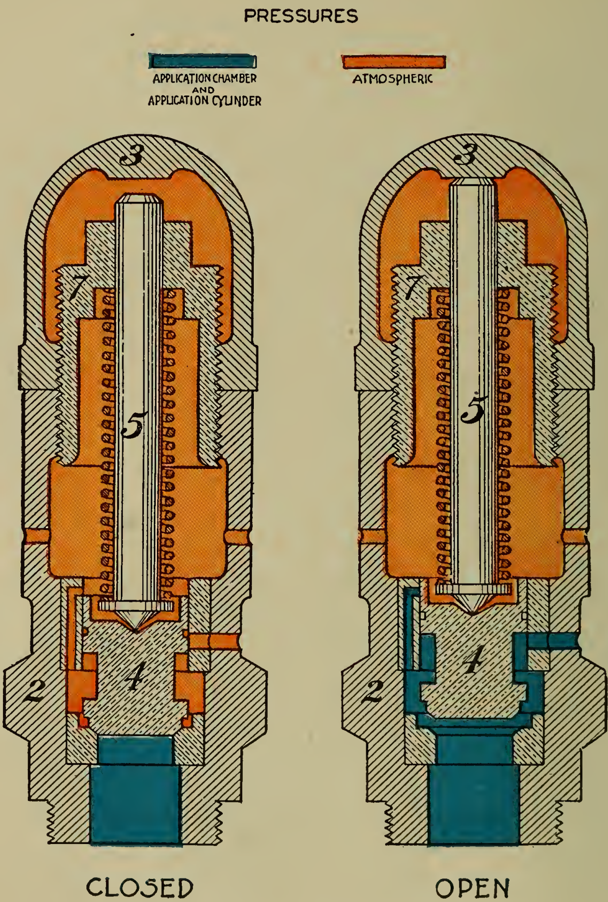

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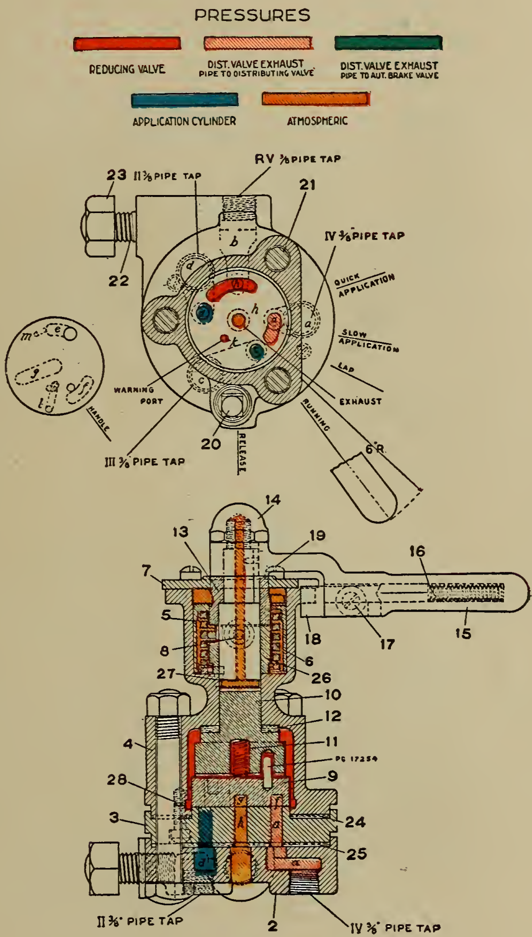
PLATE XLVI—E-6 SAFETY VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT
(Closed and Open Positions)



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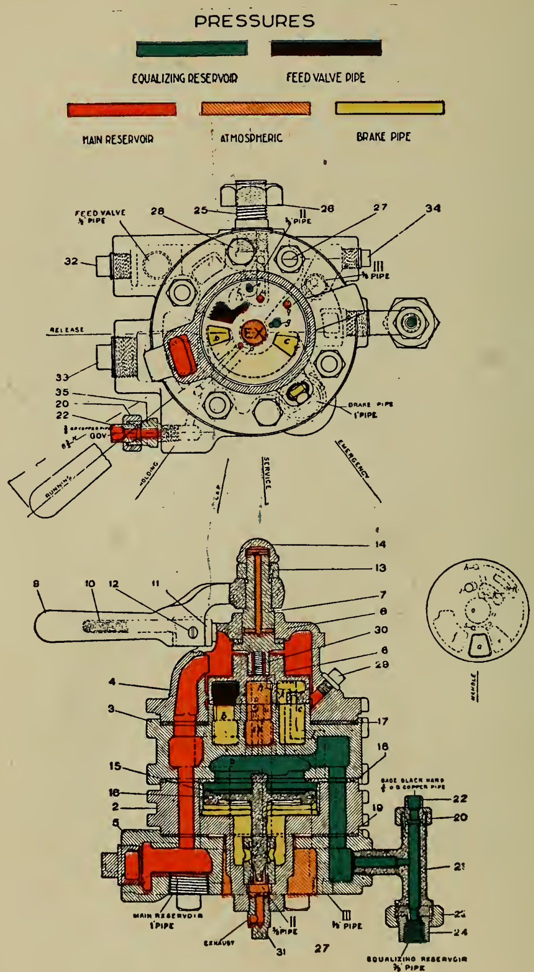
Westinghouse Air Brake Series

PLATE XLVII—S-6 INDEPENDENT BRAKE VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT



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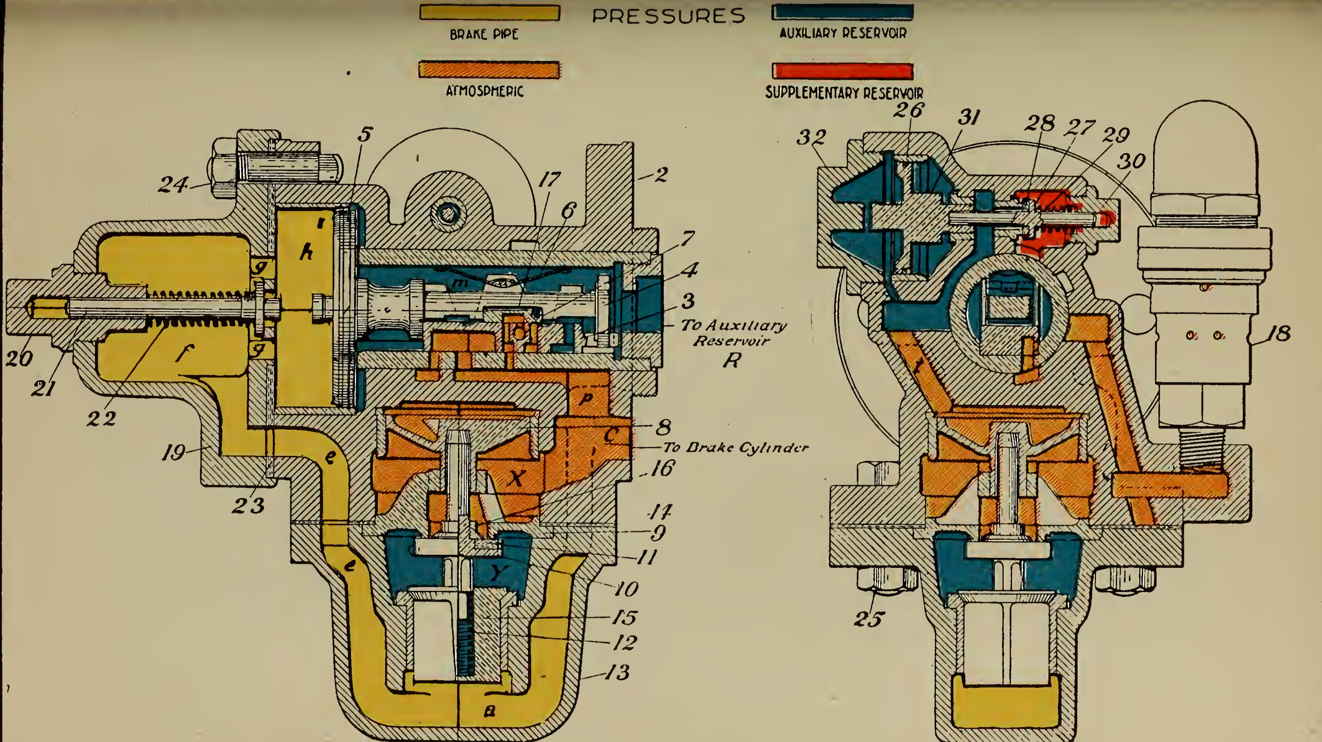
Westinghouse Air Brake Series

PLATE XLVIII—H-6 AUTOMATIC BRAKE VALVE, No. 6 ET LOCOMOTIVE BRAKE EQUIPMENT

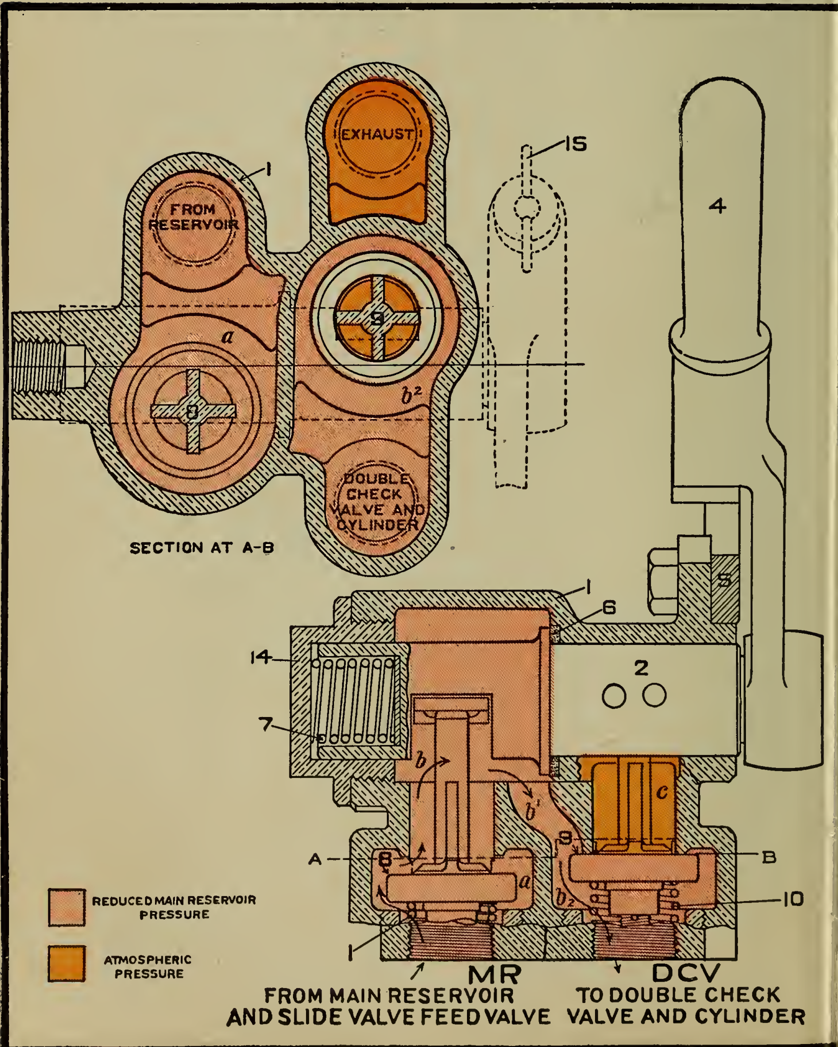


WESTINGHOUSE AIR BRAKE SERIES.

PLATE LIX —TYPE L, PASSENGER, HIGH SPEED TRIPLE VALVE

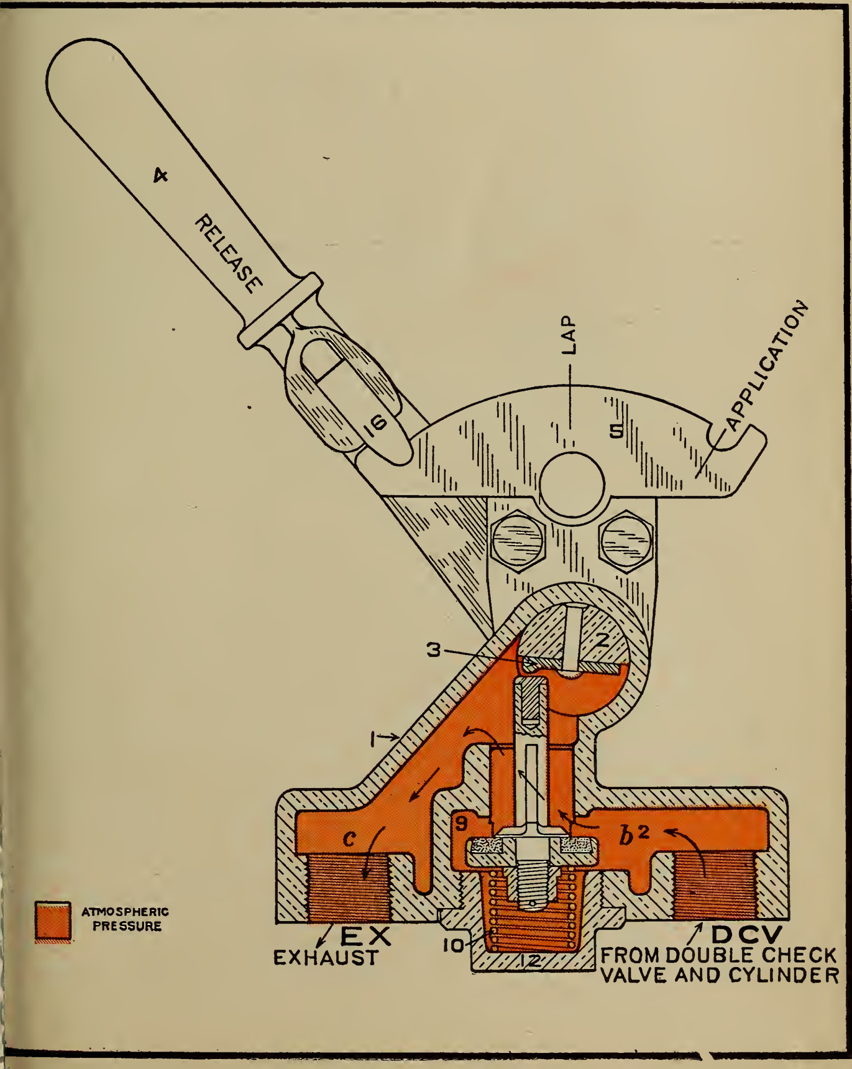
$\frac{3}{4}$-INCH STRAIGHT AIR BRAKE VALVE.

Application Position.

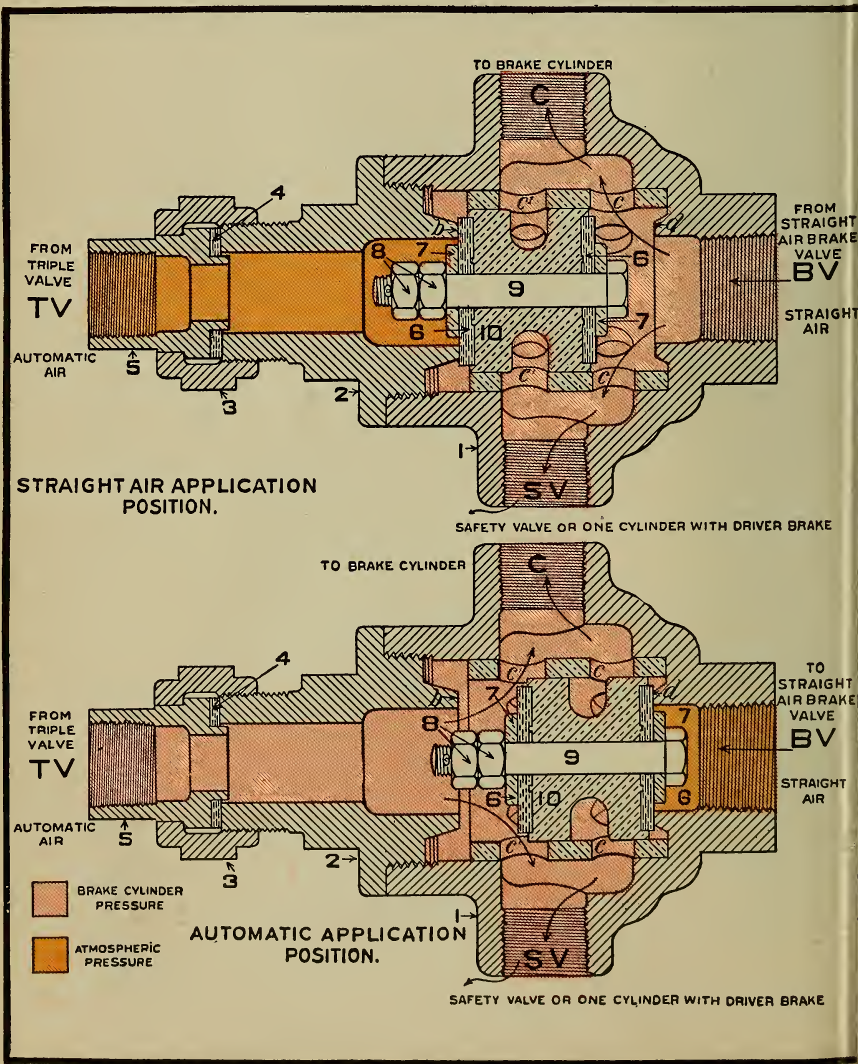


$\frac{3}{4}$-INCH STRAIGHT AIR BRAKE VALVE.

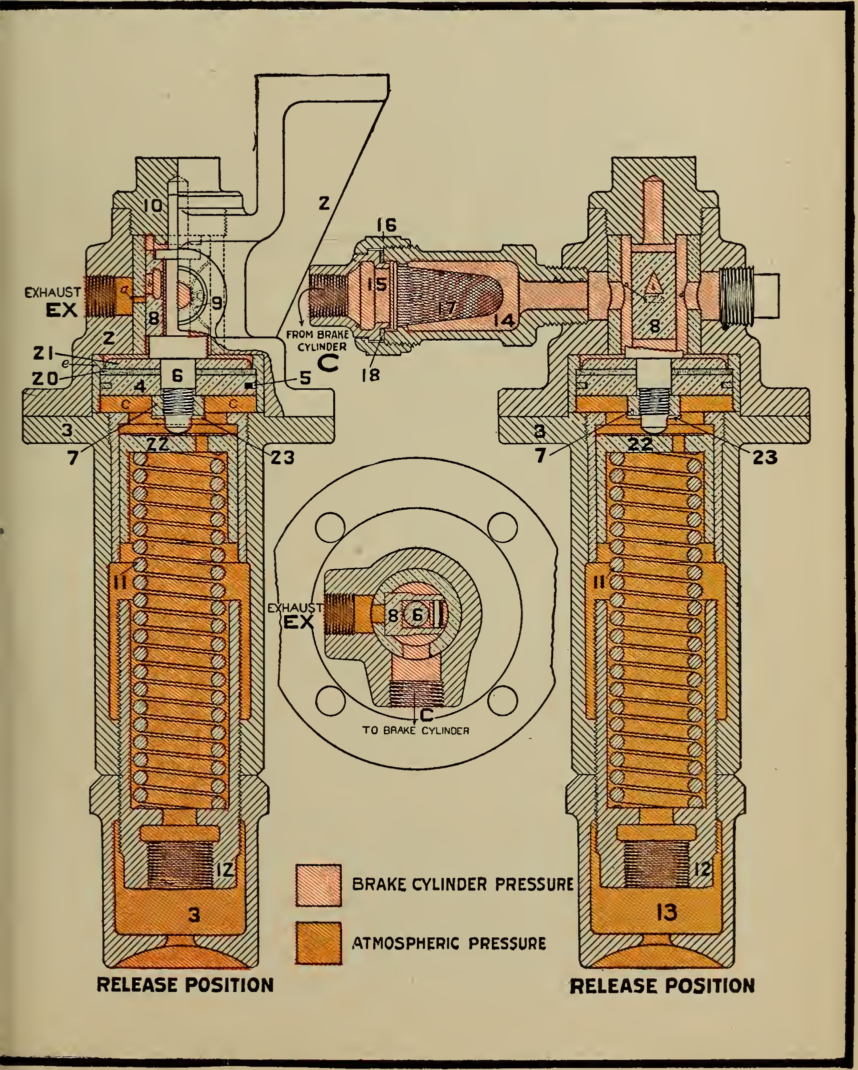
Release Position.



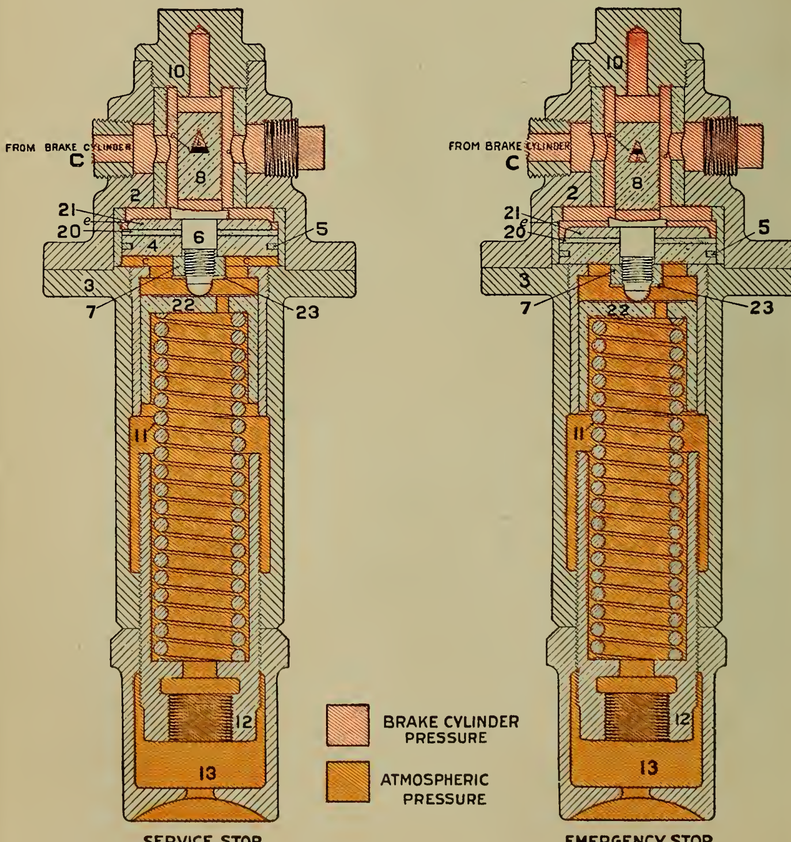
DOUBLE CHECK VALVE



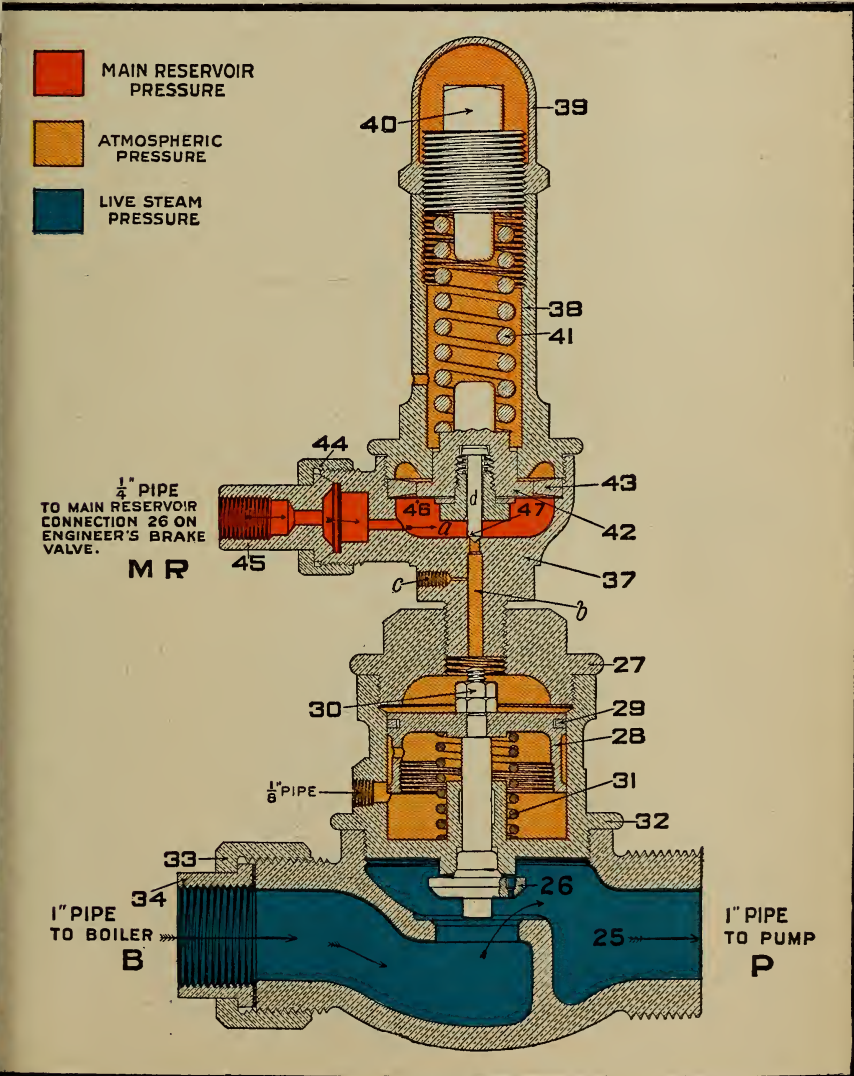
HIGH-SPEED BRAKE REDUCING VALVE



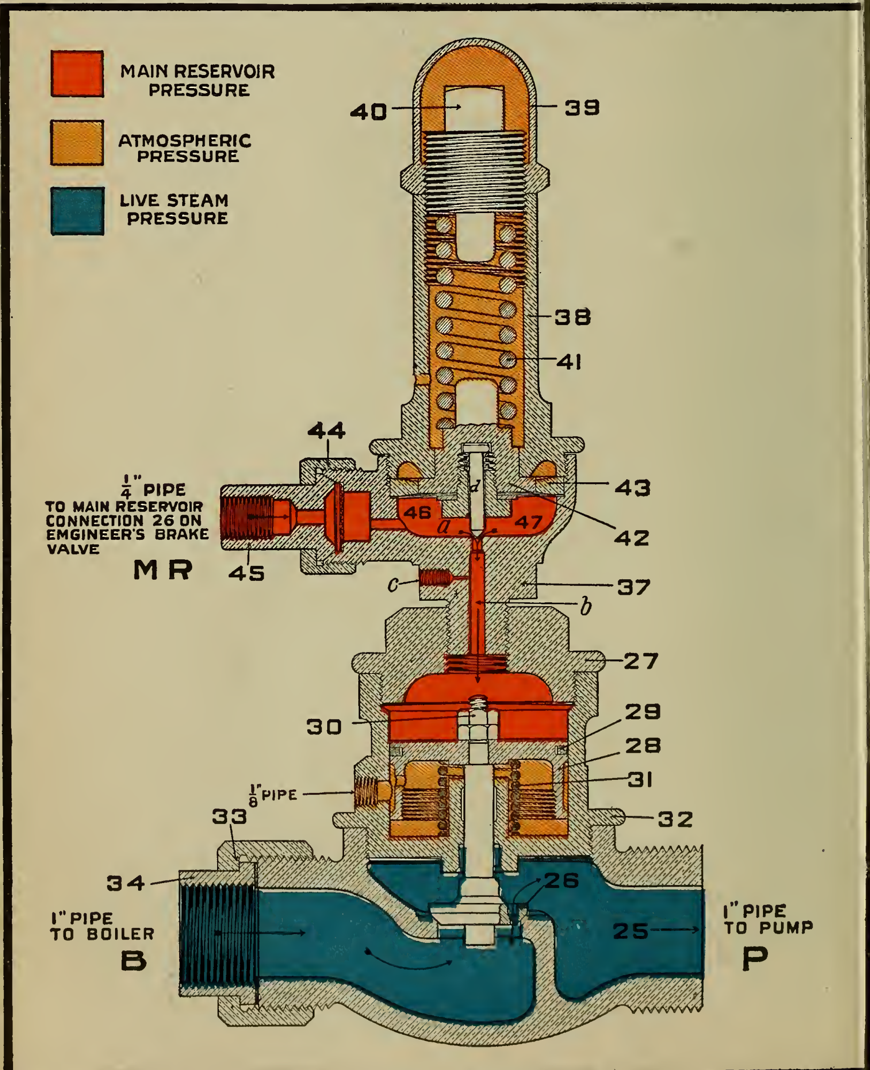
HIGH-SPEED BRAKE REDUCING VALVE



PUMP GOVERNOR, STEAM VALVE OPEN



S-4 PUMP GOVERNOR CLOSED POSITION



The Westinghouse Air Brake System

The essential parts of the Westinghouse air brake equipment, including both freight and passenger service may be enumerated as follows:

First. The Air Pump which produces the pressure.

Second. The Pump Governor which controls the pressure.

Third. The Main Reservoir in which the pressure is stored.

Fourth. The Engineman's Brake Valve which controls the admission to and exhaust of air from the brake pipe to release and apply the brakes.

Fifth. The Straight Air and Independent Brake Valve applying and releasing the brakes on locomotive and tender only.

Sixth. The Brake Pipe, Angle Cocks and Hose Couplings.

Seventh. The Triple Valve and Auxiliary Reservoir.

Eighth. The Brake Cylinder and its piston connected to the brake lever.

Ninth. The High Speed Reducing Valve, for reducing the pressure in brake cylinder when it exceeds 60 pounds.

Tenth. The Conductor's Valve, which is found in passenger equipment cars and also in such other cars as authorized.

Eleventh. The Pressure Retaining Valve, to be found on all freight equipment cars, some Pullman, foreign and private passenger equipment cars.

Twelfth. The Cut-Out Cock placed in the pipe connecting the main reservoir with the engineman's brake valve, used on locomotives on divisions where it is the practice to haul trains with two or more locomotives.

Thirteenth. The Train Air Signal Reducing Valve, which reduces main-reservoir pressure to signal line pressure.

Fourteenth. The Signal Pipe, its strainer, stop cock, cut-out cock, hose and hose coupling.

Fifteenth. The Signal Valve.

Sixteenth. The Signal Whistle.

Seventeenth. The Car Discharge Valve.

THE WESTINGHOUSE AIR PUMP.

A short description with illustrations of the earlier types of air pumps which were in use when air braking was in its infancy, cannot fail to be both interesting and profitable. The first form of air compressor used with the straight air brake was converted from an old Worthington duplex water pump, by Mr. George Westinghouse, in 1869. This pump was quite crude and inefficient and gave way to the better "trigger" form, whose operation was also quite erratic at times, and engineers were obliged to frequently operate the valve

FIG. 5.—DIAGRAM SHOWING GENERAL ARRANGEMENT OF ESSENTIAL PARTS.

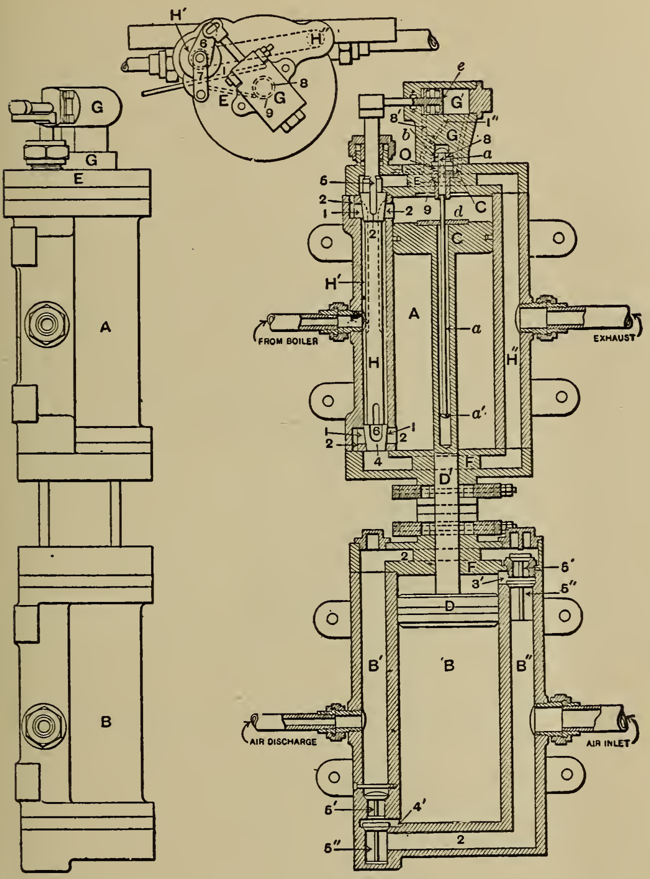


Fig. 1—Westinghouse "Trigger" Air Pump.

motion with either a stick or a string to keep it going in order to accumulate the necessary amount of compressed air to supply the brakes of the train.

Fig. 1 shows the "trigger" air pump which consisted of the usual steam cylinder and air cylinder in vertical tandem. Steam entered from the boiler at the left side of the pump, and surrounded valve H, which had a rotary motion, this motion being given to it by the

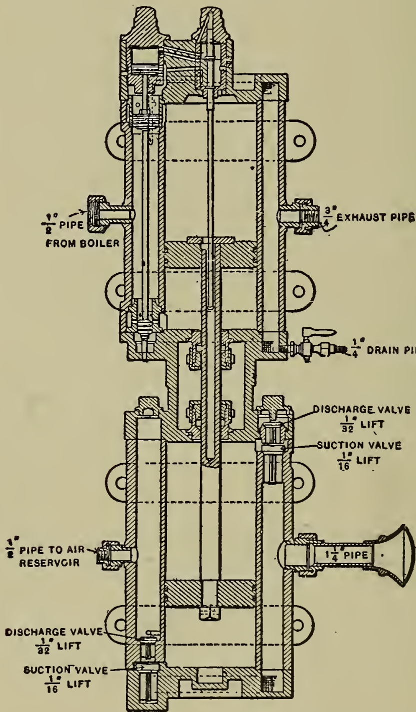


Fig. 2—Westinghouse Six-Inch Air Pump.

"trigger" valve arrangement in the top head. In chamber G was fitted a piston, e, which received alternately steam pressures on its two sides, the side on which the steam was operative being dependent upon the reversing slide valve operated in its chamber by the usual reversing slide valve rod, extending down into the hollow rod of the steam piston. In the air cylinder were located the receiving and discharge valves, similar in design and operation to those in the 6-inch pump.

The next step in the progress and improvement of the air compressor resulted in the completion of the 6-inch pump shown in Fig. 2. In this air pump the steam valve motion is of the well-known 8-inch pump type which is hereinafter described. The air valves in the air cylinder are similar in their arrangement and operation to those of the earlier form of the "trigger" pump. On the up stroke, air is drawn in at the lower suction valve. On the same stroke, the atmospheric air in the air cylinder above the piston is compressed and forced out through the upper discharge valve to the main reservoir. On the down stroke, air is drawn into the upper end of the cylinder, through the upper suction valve, and the atmospheric air in the lower end of the cylinder is compressed and forced out through the lower discharge valve to the main reservoir. The steam pipe from the boiler is ½ inch in size; the exhaust pipe is ¾ inch, and the air discharge pipe is ½ inch. The suction pipe is 1¼ inch.

THE EIGHT INCH PUMP.

Fig. 3 is a vertical section of the Westinghouse 8 inch pump, and a clear idea of its construction and operation may be obtained from the following description:

The Action of the Steam End of the Pump is as follows: Steam from the boiler enters the pump at the union swivel 54, and besides filling the chamber which contains the main valve 7, passes through a port in the wall of this chamber and through a passage (not shown) to the chamber in which the reversing valve works, thereby constituting the main valve chamber and the reversing valve chamber as the two steam chests of the pump.

From the reversing valve chamber the steam passes through a small port into the space occupied by the reversing piston 23, and as the combined area of piston 23 and small piston 9 is greater than the area of the large piston 8, the main valve 7 is forced down until the small piston strikes the stop pin 50 and thus uncovers the port in bushing 26, which admits steam to the underside of main piston 10, forcing it up.

As the main piston moves up, plate 18 strikes the shoulder of stem 17 and thus changes the position of the reversing valve, so that the top port in its chamber is closed to piston 23, and the two lower ports are connected by the cavity in the reversing valve, which allows the steam to flow from off the top of piston 23, and pass under it into the exhaust passage across the head, as shown by dotted lines, to the main exhaust. When the pressure is thus shut off from piston 23, the main valve raises and causes the small piston to close the steam port to the underside of the main piston, and opens the exhaust port leading into the passage in the bottom of the cylinder, shown by dotted lines, and out at the main exhaust, at the same time piston 8 of the main valve closes the top exhaust port in bushing 25 and opens the supply port through the bushing, and thus admits steam on top of the main piston, which drives it down.

In making the down-stroke, plate 18 engages the button on stem 17 and again changes the position of the reversing valve, which again admits steam on top of the reversing piston, which causes the main valve to move

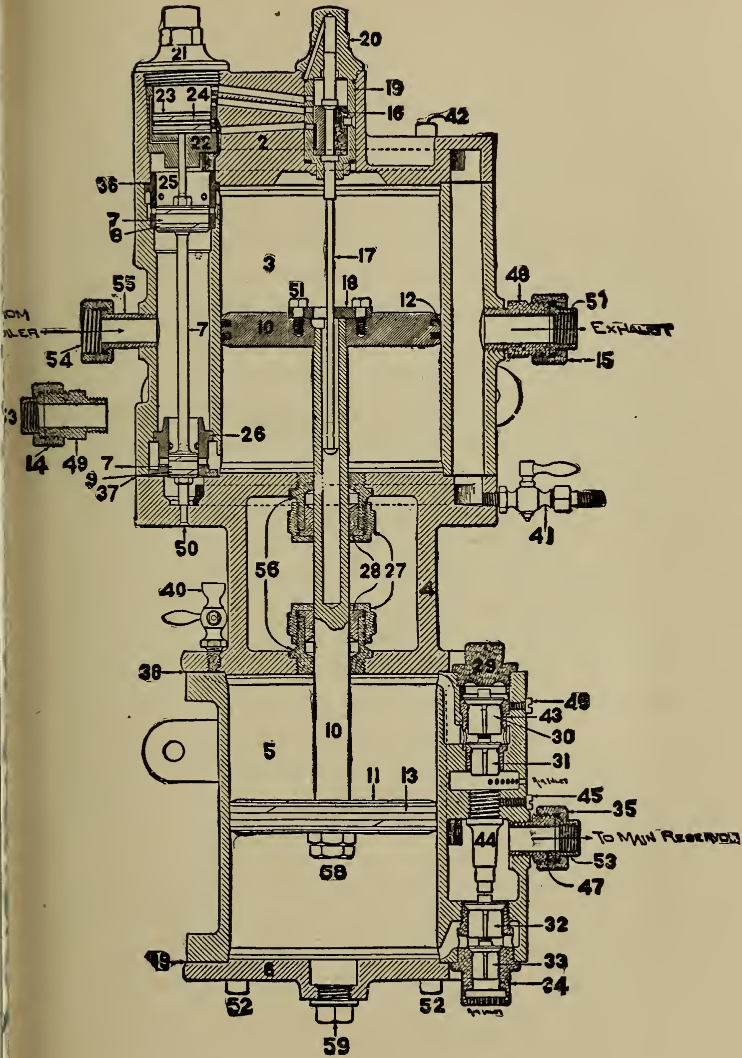


Fig. 3—Eight-inch Air Pump.

down as before, and piston 8 uncovers a port in the bushing 25 which exhausts the steam from off the top of the main piston, and at the same time piston 9 opens the supply port in bushing 26, which admits steam to the underside of the main piston, and at the same time closes the lower exhaust. The pump has now made a complete double stroke.

Drain cock 41 must always be opened before the pump is started, and left open until the pump is warmed up, or until there is about thirty pounds pressure in the main reservoir, and great care must be taken to start the pump slow, to avoid pounding and jarring, as the condensation cannot be compressed, and there must be an air cushion for the piston head to strike against in the lower cylinder.

The Action of the Air End of the Pump is as follows: There are four air valves, two are called receiving valves 31 and 33, and two are called discharge valves 30 and 32. There are two valve cages 34 and 43, and as the discharge valves have a greater area than the receiving valves, in the eight-inch pump, the flow of air past the valves is determined by the lift each valve has; the receiving valves have a lift of one-eighth of an inch, while the discharge valves have a lift of three thirty-seconds of an inch, or one thirty-second less than the receiving valves.

These standards must never be changed, as too much lift of any of the valves will cause the pump to pound, and not enough lift will cause it to run hot.

The way in which the pump receives and discharges air is as follows: When piston 11 is drawn up by steam piston 10 there is a partial vacuum formed in the air cylinder beneath piston 11, and as the atmospheric pressure is about fifteen pounds to the square inch, the receiving valve 33 is forced off its seat by the air rushing in to fill up the space created by the partial vacuum, and if the piston was to stop when it reached the top, the valve would be seated by its own weight when the pressure inside and out of the cylinder equalized; but as the piston reverses just as it reaches the top, the valve is forced to its seat and held there by the compression of the air on top of it, and if the valve has too much lift the pound heard when the valve is seated is great in proportion.

When the piston starts on the down-stroke it compresses the air higher and higher as it nears the bottom, and when the pressure in the pump becomes greater than that in the main reservoir, the lower discharge valve 32 is forced up and the air from the pump rushes into the main reservoir, until the valve is seated by the main reservoir pressure becoming greater than that in the pump.

The action of the top receiving and discharge valves is the same as the lower ones, except on the opposite stroke.

THE NINE AND ONE-HALF INCH PUMP

The 9½-inch pump shown in section in Fig. 4 differs from the 8-inch pump in several ways. In the first place it is larger by 1½ inches in the bore; second, the valve motion of the steam end is all contained in the top head, except the reversing valve stem, which is the same as in the 8-inch pump; third, the air valves are all the same size, and all have the same lift of three thirty-seconds of an inch, and the valves are placed so that the discharge valves are both on one side, and the receiving

NINE AND ONE-HALF INCH AIR PUMP.

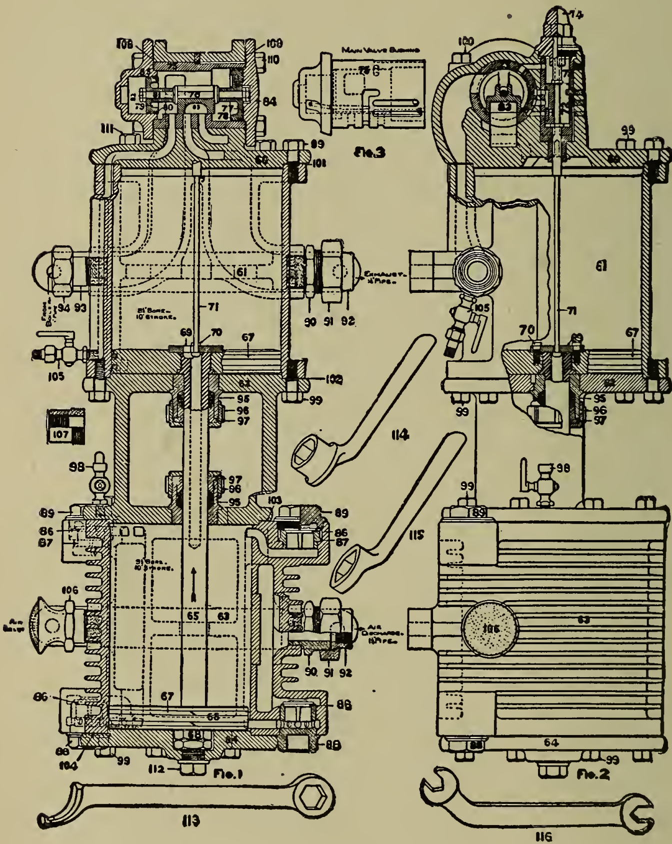


Fig. 4—Nine and One-half Inch Air Pump.

valves on the opposite side of the air cylinder; fourth, there is but one air inlet for the receiving valves, making it possible to strain all the air through one strainer, as indicated by 106, Fig. 4. The main piston is the same in construction as in the 8-inch pump; there are two heads 67 on one piston rod 65, and this rod is hollow to admit the stem 71 of the reversing valve 72, and the reversing valve stem is driven up or pulled down by the reversing plate 69 striking the shoulder j or the button 70, just as it does in the 8-inch pump.

As the reversing valve was the channel through which the steam had to pass to and from the top of the reversing piston in the 8-inch pump, in like manner the reversing valve in the 9½-inch pump controls the flow of steam to and from the plain side of piston 77 of the main valve, which in connection with the slide valve 83 controls the supply and exhaust ports in the steam cylinder.

To explain this it is necessary to use two sectional views of the pump, as shown in Fig. 4. In the left hand view designated Fig. 1 the pipe connection 93 shows by dotted lines how the steam from the boiler is carried through a passage in the back of the pump to the main-valve chamber.

The main valve is composed of two pistons of unequal diameters, fastened to a suitable rod 76, and on this rod there are two shoulders between which a common D slide valve 83 is held. The small view at the top of Fig. 4, designated as Fig. 3, represents the bushing in which the main valve and slide valve works.

The slide-valve seat has three openings: the one on the left, in Fig. 1, leads to and from the underside of the main piston; the one on the right leads to and from the top side of the main piston, and the one in the middle leads to the main exhaust, 92. Consequently when steam enters the main-valve chamber the piston 77, having the largest area, is forced to the extreme right, as in Fig 1, against the head 84, which causes the slide valve to uncover a port in the seat so that the steam can pass from the main-valve chamber down through a passage in the side of the cylinder to the underside of the main piston, which it forces up, and the reversing plate strikes the shoulder, j, on the reversing-valve stem, which drives the reversing valve up and allows the steam in the reversing-valve chamber to pass through the lower horizontal port in the main-valve bushing (see Fig. 3) into the chamber between the head 84 and piston 77. As this balances the pressure on both sides of the large piston 77, the small piston 79 now pulls the slide valve to the opposite end of the chamber, which uncovers the supply port to the top of the main piston, and allows the steam to force it down, and at the same time the steam from the underside is being exhausted by way of the cavity in the slide valve, which now has the lower supply port and the main exhaust connected.

The reason the small piston pulls the large piston over, after the pressure is balanced on both sides of piston 77, is because there is a small port between the plain side of piston 79 and the head 85, which is always open to the main exhaust, so that no back pressure can remain in the chamber indicated by 82, and no partial vacuum can be formed on that side of the small piston.

The main-valve chamber is always in communication with the reversing-valve chamber by a small port in the bushing 75, as shown in Fig. 2; cap nut 74 has a small port in it which allows live steam to always reach the top of the reversing-valve stem, for the purpose of keeping the pressure balanced on both ends of it.

As the main piston is now making its down-stroke the reversing plate 69 engages the button on the end of the reversing-valve stem and draws the reversing valve down to the position shown in Fig. 2, which connects the second horizontal port in the bushing with the port which in Fig. 3 appears to be vertical and having a short extension to the right, and as this port is always open to the main exhaust, the steam between piston 77 and the head 84 is exhausted, which allows the steam in the main-valve chamber to again force piston 77 to the position shown in Fig. 1, which places the slide valve in position to allow the steam to exhaust from the top of the main piston, and at the same time connects the main-valve chamber with the underside of the main piston, causing it to be forced up, as before.

Like the eight-inch pump, the stuffing boxes 95 must be kept well packed, and the gland nuts 96 just tight enough to stop leaks, but not tight enough to cause groaning. With metallic packing, the nuts can be tightened more than they could if a fiber packing is used, for if screwed down too tight on a fiber packing it will ruin it.

The drain cock 105 must be handled in the same way as the one on the eight-inch pump, but in addition to this one there is one in the main exhaust (not shown in Fig. 4), and it also must be opened when starting the pump.

THE ELEVEN INCH PUMP

Fig. 5 shows two views of the Westinghouse 11-inch air pump, the one on the left being sectional, and the one on the right semi-sectional. This pump differs from the 9½-inch pump principally in size, although a number of decided mechanical improvements have been made in its construction. Although the lift of the air

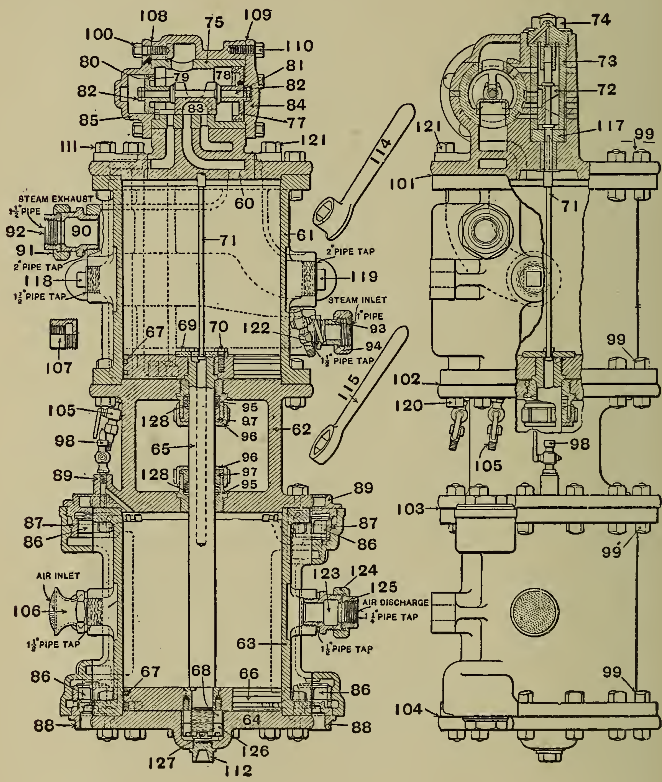


Fig. 5—Westinghouse Eleven-Inch Air Pump.

valves in this pump is the same as in the 9½-inch, viz., $\frac{3}{32}$ in. the valves are not interchangeable with those of the 9½-inch pump for the reason that they are larger in diameter. The bore of the steam, and air cylinder is 11 inches, and the stroke of the pistons is 12 inches. The same simple valve gear is used in the 11-inch pump, that has been described in connection with the 9½-inch pump. So far as care and operation are concerned, the same general rules apply to both pumps. Regarding efficiency, it is claimed for the 11-inch pump that, operating under similar conditions it is about 30 per cent more efficient than the 9½-inch pump.

Right and left hand pumps are pumps having two sets of plugs on either side of the steam cylinder, so that the pump can be located on either side of the engine as desired. All 9½-inch and 11-inch pumps are now made right and left.

To change a pump from right to left, or vice versa, remove the steam port fittings and opposite plug and exchange them, remove the exhaust port fitting and its opposite plug and exchange them.

In oiling either the 8, 9½ or 11-inch pump the steam end is oiled by a lubricator, and when first starting the pump, the oil should be allowed to flow at the rate of about fifteen drops per minute, but as soon as the pump is nicely warmed up, or say about thirty pounds pressure in the main reservoir, then the oil should be cut down to about one drop per minute, if that will keep the pump lubricated so that it won't groan. Some pumps require more oil than others, according to the work they have to do. There is now being supplied on all pumps, when so specified, an automatic oil cup for the air end of the pump on both the Westinghouse and New York Air Pumps. An automatic cup is very essential, as too much, or too little oil in either end of the pump is ruinous.

The air cylinder should be oiled regularly with good valve oil, as the old practice of oiling it only when the pump groans is now found to be bad practice. The old practice of having a good fat swab on the piston rod of the pump is a very good one, although it is a bad practice to expect sufficient oil to pass into the cylinder to lubricate it from this source, for the simple reason that the piston rod packing is supposed to be air tight.

Under no circumstances should oil be sucked in through the air inlet. Whenever the air cylinder is to be oiled, the pump should be throttled down to a very slow speed, and after first filling the oil cup, watch the stroke of the piston, and when it is going down, quickly open the oil cup and allow the oil to be drawn in before the piston starts up. This causes the oil to be sprayed around the cylinder. If oil was poured in while the pump was cold, just as soon as it was started up the oil would be forced into the main reservoir, and eventually find its way to the brake valve, and gum up the rotary, feed valve, and pump governor.

If the oil blows back on the down-stroke, it indicates very plainly that new packing rings are needed. One of the most common causes for the pump running hot is leaky packing rings. A leaky discharge valve might cause a back blow, but if the pump is completely stopped and the finger is held slightly above the open oil cup it will show if the trouble is there.

Never use anything but good valve oil for either end of the pump, as the heat generated by the compression of air is so great that it requires oil of a high flash point to withstand it. On a warm summer's day the temperature of the air in a pump working against a ninety-pound pressure in the main reservoir is about 550 degrees Fahr., and on a cold winter's day, when the thermometer is thirty degrees below freezing, the pump generates a heat of 300 degrees against a ninety-pound main reservoir pressure. The speed of the pump should not exceed 60 or 70 full strokes per minute, otherwise the temperature is raised considerably higher.

THE WESTINGHOUSE TANDEM COMPOUND AIR PUMP

Although the steam is not compounded in this pump, it has two stages of air compression from the time that the air is admitted into the air cylinder until it is discharged into the main reservoir, and the result is, that by thus compounding the air, a much smaller steam cylinder can be used to operate the pump, thus effecting a marked economy in steam consumption. The steam cylinder is only 8 inches in diameter, but the pump has an air compressing capacity equal to the 11-inch pump.

The steam cylinder proper is practically the same as that of the 8-inch standard pump, but the valve mechanism, and pipe connections correspond exactly with that of the special 9½-inch pump. Reference to Fig. 6 will show that the pump consists of three cylinders placed vertically in tandem, the two lower ones joined by a thin center piece forming the air end, while the steam cylinder is on top, the whole being joined by the center piece 62. The air cylinders are each 11 inches bore by 12 inches stroke. The two air pistons 66 and 119 are connected to the piston rod 65, which receives its motion from the steam piston. The two air pistons are also connected with each other by a drum of smaller diameter, thus forming what might be termed a spool shaped piston. Center piece 122 fits closely about the connecting drum, and is equipped with packing rings 124 and

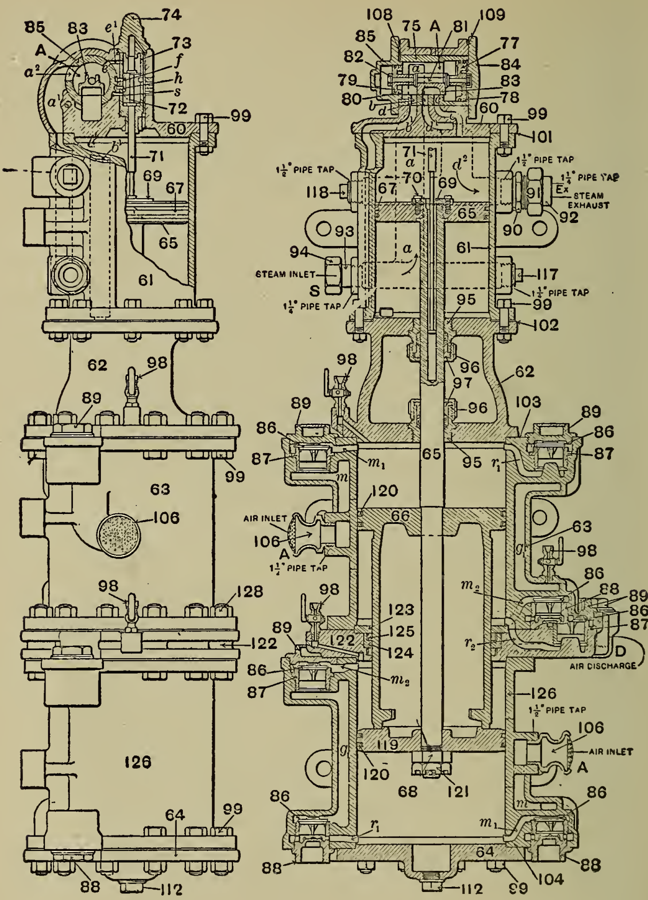


Fig. 6—Westinghouse Tandem Compound Air Pump.

125, which prevent the passage of air from one cylinder to the other. The action of the air end is as follows: On the down-stroke air is drawn through the upper air inlet on the left hand side of the cylinder. It passes through the air inlet 106, passage m, receiving valve 86, and passage m1 to the lower pressure volume above piston 66. When the piston reaches the lower limit of its stroke and moves up this air is compressed until the upper discharge valve 86 (on the upper right hand side of the cylinder) is raised, than the air is forced through port r1, discharge valve 86, passage g1, receiving valve 86 and port m2 to the annular cavity between the drum portion of piston 66 and the cylinder 63. Since this volume is much smaller than the low pressure volume the air is being compressed during its passage from the low pressure to the high pressure volumes, until when the piston reaches the upper limit of its stroke the air in the low pressure clearances, passages and high pressure volume has reached the intermediate pressure of approximately 40 lbs.

During the next down-stroke this intermediate air pressure is compressed until it raises the final discharge valve 86, when it passes through port r2 and the discharge valve to the "air discharge" orifice in the center piece 122, thence to the main reservoir.

This same operation occurs in the lower cylinder when the piston goes in the opposite direction from that described above, and as corresponding passages are designated by the same letter the operation can be readily followed.

The compound feature of the pump, and the advantages gained thereby may be explained as follows: When the pistons are moving upward air is being forced from the cylinder above piston 66 to the annular cavity between the drum portion of the piston 66 and the cylinder 63, the air gradually increasing in pressure as the piston advances, reaching a pressure of about 40 pounds at the termination of the stroke. This pressure under piston 66 and above center piece 122 exerts an upward force on the piston the same as does the steam under piston 65, while at the same time the air under compression to the main reservoir is exerting only a resistance equal to the area of that portion of the upper side of piston 119 exposed to the air being compressed in the annular opening between the piston trunk or spool and the cylinder 63.

The air cylinders are lubricated by three oil cups 98. The upper end receives its oil from that cup placed just to the left on the upper center piece. The piston drum receives its lubrication by the oil from the cup connecting with passage 91 in the upper air cylinder and is drawn into the high pressure volume of the air as it goes from the low pressure to the high. The lower end of the air piston is lubricated by the oil cup situated on the left side of the lower center piece 122.

WESTINGHOUSE AIR PUMP GOVERNOR—SINGLE TOP.

The function of the pump governor is to regulate the supply of steam to the pump in such a manner that the speed of the latter will maintain the desired air pressure. Figures 7 and 8 show sectional views of the single top governor, in two positions, viz., open and closed. The pipe connections are as follows: B leads to the boiler, P to the pump and MR to the main reservoir, except on engines equipped with the D8 brake valve, in which case connection MR leads to the train pipe. Referring to Fig. 7, which shows the valves in the open position, it will be seen that the steam has a free passage from B to P, as indicated by the arrows. This is the position of the governor valve at the time of starting the pump, and until main reservoir pressure is pumped up. Nut 40 in the top of the governor is for the purpose of adjust-

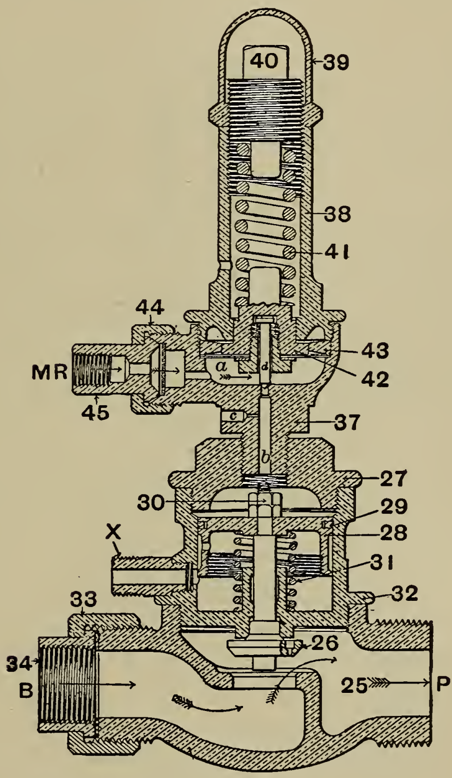


Fig. 7—Air Pump Governor, Open.

ing the tension of spring 41 on diaphragm 42, which holds pin valve d to its seat. The steam valve 26 is actuated by piston 28. Assuming that the governor has been properly adjusted, its action is as follows:

Air pressure entering the governor MR passes into chamber a, below diaphragm 42, until such time as the air pressure exceeds the tension of adjusting spring 41,

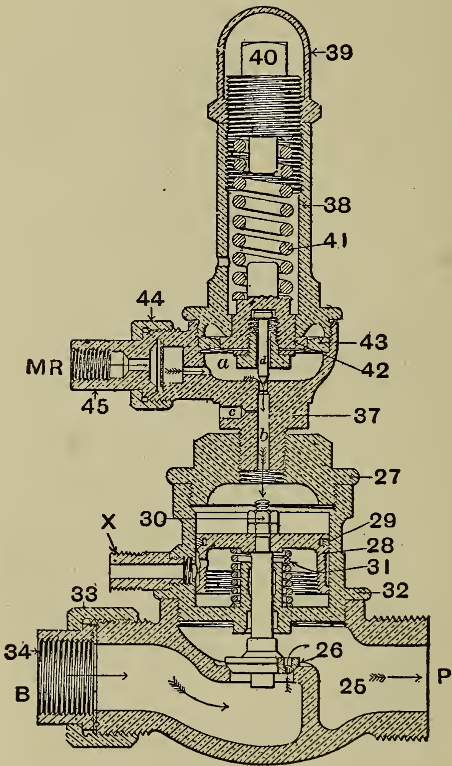


Fig. 8—Air Pump Governor, Closed.

when the diaphragm will yield and cause the pin valve d to be raised from its seat. With pin valve d from its seat, air is free to pass from chamber a, through port b, and into the chamber above the governor piston 28, as shown by the arrows in Fig. 8, air pressure now being present above piston 28, forces it down, compressing spring 31, and seating steam valve 26, and stopping the pump. When the air pressure in chamber a is reduced below the pressure that the governor is adjusted for, the tension of adjusting spring 41 will cause diaphragm 42 to move down and seat pin valve d, thus shutting off the air pressure from port b, and the chamber above piston 28.

Port b and the chamber above the governor piston 28 is always open to the atmosphere, through the small relief port c; therefore, the air pressure from above the piston will immediately escape and allow spring 31, with the assistance of the steam below valve 26, to raise the piston and valve to their normal positions, which will again start the pump to work.

WESTINGHOUSE DUPLEX AIR PUMP GOVERNOR.

The object of the duplex governor shown in Fig. 9 is to permit of controlling the air pump with two different air volumes, or a ready change in the pump control from one pressure to another, without having to readjust the governor. The principles controlling the operation of the duplex governor and the single top governor are practically the same, the only difference in the construction of the two governors being in the upper, or air end of the duplex type, in which two springs and two diaphragms are used instead of one, as in the single top. These are connected to the steam portion of the governor by a siamese fitting. As the adjustment of the two diaphragms in the duplex head differs, different pressures are required to operate them; but one diaphragm only, operates at a time.

It will be noticed by reference to Fig. 9, that one of the vent ports c is plugged. This is done to prevent a

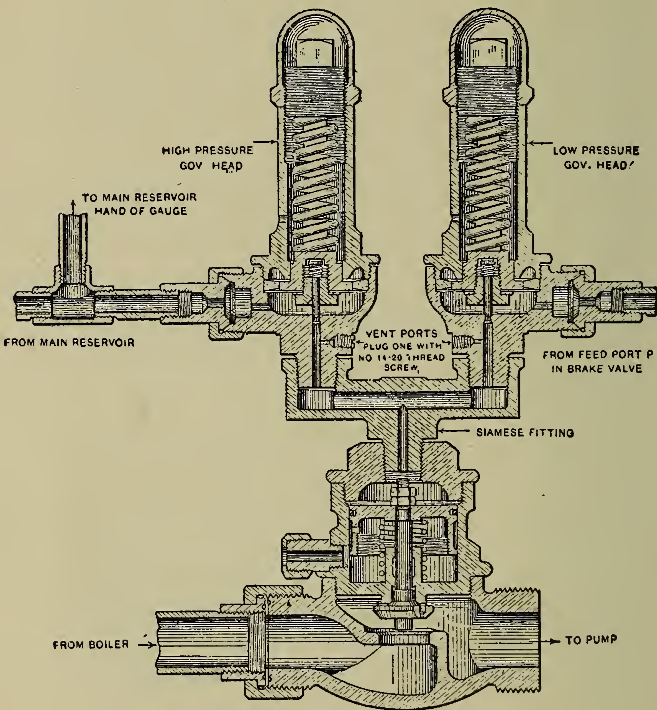


Fig. 9—Westinghouse Duplex Pump Governor.

needless waste of air, as the siamese fitting directly connects both diaphragm chambers together, one vent port is sufficient, as only one head is operating at any one time. Connection X (Figures 7 and 8), from below piston 28 is for the purpose of permitting any steam that may leak past 28, to escape to the atmosphere. During the time that pin valve d is unseated, there is a continuous blow from relief port c. This leakage in conjunction with the flow of steam through the small port in steam valve 26, indicated by the arrow in Fig. 8, serves to keep the pump working slowly, thus preventing the accumulation of condensation in the steam end. The equipments with which the duplex pump governor is used are: the high speed brake, "schedule U," or the high pressure control, and the duplex main reservoir control. The Westinghouse SF-4 Pump Governor will be described in connection with the No. 6 ET Locomotive brake equipment.

AUTOMATIC OIL CUPS.

Mention has already been made of the difficulties attending the lubrication of the air cylinder by means of the old style hand oilers. Fig 10 is a sectional view of the Westinghouse automatic oil cup No. 1, showing clearly its construction. The body of the cup is brass, with chamber A in which the oil is placed. The small regulating valve stem B, passing down through this chamber can easily be adjusted from the top by removing cap C which fits into the top of the body, and is secured by the small chain, so that it cannot be lost. A small lock nut L on the valve stem insures against the feed changing, once it is adjusted. The action of the cup is as follows: When valve V is slightly raised, oil will pass, drop by drop, into the small chamber below. This chamber connects to a passage through the body, up through passage G, to the cap and through small holes J in this cap, to the atmosphere. Thus it is always under atmospheric pressure.

Chamber I also connects to the air cylinder by a steel valve D. It will be noted that the upper part of the cavity in which this ball valve is placed, connects to a smaller passage to the air cylinder, consequently, when

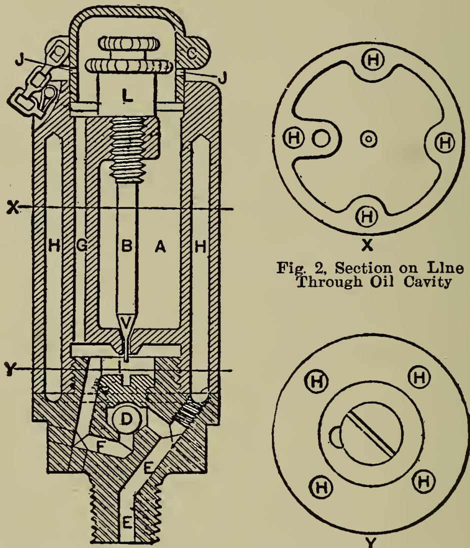


Fig. 1, Verticle Section

Fig. 3, Section on Line Through Feed Cavity

Fig. 10—Westinghouse Automatic Air Cylinder Oil Cup No. 1.

the air piston descends the suction causes the ball valve D to rise, and the air will be drawn through holes J in the cap and the passage G into the body. As the air is drawn into the pump cylinder, any oil that may have dropped from the regulating valve onto the top of the nut which holds the ball valve D in position, is drawn down into the pump cylinder and performs its work of lubrication.

As soon as the piston starts on its return stroke, the ball valve promptly reseats itself, so that no air can be discharged to the atmosphere through the oil cup. In this way the oil cup is always subject to atmospheric pressure, and may be re-filled, if necessary, as well when the pump is running as when it is stopped.

Four holes are drilled up through the body of the cup.

These holes H connect with a circular groove in the base, so that all four holes are connected with each other. This groove also connects with the passage leading from the pump cylinder to the top of the ball valve; thus, on the up-stroke of the pump air piston, the compressed air is forced not only on top of the ball valve, but also in the grooved canal in the base, and thence to the vertical drilled holes or passages H in the body.

The function of these ports or passages is to store hot air, and thus keep the oil warm enough to permit it to feed regularly, otherwise the oil in the cup would tend to cool and become too thick to feed when the engine is running. This cup is easily adapted to the 9½-inch and 11-inch pumps, but for the 8-inch pump a special fitting is supplied to make the connection. If the cup fails to feed the cause may be dirt clogged between valve V and its seat, or ball valve D may have become corroded by using poor oil. If the cup should feed too fast, it may be on account of improper adjustment, or the lock nut L may have become loosened, thus allowing the pounding action of the pump to increase the feed. This may also close the feed entirely. The cup should always be shut off at the end of each trip, otherwise the oil will feed from chamber A, past valve V, into chambere I and port F, thus flooding the pump with oil when it is started.

AUTOMATIC OIL CUP NO. 2.

This cup, as illustrated in Fig. 11, is composed of a steel base, screwing into the air cylinder of the air pump,

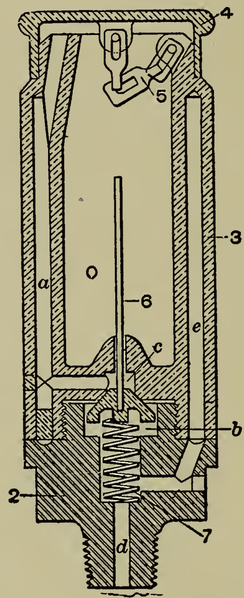


Fig. 11—Westinghouse Automatic Air Cylinder Oil Cup No. 2.

to which is properly connected a brass cup for holding the oil. On this cup is a cap 4 which fits snugly and is fastened to a three-link chain to prevent loss of the cap.

Oil is contained in chamber O. The operative parts consist of a needle feed stem 6, valve C and spring 7. On the downward stroke of a pump, the valve C is drawn from its seat by suction, compressing the spring 7, and a slight amount of air is drawn in through the port a. On the up-stroke of the pump, valve C is forced against its seat and closes off all feed of oil which passed along the needle 6 from the chamber O down to the valve C. Thus it will be seen that on each down stroke of the pump, oil is drawn past the needle 6, past valve C and down through port d to the air cylinder.

Port e is one of a series of heater ports, cast in the cup for the purpose of admitting warm air to the body of the cap to keep the oil in a free liquid state for feeding from chamber O, past the needle 6 and valve C to the air cylinder.

This cup is similar to No. 1 cup with the exception that while the feed of No. 1 is adjustable, that of No. 2 cup is a definite fixed feed.

THE WESTINGHOUSE CROSS COMPOUND AIR COMPRESSOR.

The great increase in pump capacity called for in modern service has resulted in a much more careful consideration of the matter of steam consumption than formerly, and as a result the Westinghouse 8½-inch Cross Compound Compressor was developed for the specific purpose of combining maximum capacity and highest efficiency, by compounding both the steam supplied and the air compressed to the extent that, while this compressor has a capacity over three times greater than the well known 9½-inch single stage compressor, the steam consumption per cubic foot of air compressed is but one-third.

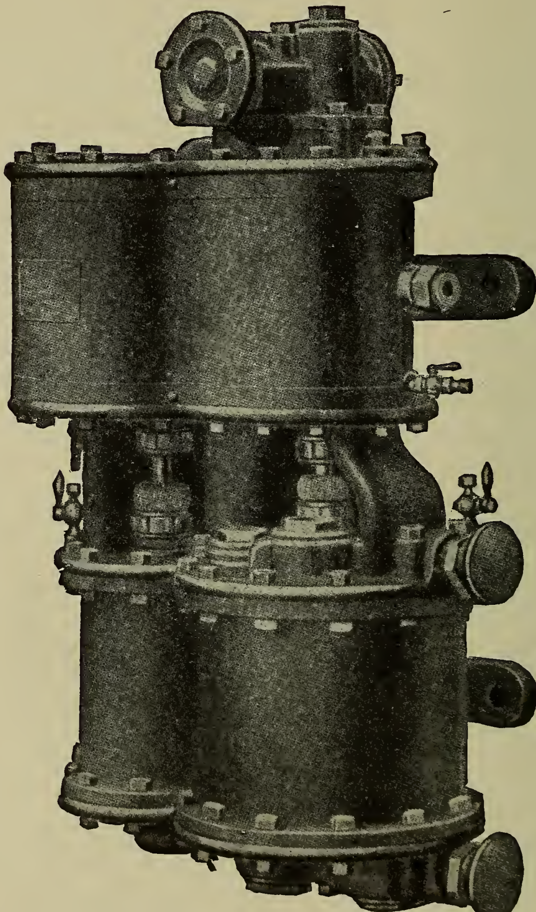


Fig. 12—The Westinghouse Cross Compound Pump.

DESCRIPTION.

As in the case of the Standard Westinghouse Single Stage Compressors, the steam cylinders are placed ver-

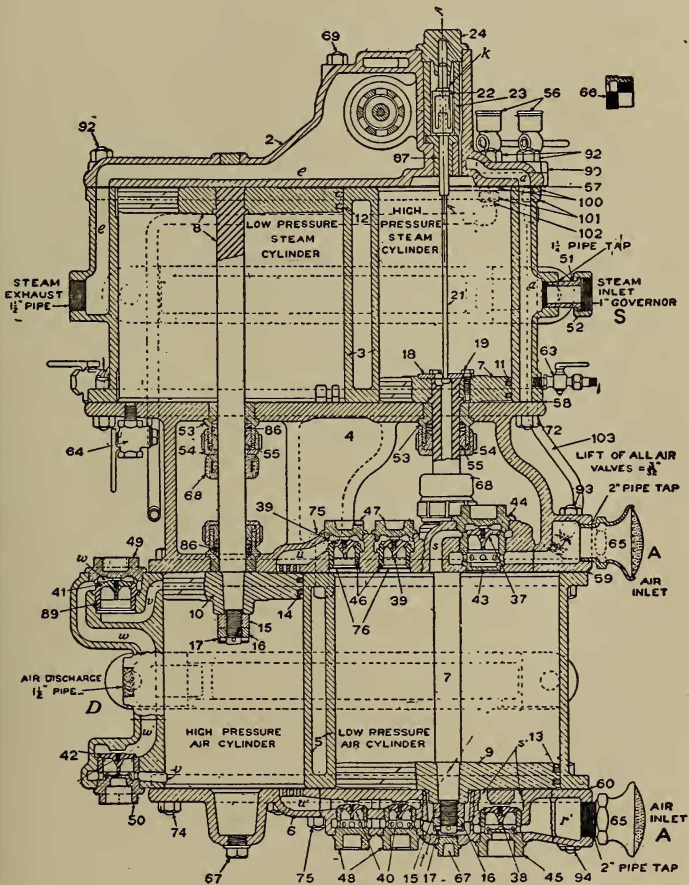


Fig. 13—8½″ Cross Compound Compressor. Vertical Section.

tically above the air cylinders and joined by a common center piece, see exterior view Fig. 12.

The diagrammatic views (Figs. 16 and 17) serve to illustrate the simplicity of this design and emphasize the fact that the cross compound compressor is a serial arrangement of two standard single stage pumps, actuated by the same controlling mechanism, but with pistons moving uniformly in opposite directions. These cuts also show the few moving parts employed, which are: The high pressure steam low pressure air pistons, joined by a Vanadium steel rod drilled for the reversing valve rod which operates the reversing valve, and which in turn moves the main piston valve controlling the admission of steam to, and the exhaust from both the high and low pressure steam cylinders. The low pressure steam, and high pressure air pistons are connected by a solid Vanadium rod having no mechanical connection with the valve gear.

Figs. 13, 14, 15 and 16, are sectional views showing the ports and passages, also numbered parts which are referred to as follows: 2, top head; 3, steam cylinders; 5, air cylinders; 4, center piece forming the connection between 3 and 5; 6, lower head; 7, high pressure steam piston, 8½ inches in diameter, and its rod; 8, low pressure steam piston, 14½ inches in diameter; 9, low pressure air piston, 14½ inches in diameter; and 10, the high pressure air piston, 9 inches in diameter. The maximum stroke of each pair of pistons is 12 inches; 11, high pressure steam piston ring; 12, low pressure steam piston ring; 13, low pressure air piston ring; 14, high pressure air piston ring; 15, piston rod nut; 16, piston rod jam nut; 17, piston rod cotter; 18, reversing valve plate; 19, reversing valve plate bolt; 21. reversing valve

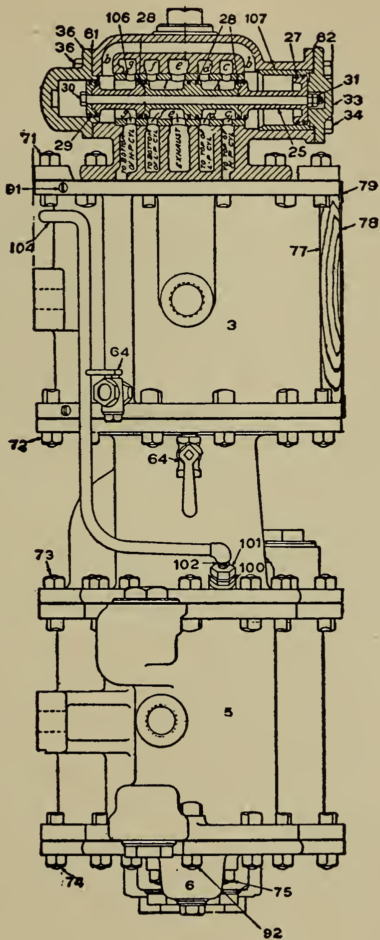


Fig. 14—8½″ Cross Compound Compressor. Side Elevation.

rod; 22, reversing valve; 23, reversing valve chamber bush; 24, reversing valve chamber cap; 25, piston valve, complete; 27, large piston valve ring; 28, exhaust piston valve ring; 29, small piston valve ring; 30, piston valve bolt, complete; 31, piston valve bolt nut; 33, large piston

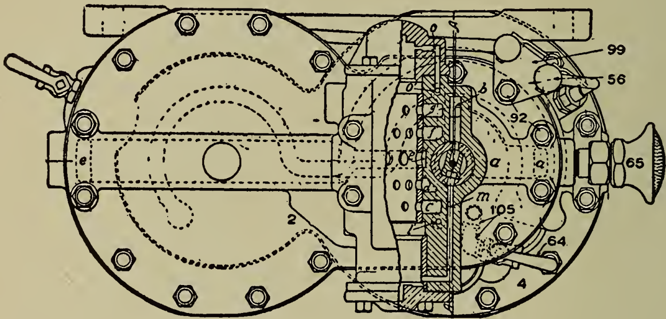
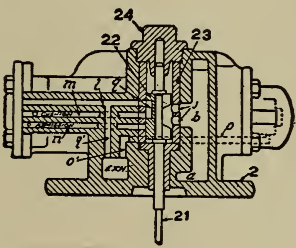


Fig. 15—Horizontal Section of Reversing Valve Chamber.

valve cylinder head; 34, large piston valve cylinder head cap screw; 35, small piston valve cylinder head; 36, small piston valve cylinder head cap screw; 37, upper inlet valve; 38, lower inlet valve; 39, upper intermediate valve; 40, lower intermediate valve; 41, upper discharge valve; 42, lower discharge valve; 43, upper inlet valve seat; 44, upper inlet valve chamber cap; 45, lower inlet valve cage; 46, upper intermediate valve seat; 47, upper intermediate valve cap; 48, lower intermediate valve cage; 49, upper discharge valve cap; 50, lower discharge valve; 51, 1-inch steam pipe stud; 52, governor union nut; 53, stuffing box; 54, stuffing box nut; 55, stuffing box gland; 56, air cylinder lubricator; 57, upper steam cylinder gasket; 58, lower steam cylinder gasket; 59, upper air cylinder gasket; 60, lower air cylinder gasket; 61, small piston valve cylinder head gasket; 62, large piston valve cylinder head gasket; 63, ¼-inch drain cock;

64, ½-inch drain cock; 65, air strainer; 66, 1-inch steam pipe sleeve; 67, lower head plug; 68, piston rod swab; 69, top head bolt and nut; 71, tee head bolt and nut; 72, 73, 74 and 75, tee head bolts and nuts; 76, guard plate for



SECTION A-A

Fig. 16—Vertical Section of Reversing Valve Chamber.

upper intermediate valves; 77, lagging; 78, jacket; 79, jacket band; 82, packing nut wrench; 86, piston rod packing; 87, reversing valve rod bush; 89, upper discharge valve seat; 91, jacket band screw; 92, tee head bolt and nut; 99, lubricator bracket; 100, union stud; 101, union nut; 102, union swivel; 103, oil pipe to low pressure air cylinder; 104, oil pipe to high pressure air cylinder; 106, piston valve bush; 107, large piston bush. The total weight is 1,500 pounds, and the normal speed is 100 single strokes per minute, with 180 lbs. steam pressure and working against 140 lbs. air pressure. The drain cock 63 is intended to draw off any condensation in the steam passage a, and should always be opened when the pump is first started. The drain cock 64 connected to the low pressure steam cylinder is for the same purpose, and should also be opened for a short time before the compressor is started so that any condensation of steam in the cylinder may be removed.

The Governor is connected to the steam inlet at S. Steam entering passes through port a to the top head, and thence through ports a and b (Fig. 16) to the reversing valve chamber o and main valve chamber (Fig. 13); e is the exhaust passage leading to the steam exhaust pipe. As it is difficult to follow the ports in these cuts, two diagrams have been prepared, as shown in Figs. 17 and 18, in which the steam valve gear is turned so as to be parallel with the cylinders in order to make the operation more easily understood, and all ports and passages are connected in the simplest possible manner, without regard to the actual construction of the compressor.

Referring to Fig. 16, passage a communicating with cavity C and the two chambers b convey the steam from the source of supply to the operating valves, of which there are two, namely: the reversing valve and the piston valve. The piston valve is a multiple piston device, consisting of a large piston at one end, a small piston at the other, with three intermediate pistons of uniform size, which will be referred to hereinafter as numbers 1, 2 and 3, numbering from the small piston end of the piston valve.

It is self-evident that, with five pistons mounted on a common rod and working in a cylinder, we have, including the ends, six separate chambers. In this particular construction, five of these chambers have permanent connections as follows:

The first chamber, E, behind the outer end of the small piston, to the atmosphere

The second chamber, b, between the small and No. 1 intermediate piston, to passage a.

The third chamber, i, between the No. 1 and No. 2

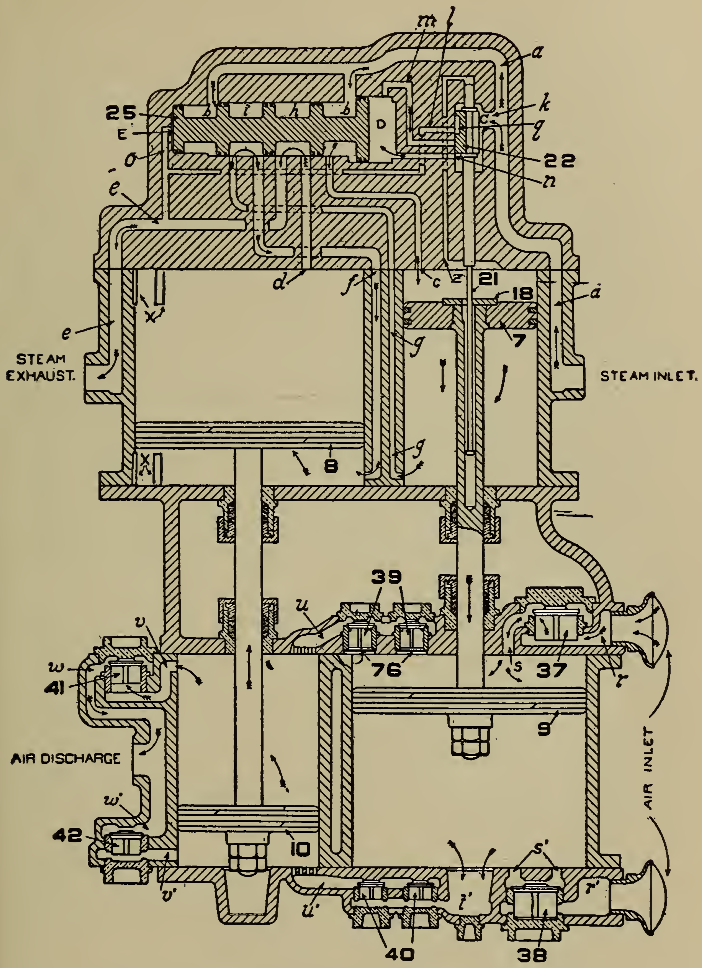


Fig. 17—Diagram of 8½" Cross-Compound Compressor. The High Pressure Steam (Low Pressure Air) Piston on Its Downward Stroke.

intermediate pistons, to the lower end of the low pressure steam cylinder.

The fourth chamber, h, between the No. 2 and No. 3 intermediate pistons to the upper end of low pressure steam cylinder. The fifth chamber, b, between the third intermediate and the inner side of large piston to passage a.

The fifth chamber, b, between the third intermediate and the inner side of large piston to passage a.

The reversing valve, 22, moving vertically on its seat in chamber C, controls the admission and exhaust of steam from the cavity D, behind the outer end of the large piston of the piston valve, causing it to operate horizontally, the intermediate pistons moving as follows:

Intermediate piston No. 3 crosses a port connecting passage c controlling the flow of steam to the upper end of the high pressure steam cylinder, and also the exhaust into the upper end of the low pressure steam cylinder.

Intermediate piston No. 2 crosses a port connecting with passage e, controlling the exhaust of steam from either end of the low pressure steam cylinder. Intermediate piston No. 1 crosses a port, connecting the passage g, causing steam to be admitted to the lower end of the high pressure steam cylinder, or exhausting the same from this cylinder into the lower end of the low pressure steam cylinder.

A passage z, leading from the upper end of the high pressure steam cylinder is the means of supplying pressure to balance the reversing valve rod.

Operation. When the high pressure steam piston has nearly completed its up stroke, the reversing valve plate 18, comes in contact with the shoulder on the reversing rod, forcing said rod 21 to its uppermost position carrying with it reversing valve 22, the movement of which in turn not only blanks port to passage m, thereby cutting off means of exhausting steam from the cavity behind the large end of the piston valve, but also opens the port to passage n, filling this chamber D with live steam from passage a. The pressure thus exerted on the outer side of the large piston, added to the pressure on the inner side of the small piston is now greater than the pressure exerted on the inner side of the large piston, and the piston valve moves to the left, or in the direction of chamber E, which movement admits steam to the upper end of the high pressure steam cylinder, starting the high pressure steam piston on its downward stroke. All parts have now assumed the position shown in Fig. 17.

A direct communication is now established whereby live steam is supplied through passage a, chamber b, and passage c to the upper end of the high pressure steam cylinder, forcing downward the high pressure steam piston and low pressure air piston to which it is rigidly connected by the piston rod, that is free to move in the necessary stuffing boxes. The downward movement causes steam to be exhausted from the lower end of the high pressure steam cylinder through passage g, cavity i and passage f, into the lower end of the low pressure steam cylinder. The latter being of materially larger volume than the former, it will be seen that the steam is thereby made to do its work expansively in the low pressure steam cylinder. At the same time—

a the low pressure air piston, 9, is compressing air in the lower end of the low pressure air cylinder and forcing same through the intermediate valves 40, and

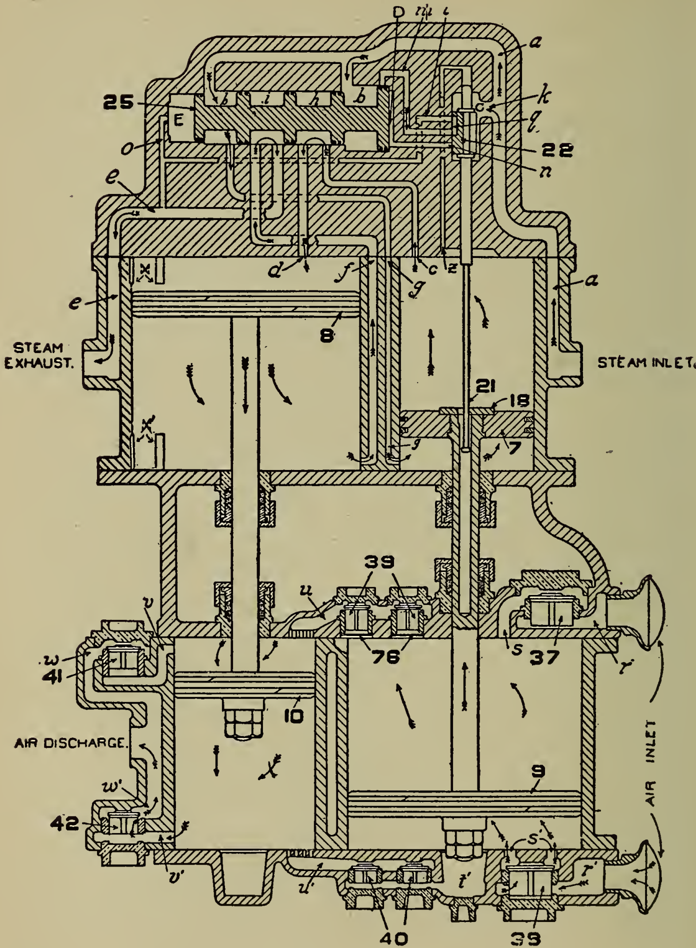


Fig. 18—Diagram of 8½″ Cross-Compound Compressors. The High Pressure Steam (Low Pressure Air) Piston on Its Upward Stroke.

passage u′ into the lower end of the high pressure air cylinder, and—

b air at atmospheric pressure is being drawn into the upper end of the low pressure cylinder, through the upper air strainer and inlet valve 37.

It will be observed that the steam exhausted into the lower end of the low pressure steam cylinder, and the low pressure air forced into the lower end of the high pressure air cylinder act simultaneously on the lower sides of their respective pistons. The force thus exerted results in an upward movement of the low pressure steam and high pressure air pistons. The upward movement causes—

a steam to be exhausted from the upper end of the low pressure steam cylinder through passage d, chamber h and passage e to the atmosphere, and—

b the high pressure air piston 10, to compress the air in the upper end of the high pressure air cylinder to its final pressure and to discharge it through passage v, discharge valve 41, and passage w into the main reservoir.

After the low pressure steam (high pressure air) piston has completed its upward stroke, as explained, the lower end of the high pressure air cylinder is, of course, filled with air compressed from the lower end of the low pressure air cylinder, and the lower end of the low pressure steam cylinder is filled with steam exhautsed from the lower end of the high pressure steam cylinder. However, just as the low pressure steam (high pressure air) piston has completed its upward stroke, steam is by-passed through three by-pass grooves x from the lower to the upper side of the low pressure steam piston, thereby preventing an accumulation of back pressure in the lower end of the high pressure cylinder.

At this stage of the cycle, also, the upper end of the low pressure air cylinder is filled with air at atmospheric pressure, and the upper end of the high pressure steam cylinder is filled with live steam; but just before the high pressure steam low pressure air piston completes its downward stroke, reversing valve plate 18 engages the button end of the reversing valve rod, moving it downward, and carrying the reversing valve to its extreme lower position, thereby closing the port leading to passage n, cutting off the supply of live steam to chamber D, and connecting passage m, cavity g, and passage l, thereby exhausting steam from cavity D behind the outer end of the large piston of the piston valve. Since the pressure against the inner side of the large piston is now greater than the pressure exerted against the inner side of the small piston the piston valve moves to the right, or in the direction of chamber D, and all parts are in the position shown in Fig. 18. Live steam is now supplied from passage a, through chamber b, and passage g to the lower end of the high pressure steam cylinder, forcing upward the high pressure steam piston which, as already explained carries with it the low pressure air piston. The upward movement causes steam to be exhausted from the upper end of the high pressure steam cylinder, through passage c, chamber h, and passage d, into the upper end of the low pressure steam cylinder.

At the same time

a The low pressure air piston is compressing the air in the upper end of the low pressure air cylinder and forcing same through the intermediate valves 76, and passage u, into the upper end of the high pressure air cylinder, and

b air at atmospheric pressure is drawn into the lower end of the low pressure air cylinder, through the lower air strainer, passage r′ and lower inlet valve 38.

Again it will be observed that the steam in the low pressure steam cylinder, and air in the high pressure air cylinder act simultaneously against their respective pistons, steam being exhausted from the upper end of the high pressure steam cylinder through passage c, chamber h and passage d to the upper end of the low pressure steam cylinder in which it acts expansively on the low pressure steam piston. The downward movement of the low pressure steam piston causes steam to be exhausted from the lower end of the low pressure steam cylinder, through passage f, chamber i and passage e, to the atmosphere and the high pressure air piston to compress the air in the lower end of the high pressure air cylinder to its final pressure forcing same through passage v′, discharge valve 42, and passage w′, into the main reservoir. When the pistons have moved as explained, the low pressure steam high pressure air piston has completed its downward stroke; the upper end of the high pressure air cylinder is filled with air compressed from the upper end of the low pressure air cylinder; and the upper end of the low pressure steam cylinder is filled with steam exhausted from the upper end of the high pressure steam cylinder. However, just before the low pressure steam (high pressure air) piston has completed its downward stroke, steam is by-passed through the three by-pass grooves from the upper to the lower side of the low pressure steam piston, thereby preventing an accumulation of back pressure in the upper end of the high pressure steam cylinder. At this stage of the cycle also, the high pressure steam (low pressure air) piston has completed its upward stroke; the lower end of the high pressure air cylinder is filled with air at atmospheric pressure; and the lower end of the high pressure steam cylinder is filled with live steam. Here again the pump is reversed, by means of the reversing valve plate attached to the high pressure steam piston coming in contact with the shoulder of the reversing valve rod which, in turn, actuates the reversing valve, and the cycle of operation already described is repeated.

INSTRUCTIONS.

Piping. All pipes should be hammered to loosen the scale and dirt, have fins removed, and be thoroughly blown out with steam before erecting; bends should be used wherever possible instead of ells, and all sags avoided. Shellac or Japan varnish should be applied on the male threaded portion only, and never in the socket. Do not use red or white lead.

Starting and Running. The drain cocks are placed at the lowest points of the steam passages, as shown, for the purpose of draining condensed steam when the compressor is stopped and when starting it. They should always be left open when the compressor is to stand idle for any length of time. These drain cocks are provided with suitable union fittings, so that drain pipes may be connected if desired. In starting the compressor, always run it slowly until it becomes warm, permitting the condensed steam to escape through the drain cocks and the exhaust, until there is sufficient pressure in the main reservoir (25 to 30 lbs.) to provide an air cushion. Then close drain cocks and open the steam (throttle) valve sufficiently to run the compressor at the proper speed, according to circumstances. Racing, or running at excessive speeds should not be allowed. The pump governor automatically controls the operation of the compressor when maintaining the air pressure.

To Stop the Compressor. (1) Close the feed and steam valves on the sight feed lubricator, provided the compressor has a separate one, or the feed if supplied from the locomotive lubricator; (2) then close the steam (throttle) valve; (3) open all the drain cocks on the compressor. Keep the steam valve closed, and the drain cocks open when the compressor is not working. The main reservoir cocks should also be left open when the compressor is stopped for any length of time. The compressor should always be stopped while the engine is over the ash pit. If kept running, ashes and dust will be drawn into the air cylinder and injure it, besides clogging up the air strainer.

Lubrication—Air Cylinder. On account of the high temperatures developed by air compression, the variation between maximum and minimum delivered air pressures, and the necessity of preventing oil from passing into the system, one of the vital problems in efficient compressor operation is to provide a simple means for supplying lubrication to the air cylinders in proper quantity and at regular intervals.

To overcome the difficulties attending the lubrication of the air cylinder of the 8½-inch cross-compound compressor, two non-automatic oil cups are mounted on a bracket, which, in turn, is connected to the air cylinders by the necessary piping, thereby establishing an independent passage from each cup to the high and low pressure air cylinders respectively.

This cup (Fig. 19) is of extremely simple design. The lower end is threaded for a ⅜-inch tapped opening, while the upper end is provided with a tight-fitting screw cap.

A screen prevents any dirt in the oil being carried into the cylinder. When the handle is turned, a cavity in the key, which normally forms the bottom of the oil cup, de-

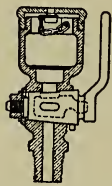


Fig. 19—Oil Cup.

posits a definite amount of oil in the air cylinders, at the same time preventing back pressure from reaching the oil chamber.

The bracket may be attached to the top head of the compressor, or placed in the locomotive cab, to suit the convenience, or standard practice of any railroad.

To oil the air cylinder, open its oil cup and blow out all dirt, close and fill it with valve oil, and on the down stroke of the piston open the cup to allow the oil to be drawn into the cylinder, closing the cup before the beginning of the up stroke. This is most easily done when the speed is moderate and the air pressure low. Valve oil only should be used in the air cylinder. A lighter oil will not last, and is dangerous. A heavier oil very soon clogs and restricts the air passages, causing the compressor to heat unduly and compress air slowly. Valve oil gives the best service. Judgment should determine the amount for both air and steam cylinders, it being remembered that the lack of a little oil when needed may result in much damage to the compressor. A swab, well oiled, is essential on each piston rod. Many master mechanics now consider quite essential the use of a sight feed lubricator fitting located in the cab, and connected in the piping leading from the oil well of the locomotive lubricator to the compressor air cylinders, and, judging from the very satisfactory results obtained, it appears to be a very effective arrangement. Fig. 20 shows a sight feed

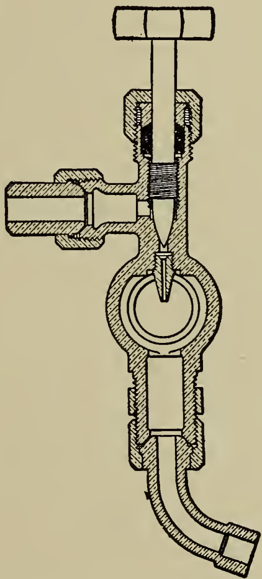


Fig. 20—Single Sight Feed Fitting.

lubricator adapted for the system referred to, and it gives the engineer complete and convenient control of air cylinder lubrication, so that the minimum amount, and proper quantity of oil required may be supplied at regular intervals. This sight feed lubricator can be attached to any locomotive lubricator. In order to prevent compressed air from entering the oil delivery pipe between the sight feed fitting and the air cylinder, a ball check valve connection is screwed into the air cylinder. No trap should exist in the oil delivery pipe between the sight feed fitting and air cylinder.

Lubrication—Steam Cylinder. The steam cylinder lubricator should not be started until all condensation has escaped from the compressor and the drain cocks closed. After closing the drain cocks start the lubricator to feed in ten or fifteen drops of oil as rapidly as possible, then regulate the feed to about one or two drops per minute for each steam cylinder. No definite amount can be specified, as the amount of lubrication required depends on the work the compressor has to do, the quality of the steam, condition of compressor, and so on. Keep the lubricator feeding while the compressor is running.

DISORDERS—CAUSES AND REMEDIES.

Compressor Refuses to Start. Cause: insufficient oil, from scant or no feed, or working water; worn main-piston rings; or rust having accumulated during time compressor has lain idle. Remedy: Shut off steam, take off cap nut, put in about a tablespoonful of valve oil (not too much), let the oil soak down for one or two minutes, and then turn on the steam quickly. In many cases when the compressor will not start when steam is first turned on, if steam is then turned off and allowed to remain off for one or two minutes, and then turned on quickly, it will start without the use of any oil, except that from the lubricator.

Compressor Groans. Cause: air cylinder needs oil. Remedy; put some valve oil in air cylinder, and saturate piston swab with valve oil, then replace it on the rod. Another cause of groaning may be need of oil in the steam cylinder; the remedy for which is an increase in the feed from the lubricator.

Leakage past the air piston packing rings or past a discharge valve causes heating, destroys lubrication, and results in groaning. Piston rod packing dry and binding is another cause of groaning.

Uneven Strokes of the Compressor. Cause: probably 1 leakage past air piston packing rings and sticky air valves; 2 unequal lift of air valves; 3 clogged discharge valve passages; or, 4 leaky air valves. Remedy: locate cause, if possible, and correct it by cleaning out clogged or dirty passages, adjusting lift of valves or replacing leaky valves or rings.

Slow in Compressing Air. Cause: 1 leakage past the air piston packing rings, due to poor fit, or wear in cylinder or rings; 2 valves and passages dirty; or, 3 air suction strainer clogged. Remedy: 1 and 2. To determine which is causing the trouble, obtain about 90 lbs. air pressure, reduce the speed to from 40 to 60 single strokes per minute, then listen at the "Air Inlet" and note if air is drawn in during only a portion of each stroke, and if any blows back. If the latter, an inlet valve is leaking. If the suction does not continue until each stroke is nearly completed, then there is leakage past the air piston packing rings or back from the main reservoir past the air discharge valves. One of the latter leaking will cause an uneven stroke. Remedy: 3 clean strainer thoroughly.

Compressor Erratic in Action. Cause: Worn condition of valve motion. Remedy: Renew it.

Compressor Heats. Cause: 1 air passages are clogged; 2 leakage past air piston rings; or, 3 the discharge valves have insufficient lift. Remedy: 1 clear air passages; 2 renew air piston rings; 3 regulate lift of discharge valves to $\frac{3}{32}$ of an inch. A compressor in perfect condition will become excessively hot, and is liable to be damaged if run very fast and continuously, for a long time.

Compressor Pounds. Cause: 1 air piston is loose; 2 compressor not well secured to boiler, or causes some adjacent pipe to vibrate; 3 the reversing valve plate, 18, is loose; or, 4 the reversing rod or plate may be so worn that the motion of compressor is not reversed at the proper time. Remedy: repair and renew worn parts and tighten loose connections.

MAINTENANCE.

The air cylinder heating is a feature of air compression which cannot be prevented. As an example of the normal heating, resulting from extreme duty, a 9½-inch compressor in good order which for one hour maintained an average speed of 174 single strokes or exhausts per minute, working constantly against 100 pounds of air pressure, was discharging the air at a temperature of 408 degrees.

Higher speed or greater air pressure would have increased the heating, while slower speed, shorter time of test, or lower air pressure would have decreased it.

Speaking generally, the speed should not exceed 140 exhausts per minute and such a speed should not be continuously maintained for any considerable time, as even this speed will cause excessive heating. This is shown by another test where an average speed of about 60 exhausts per minute, after the main reservoir pressure was pumped up, and a maximum of 77 strokes per minute at the completion of an hour and fifty minutes of the test, gave a discharge temperature of 316 degrees. The foregoing show plainly the great need of good maintenance, of not wasting air either by leakage or poor handling and of giving the compressor as much time to do its work as is practicable.

One of the most serious leaks is through the air cylinder stuffing box as it not only greatly decreases the air delivered and, by the faster speed required, increases the heating, but it also causes pounding through loss of cushion. When tightening the packing, do not bind the rod, as to do so will damage both the packing and the rod. Be careful not to cross the gland nut threads.

With two compressors per engine, the separate throttles should be kept wide open, and the speed regulated by the main compressor throttle. The purpose is to equally divide the work.

If necessary to replace a broken air valve on the road or elsewhere not permitting of proper fitting, at the earliest opportunity have the repairman replace the temporary valve with another so as to insure the correct angle and width of valve and seat contact, the needed ground joint and the requisite lift of $\frac{3}{32}$ of an inch for all valves.

Never remove or replace the upper steam cylinder head with the reversing valve rod in place, as to do so will almost invariably result in bending the rod. A bent rod is very liable to cause a "pump failure."

It is evident that a compressor cannot compress more air than it draws in and not that much if there is any leakage to the atmosphere about the air cylinder. Bearing this in mind, practice frequently listening at the "Air Inlet" when the compressor is working slowly while being controlled by the governor, and wherever a poor suction is noted on either, or both strokes locate and report the fault.

Any unusual click or pound should be reported as it may indicate either a loose piston or a reversing-valve plate cap screw or other serious fault.

Any steam leakage that can reach the Air Inlet of the compressor should be promptly repaired as such increases the danger of water entering the brake pipe.

Keeping the suction strainer clean is of the utmost importance, as even a slightly clogged strainer will greatly reduce the capacity where the speed is at all fast. A seriously or completely obstructed strainer, as by accumulated frost, aggravated by rising steam, will increase the compressor speed and will also be indicated by inability to raise or maintain the desired pressure.

It is an aid to good operation to thoroughly clean the air cylinder and its passages at least three or four times a year, by circulating through them a hot solution of lye or potash. This should always be followed by sufficient clean, hot water to thoroughly rinse out the cylinder and passages, after which a liberal supply of valve oil should be given the cylinder. Suitable tanks and connections for performing this operation can easily be arranged in portable form. Never put kerosene oil in the air cylinder to clean it.

THE MAIN RESERVOIR.

The function of the main reservoir is to receive the compressed air delivered from the pump, and store it for use as needed. The main reservoir also acts as a catch basin for any moisture, or dirt that may be in the air. It is generally located on the engine, although in some instances it is on the tender. The minimum capacity permissible for main reservoirs is 40,000 cubic inches for freight and 20,000 cubic inches for passenger engines, and many of the leading railroads are now equipping their heavy freight engines with reservoirs of 50,000 and 60,000 cubic inches capacity, and are getting good results from the increased volume. Among the many advantages derived from this increased volume of air, are the prompt charging up of an empty train; quick recharging of train pipe, and auxiliary reservoirs after an application of the brakes; increased cooling or radiating surface by means of which the temperature of the compressed air is reduced and the moisture contained therein is better separated. The water thus trapped in the main reservoir settles to the bottom, from whence it should be drained at the end of each trip, because if it should pass into the train pipe it is detrimental in several ways, causing the pipes to rust, destroying the lubrication in the triple valves, and in winter it is liable to freeze in the pipes; the result of which would be a stopped-up train pipe.

Freight engines require a larger main reservoir than do passenger engines, owing to the fact that longer trains are handled, and a greater number of auxiliary reservoirs are to be recharged after each application of the brakes. The question might arise, why not pump the air directly into the train pipe and thus release the brakes without carrying this large volume of air on the engine at all times? In reply it may be said that, pumping brakes off is very unsatisfactory, because the pressure would be raised so slowly in the train pipe on a long train that many of the brakes would fail to release, while at the same time the air pump would be required to supply such a large volume of air in so short a time, that it would be liable to run hot. The pressure ordinarily carried in the main reservoir is 90 lbs., except in cases where special equipments are used, when the amount of pressure is varied to suit the conditions. The form of reservoir found to be most efficient is of the long, slender style, as it gives greater radiating surface, and wherever possible it should be located on the engine, for the reason that when located on the tender two extra lines of hose are required between engine and tender. The amount that the pressure in the main reservoir exceeds that in the train pipe is termed excess pressure, and its purpose is to insure a prompt release of the brakes, and recharging of the auxiliary reservoirs; also to supply the other air-operated devices on the engine and train. Main reservoir pressure begins at the discharge valves of the air pump, and ends at the engineer's brake valve.

EXAMINATION QUESTIONS AND ANSWERS

Development of the Westinghouse Air Brake.

Q. What is a brake?

A. A device or mechanism for retarding oı stopping rotation of the wheels of a vehicle.

Q. What is a power brake?

A. A brake in which the operating power is supplied by mechanical means such as compressed air, vacuum, hydraulic, or spring tension.

Q. What is a continuous brake?

A. A brake that works simultaneously on all the vehicles in a train.

Q. What is an air brake?

A. A brake operated by compressed air.

Q. What was the first or simplest form of air brake?

A. The "straight air" designed and invented by Mr. George Westinghouse, Jr., about 1869.

Q. Was this brake satisfactory?

A. It was not; in many respects.

Q. Give some of the principal reasons for its failure to give perfect satisfaction.

A. (1) If an accident happened to brake pipe or connections permitting the air pressure to escape, it could not be detected until the engineer attempted to apply the brakes, when the air would then escape at the damaged spot, and render the brake inoperative and useless. (2) The brake could only be applied at the engineer's valve on the engine. Third, on a long train of cars brake application was too slow, the time required to get the air to the rear end of the train being so great that the stop was much longer than with a short train; likewise the time required to release the brakes on a long train was too slow, thereby causing delays in train starting. Fourth, as the supply of pressure for all brake cylinders of the train came direct from the engine, the longer the train the more cylinders there were to supply, and consequently the brake cylinder pressures would equalize lower on a long train than on a short train.

Q. What form of brake superseded the straight air brake?

A. The plain automatic brake, designed and invented by Mr. George Westinghouse, Jr., in the year 1873.

Q. Wherein was this brake an improvement over the "straight air" brake?

A. It was an indirect brake, being automatic in its action. Each car carried in an auxiliary reservoir its own storage supply of pressure for its brake cylinder, and the train pipe pressure, operating against a triple valve, held this storage of pressure from passing to the brake cylinder. Second, any accident to, or breakage of the brake pipe and its connections on the train or engine, was shown up at once by the brake applying. The automatic applying feature of this design of brake gave it great value. Third, as a reduction of pressure in the brake pipe would cause the brakes to apply, it was made possible for any of the train crew to apply the brake from any car in the train, equally as well as the engineer in his cab. Fourth, as pressure was stored in the auxiliary reservoir under each car for its individual use, that pressure could be passed into its brake cylinder much more quickly, with the automatic brake, than main reservoir pressure on the engine could be sent back through the entire length of train pipe and into the cylinders of the whole train, by the straight air brake. Fifth, this feature of individual storage of braking pressure on each car made it possible to apply the brakes on a train of the ordinary length then hauled, almost as quickly as on a short train. Sixth, it also permitted as high pressures in the brake cylinders of a long train as on a short train.

Q. What were the objectionable features of the plain automatic brake?

A. While it gave satisfactory service on passenger trains and all freight trains of ordinary length, an emergency application on a long freight train, however, could not be made sufficiently sudden to prevent the slack of the rear portion of the train from running in and causing severe shocks to the cars and their lading on the rear end.

Q. When and by whom was a quicker-acting brake than the plain automatic demanded?

A. In 1887, by the Master Car Builders in their brake trials at Burlington, Ia., on the C., B. & Q. R. R. The fact was then and there developed that on long, 50-car freight trains the plain automatic brake set on the head cars first, and did not set sufficiently rapid to prevent the rear cars from running up against the forward portion of the train with such destructive force as to cause damage to the cars and their contents.

Q. Did this occur in the service application or the emergency application of the brakes?

A. Both, but with greater violence in the emergency application.

Q. What form of brake then superseded the plain automatic brake?

A. The quick action form, which grew out of the

Burlington brake trials. It was much quicker in its operation in emergency application and prevented the slack of the rear cars from running forward and doing damage to the lading and equipment of the train. The quick action brake has ever since been the standard brake in steam railroad service.

Q. The quick action form of brake gave a quicker emergency application; how did it operate in service application?

A. It operated in service application in the same harmonious manner as did the plain automatic brake, and operated independently of the emergency feature.

Q. What are the leading features of the quick-action triple valve?

A. First, the service feature, or part which calls into play only the piston, slide valve and graduating valve, in service application. Second, the emergency feature, or part which calls into play the emergency piston, emergency valve and rubber seated check valve, in addition to the piston and slide valve of the service feature.

Q. Have any other improvements been introduced in air brake practice since the development of the quick-action brake?

A. Yes; although the underlying principles of the brake proper remain; still many supplementary improvements have been added in recent years.

Q. Describe in brief the parts that comprised the straight air brake.

A. The air pump, the reservoir, the three way cock in the engineer's cab, for manipulating the pressure in and out of the brake pipe; the brake pipe, for conveying the air back to the brake cylinders, and the brake cylinder and its attachments under the car.

Q. How were brakes applied?

A. The engineer turned the three-way cock to a position which permitted reservoir pressure on the engine to pass back, through the brake pipe, into the cylinders under the cars. If a light application was desired only a small quantity of pressure was allowed by the engineer to pass from the reservoir to the brake cylinders. If it was desired to apply the brakes harder a larger quantity of air was permitted to pass through the three-way cock to the brake cylinders.

Q. How were the brakes released?

A. The position of the three-way cock handle was reversed by the engineer, cutting off reservoir pressure on the engine, and at the same time making a connection between the brake pipe and the atmosphere, thus permitting brake cylinder pressure to discharge through the brake pipe and three-way cock to the atmosphere. If a partial release was desired only a part of the pressure was allowed to escape at the three-way cock. If a full release was desired, all the pressure was permitted to be discharged from the brake cylinders and brake pipe, through the three-way cock, to the atmosphere.

THE WESTINGHOUSE AIR COMPRESSOR.

Q. What form of air compressor did Goerge Westinghouse, Jr., first use in operating the air brake?

A. An old Worthington duplex water pump was converted and made to pump air.

Q. Describe in brief the construction and operation of the old style "trigger" or straight air pump.

A. This pump succeeded the Worthington. It consisted of a steam cylinder and air cylinder in vertical tandem. Steam entered the steam chest at the side, and surrounded a valve which had a rotary motion imparted to it by "trigger" device in the top head operated conjointly by steam and the usual reversing slide valve rod extending down into the hollow piston rod. The operation of the air end resembled that of the later 6-inch pump.

Q. Briefly describe the action of the Westinghouse 6-inch air pump.

A. The action of the steam end is identical with that of the 8-inch pump. The action in the air end is as follows: On the up stroke, air is drawn in at the lower suction valve. On the same stroke, the atmospheric air in the air cylinder above the piston is compressed and forced out through the upper discharge valve to the main reservoir. On the down stroke, air is drawn into the upper end of the cylinder, through the upper suction valve, and the atmospheric air in the lower end of the cylinder is compressed and forced out through the lower discharge valve to the main reservoir. The steam pipe from the boiler is ½ inch in size; the exhaust pipe is ¾ inch, and the air discharge pipe is ½ inch. The suction pipe is 1¼ inch.

THE 8-INCH AIR PUMP.

Q. What end of the air pump is the power developed in to operate it?

A. The upper or steam cylinder end.

Q. What is the lower or air cylinder end for?

A. It performs the function of an air compressor.

Q. How many operative parts are there in the air end of the pump, and what are they?

A. Five; the air piston and four check valves, two of which are known as receiving valves and two as discharge valves.

Q. What performs the duty of compressing the air?

A. The air piston.

Q. Explain how this is accomplished.

A. As the piston is moving up or down in the cylinder, the air on one side of the piston is being compressed and delivered out to the main reservoir, while air from the atmosphere is flowing into the cylinder on the opposite side of the piston.

Q. Trace the flow of air in and out of the air cylinder.

A. Assume the piston to be on the up stroke. Air above the piston will be compressed, and forced out into a passage under the top discharge valve which would then be lifted off its seat and allow the air to pass out under pressure to the main reservoir, while at the same time air at atmospheric pressure would pass into and fill the lower part of the air cylinder by the unseating of the lower receiving valve. The piston having completed its up stroke, now starts down, at which moment the upper discharge valve, and the lower receiving valve both drop to their seats due to gravity. The air in the cylinder below the piston will now be compressed, and pass out through the lower passage, under the lower discharge valve which will be raised from its seat, thence out through the pipe connection to the main reservoir. At the same time atmospheric air is passing through the upper air inlets, filling the cylinder above the piston.

Q. What is the lift of the air valves in the 8-inch pump?

A. The receiving valves have $\frac{1}{8}$ inch lift and the discharge valves $\frac{3}{32}$ inch.

Q. Why is it necessary to give the receiving valves more lift than the discharge valves?

A. This is due to the construction of the pump. As all valves are on one side, it is necessary to remove the receiving valves through the seats of the discharge valves, which necessitates that they be smaller in diameter, therefore require greater lift.

Q. What is the diameter of the steam and air cylinders of the 8-inch pump?

A. Steam cylinders, 8 inches. Air cylinders, 7½ inches.

Q. What is the stroke of the pistons in the 8-inch pump?

A. Nine inches.

Q. What operates the air piston of the pump?

A. The main piston in the steam end, which is directly connected with the air piston by the main piston rod.

Q. Describe in brief the steam end of the pump.

A. It is practically a small steam engine having a steam cylinder and piston, together with valves arranged to admit and exhaust steam to and from either side of the piston.

Q. How many operative parts are there in the steam end of the pump? Name them.

A. Five; the main steam piston, main valve, reversing valve, reversing rod and reversing piston.

Q. What is the duty of the reversing valve piston?

A. To assist the smaller main valve piston in overcoming the pressure under the larger main valve piston when moving the main valve to the lower position.

Q. What is the duty of the reversing slide valve?

A. To admit and exhaust the steam to and from the top of the reversing piston.

Q. What is the duty of the reversing valve rod?

A. To raise and lower the reversing slide valve.

Q. What is the duty of the main valve pistons?

A. To admit and exhaust the steam to and from the cylinder.

Q. Describe in brief the action of the steam when admitted to steam cylinder.

A. Steam entering the main valve chamber passes from thence through suitable openings into the reversing valve chamber, and, assuming this valve to be in the lower position, steam will pass into a chamber above the reversing piston. As the stem of this piston is resting on top of the main valve, this valve is forced to its lower position, owing to the combined areas of reversing piston and lower piston valve both of which have boiler pressure upon them, which overcomes the pressure under the upper piston valve. With the main valve in its lower position, the upper row of ports in the lower bushing are now open allowing steam to pass into the steam cylinder, under the steam piston forcing it up.

Q. When the piston reaches the end of its upward stroke, how is its motion reversed?

A. As it nears the end of the up stroke, the reversing plate attached to the top of the steam piston engages with the shoulder on the reversing rod and lifts the reversing valve to its upper position where the cavity in the valve connects two ports together allowing the steam above the reversing piston to pass to the atmosphere, while the live steam which is always between the two main valve pistons, now forces the main valve up, for the reason that the upper piston is larger than the lower. This upward movement of the main valve causes it to open the lower row of ports in the upper bushing, thus allowing steam to pass into the top end of the steam cylinder to drive the piston down, while at the same time the steam that is under the piston is escaping to the atmosphere by way of the lower row of ports in the lower bushing, these being now open.

Q. What pressure is always present on the two inner faces of the main valve pistons?

A. Steam pressure from the boiler when the throttle is open.

Q. What pressure is always present on the two outer ends of the main valve pistons?

A. Exhaust or atmospheric pressure.

THE 9½-INCH AIR PUMP.

Q. Wherein does the 9½-inch pump differ from the 8-inch?

A. The 9½-inch pump has a much greater capacity, while the reversing valve gear in the steam end is much more simple. The air valves are differently located also.

Q. What side of the pump are the receiving valves located on?

A. On the left side, or side the air inlet is on.

Q. What side of the pump are the discharge valves located on?

A. On the right side, or side the discharge pipe is on.

Q. What is the difference between a "right hand" pump and a 'right and left hand' pump?

A. The 'right hand' pump has but one steam supply connection which is on the right side of the cylinder, and a single exhaust connection which is on the left side of the cylinder. The "right and left hand" pumps, however, have a steam supply connection and an exhaust connection on each side of the cylinder.

Q. In piping up a pump how can the steam supply connection be distinguished from the exhaust connection?

A. The steam supply connection is the lower one, on either side, and is a smaller pipe connection than the exhaust.

Q. What are the dimensions of the 9½-inch pump?

A. Nine and one-half inch bore, by 10-inch stroke.

Q. Name the operative parts of the steam end of this air pump.

A. Main steam piston; main slide valve; differential pistons and connecting rod; reversing slide valve; and reversing valve rod.

Q. What kind of a valve controls the admission and release of the steam to and from the steam cylinder?

A. A slide valve of the D type.

Q. Where do the three ports in the slide valve seat lead to?

A. One leads to the lower end of the steam cylinder (lower admission port); one leads to the upper end of steam cylinder (upper admission port); and the middle port is the exhaust.

Q. What is the duty of the reversing valve rod?

A. To raise and lower the reversing slide valve.

Q. What is the duty of the reversing slide valve?

A. To admit and exhaust steam to and from the chamber on the right of main valve piston.

Q. What is the duty of the differential pistons and connecting rod?

A. To actuate or move the main slide valve over the ports in its seat.

Q. What is the duty of the main slide valve?

A. To admit and exhaust steam to and from the pump cylinder.

Q. What is the duty of the steam piston?

A. To operate the air piston in the air cylinder.

Q. Explain the passage of the air through the air end of the 9½-inch pump.

A. Assuming the piston to be on the up stroke, the air in the cylinder above the piston will be compressed and forced out through the upper passage under the upper discharge valve, unseating this valve and passing by it into the outer chamber, and thence out through the discharge pipe connection to the main reservoir. At the same time atmospheric air is passing through the air inlet, unseating the lower receiving valve, and passing into the air cylinder filling the space underneath the air piston. The action of the pump on the down stroke is similar to that of the up stroke, with the exception that in this case the lower discharge valve is delivering the air, while the upper receiving valve is admitting air at atmospheric pressure.

Q. How many working parts are there in the air end of the 9½-inch pump?

A. Five; the air piston; and four check valves, of which two are receiving, and two discharging valves.

Q. What is the lift of the air valves in the 9½-inch pump, and are they interchangeable?

A. The lift is $\frac{3}{32}$ inch. They are interchangeable.

Q. When the piston on the downward stroke has reached the bottom, how is its motion reversed?

A. The reversing plate on the piston strikes the knob on the end of the reversing valve rod pulling it down, thus moving the reversing slide valve down until two ports in the seat are connected. One of these ports leads to the chamber back of the larger differential piston, and the other leads to the main exhaust port. Pressure being now removed from behind the larger piston, it is free to be moved to the right by the live steam pressure, and in doing so it carries the smaller piston with it, and also the main slide valve, and thus reverses the pump.

Q. What is the function of the small port leading to the chamber above the reversing valve rod in the cap nut?

A. This is to prevent pressure from accumulating above the reversing rod which would prevent it from reversing properly. It is connected at all times with the upper end of the steam cylinder, therefore, contains no pressure when the piston is on the up-stroke.

Q. Of what use are the small cocks?

A. They are drain cocks and should be open at all times when the pump is not running to prevent condensation from accumulating in the steam cylinder and passages.

Q. How should the air pump be started?

A. Slowly, to allow the condensation to escape from the steam cylinder and to accumulate sufficient pressure in the air cylinder to form a cushion for the piston.

Q. How much air pressure is required to do this?

A. About twenty-five or thirty pounds should be sufficient.

Q. What else should be done at the same time that the steam throttle to the pump is opened?

A. The lubricator should be started feeding freely at first, until the pump has received eight or ten drops of oil; the feed should then be reduced to what may be considered proper.

Q. When should the air cylinder be oiled, and what kind of oil should be used?

A. The air cylinder should be lubricated with a small amount of oil at frequent intervals. Valve oil should be used, as it has a good body and will stand the temperature of the air cylinder.

Q. Should oil ever be introduced through the air inlets?

A. No; such oiling has a tendency to gum up the air valves and passages and does the cylinder very little if any good.

Q. How tight should the pump be packed?

A. Just tight enough to prevent blowing.

Q. How should the pump be run in descending grades?

A. With the pump throttle well open.

Q. How should it be run at other times?

A. Fast enough to maintain the full pressure and allow the pump governor to stop it once in a while, but it should not be run with a wide open throttle unless necessary to keep up the full pressure.

Q. Should coal oil, or what is termed carbon oil or kerosene, ever be used to clean out or oil a pump?

A. No; it is dangerous to use it if the pump is warm, and it does not clean it as thoroughly as other more suitable materials.

Q. What should be considered as the maximum speed to run the pump?

A. Not to exceed 120 single strokes per minute.

Q. Why is a higher speed detrimental?

A. It may not allow the cylinder to be filled with air at each stroke, and would eventually cause the pump to run hot.

Q. What benefit is a well oiled swab on the pump piston rod?

A. It keeps the piston rod packing lubricated, greatly prolonging the life of same, as well as assisting in lubricating the cylinders.

Q. From what point of the boiler should the pump receive its steam?

A. From some high point, where dry steam can be had.

THE 11-INCH AIR PUMP.

Q. In what respect does the 11-inch pump differ from the 9½-inch pump?

A. Principally in size, although a number of decided mechanical improvements have been made in the construction.

Q. In what respect does the operation of the 11-inch pump differ from the 9½-inch pump?

A. There is no difference whatever, the same simple valve gear is used in the 11-inch pump that has been described in the 9½-inch pump.

Q. What is the lift of the air valves in the 11-inch pump?

A. Three thirty-seconds of an inch, or the same as the 9½-inch pump.

Q. Are the air valves of the 11-inch pump interchangeable with the 9½-inch pump valves?

A. No; while the valves in each pump have the same lift, they are not interchangeable, as the 11-inch pump valves are larger in diameter.

Q. What is the comparative efficiency of the 11-inch pump and 9½-inch pump?

A. Operating under similar conditions the 11-inch pump is about 30 per cent. more efficient than the 9½-inch pump.

Q. What is the size of the steam and air cylinders of the 11-inch pump?

A. The steam and air cylinders are both 11 inches in diameter.

Q. What is the stroke of the pistons in the 11-inch pump?

A. Twelve inches.

Q. What points should be observed in reference to the operation and care of the 11-inch pump?

A. The same general rules as apply to the 9½-inch pump should be followed in reference to the 11-inch pump.

THE TANDEM COMPOUND AIR PUMP.

Q. What is the leading feature of the Westinghouse tandem compound air pump?

A. Two stages of air compression between the time of admission, and time of discharge to main reservoir.

Q. Is the steam compounded also?

A. It is not; the single steam cylinder is similar to that of the 9½ and 11-inch pumps.

Q. Compared with the 9½ and 11-inch pump, what is the leading feature of the Westinghouse tandem compound air pump?

A. While it has a steam cylinder of only 8 inches in diameter, it has an air compressing capacity equivalent to the 11-inch pump.

Q. What other peculiarity is there about this air pump?

A. While its steam cylinder is internally the same as that of the standard 8-inch pump, it has the valve gear mechanism and pipe connections of the special 9½-inch pump.

Q. Describe the arrangement of cylinders of the tandem compound pump.

A. There are three cylinders placed vertically in tandem, the top one or steam cylinder being joined to the two lower, or air cylinders by a center piece, while the air cylinders are united by a thin center piece or partition through which works the drum that unites the two air pistons.

Q. Describe the action of the pump in compressing air.

A. Assuming the pistons to be on the down stroke, air passes in through the upper air inlet on the left hand side, lifts the upper receiving valve, and passes into the upper cylinder filling the space above the descending piston. When the piston has completed the down stroke and moves up this air is compressed, and lifting the upper discharge valve (upper right hand side of cylinder), is forced out past the upper discharge valve, which is also now a receiving valve for the higher pressure compartment, which is the annular cavity between the piston drum and the cylinder. Since the volume of this compartment is much smaller than the low pressure volume of the cylinder from which it was received, this air is being compressed during its passage from the low pressure to the high pressure volumes, until when the piston reaches the upper end of its stroke the air in the low pressure clearances, passages and high pressure volume has reached the intermediate pressure of approximately 40 pounds.

Q. Describe the further action of the pump.

A. During the second down stroke of the piston this intermediate pressure air is further compressed until it lifts the final discharge valve, and passes out through the air discharge orifice in the center piece, and thence to the main reservoir.

Q. When air is taken at the lower end of the cylinder what takes place?

A. The same operation occurs in the lower cylinder when the piston goes in the opposite direction from that described above, and as corresponding passages are designated by the same letter the operation can be readily followed.

Q. How is the air cylinder lubricated?

A. The air cylinder is lubricated by three oil cups. The upper end receives its oil from that cup placed just to the left on the upper center piece. The piston drum receives its lubrication by the oil from the cup connecting with a passage in the upper air cylinder and is drawn into the high pressure volume of the air as it goes from the low pressure to the high. The lower end of the air piston is lubricated by the oil cup situated on the left side of the lower center piece.

Q. Why is the compound pump equal to the 11-inch air pump in air compression capacity when provided with an 8-inch steam cylinder?

A. This results from the compound feature of the air cylinders. As already explained, when the pistons are moving upward, air is being forced from the cylinder above the piston to the annular cavity between the drum portion of the piston and the cylinder, the air gradually increasing in pressure as the piston advances, reaching a pressure of about 40 pounds at the termination of the stroke. This pressure under the piston and above the center piece exerts an upward force on the piston the same as does the steam under the steam piston, while at the same time the air under compression to the main reservoir is exerting only a resistance equal to the area of that portion of the upper side of the air piston exposed to the air being compressed in the annular opening between the piston trunk or spool and the cylinder.

Q. Does this result in economy?

A. Yes; by compounding the air end a much smaller steam cylinder can be used to operate the pump, thus causing a marked economy in steam consumption.

AIR PUMP GOVERNOR.

Q. What is the function of the pump governor?

A. To regulate the supply of steam to the pump in such a manner that the speed of the pump will maintain the desired pressure.

Q. Describe the connections of the single top governor.

A. There are three; one to the boiler; one to the pump, and one to the main reservoir.

Q. Does the main reservoir connection always lead to the main reservoir?

A. No; with the D-8 brake valve this connection leads to the train pipe.

Q. Name the valves in the single top governor.

A. There are two; the steam or throttle valve, and the air valve, or pin valve.

Q. Name the other important parts of the governor.

A. The piston, which actuates the steam valve, the adjusting spring and the compressing spring, also the diaphragm.

Q. Describe the action of this governor.

A. With the governor open, which is its normal position, air pressure enters the governor at the main reservoir connection, and passes into a chamber below the diaphragm, this pressure increasing until it exceeds the tension of the adjusting spring above the diaphragm, when the latter will yield and cause the pin valve to be raised from its seat. The air is now free to pass into the chamber above the governor piston which it forces down compressing the spring and seating the steam valve.

Q. When the pressure beneath the diaphragm is reduced below that for which the governor is adjusted, what will take place?

A. The tension of the adjusting spring will cause the diaphragm to move down, and seat the pin valve.

Q. With the pin valve seated, what will cause the steam valve to again open and supply steam to the pump?

A. The chamber above the governor piston is always open to the atmosphere through a small relief port, through which the air pressure above the piston may be relieved, thus allowing the spring, with the assistance of the steam pressure under the vale to raise the piston and valve to their normal positions which will again start the pump to work.

Q. What is the function of the Westinghouse duplex pump governor?

A. To permit of controlling the pump with two different air volumes, or a ready change in the pump control, from one pressure to another, without the necessity of re-adjusting the governor.

Q. In what respect does this governor differ from the single-top governor?

A. The only difference is in the upper or air end; two diaphragm portions are used, and a siamese fitting, by which they are connected to one steam portion of the governor.

Q. Is the principle of operation of this device the same as the single-top pump governor?

A. Yes; the description of the operation of the single-top governor covers this device.

Q. Do both of the diaphragm portions operate it at the same time?

A. No; as the adjustments of the heads differ, it requires different pressures to operate them; therefore, only one head operates at one time.

Q. Does it make any difference what head is set for the high or low pressure?

A. No; not as far as the governor is concerned. This is governed entirely by the way the heads are connected up.

Q. By referring to the vent ports in the siamese connection, it will be seen that one is to be plugged. What is this for?

A. To prevent a needless waste of air. As the siamese fitting directly connects both diaphragm portions together, one vent port is sufficient, as only one head is operating at one time.

Q. What equipments is the duplex pump governor used with?

A. The High Speed Brake, "Schedule U," or High Pressure Control, and the Duplex Main Reservoir Control.

Q. During the time the pin valve is unseated there is a continuous blow from the relief port. What is this for?

A. This leakage, in conjunction with the flow of steam through the small port in the steam valve serves to keep the pump working slowly, to avoid the accumulation of condensation.

Q. What is the purpose of the connection from below the governor piston to the atmosphere?

A. This is the drip pipe connection to the chamber immediately below the piston, for the purpose of permitting any steam that may leak past the steam valve, or any air that may leak past the piston, to escape to the atmosphere.

AUTOMATIC LUBRICATION.

Q. What is the object of the automatic air cylinder oil cup?

A. To automatically lubricate the air cylinder of the air pump, instead of by hand.

Q. In what manner does the automatic cup better perform the lubrication of the pump than a hand oiler?

A. With the hand oiler, a considerable quantity of oil is given the pump at one time to last the entire trip, while the automatic oil cup is subject to alternate suction and compression strokes of the air piston, and just the required amount of oil is regularly and continuously fed to the air cylinder.

Q. Describe the construction and operation of the No. 1 automatic oil cup.

A. It consists of a brass body having an internal chamber in which the oil is placed. A small regulating valve stem passes down through this chamber. This valve stem can be adjusted from the top by simply pulling off the cap which fits into the top of the body. A small lock nut on this valve stem, guards against the feed adjustment changing. When the valve is slightly raised oil passes drop by drop into the small chamber below. This chamber connects through a passage to the cap, and by means of small holes in this cap to the atmosphere, thus bringing said chamber always under atmospheric pressure.

Q. What is the function of the ball valve in the lower part of the cup?

A. When the air piston descends, the suction causes this valve to rise, and the air will pass through the holes in the cap and by way of the passage into the body, and as this air passes on into the pump cylinders, any oil that may have dropped from the regulating valve onto the top of the nut holding the ball valve in position, is drawn into the pump cylinder, thus lubricating it. As soon as the piston starts on the return, or up stroke, the ball valve promptly seats itself, thus preventing any air from being discharged to the atmosphere through the oil cup.

Q. What is the purpose of the four holes drilled up through the cup?

A. These holes connect with a circular groove in the base, and are thus connected with each other. This groove also connects with the passage leading from the pump cylinder to the top of the ball valve, and during the up stroke of the air piston, compressed air is forced into the grooved canal in the base, and thence to the vertical drilled holes or passages in the body, and as the temperature of compressed air is always sufficiently high to heat the oil cup the oil is thus kept liquid even in cold weather.

Q. Describe the construction and operation of the No. 2 automatic oil cup.

A. This cup is composed of a steel base screwing into the air cylinder of the air pump, to which is connected a brass oil reservoir. A brass cap fits the top snugly. Oil is contained in the inner chamber. The operative parts are a valve, valve spring and needle feed stem. On the down stroke of the air piston the valve is drawn from its seat by suction, compressing the spring, a slight amount of air is drawn in to the cup, and oil is drawn past the needle and down into the air cylinder. The temperature of the oil in the cup is kept warm by the same means as in No. 1, that is, the admission of warm air to passages cast in the body.

Q. What is the principal difference between this cup and No. 1 cup?

A. No. 1 has an adjustable feed, while No. 2 has a fixed feed.

PUMP GOVERNOR DISORDERS.

Q. If trouble is experienced in the regulation of main reservoir pressure how may the engineer ascertain whether or not the defect is in the steam, or air portion of the governor?

A. By examining the vent port of the governor. If it is found to be open and air flowing freely from it, it indicates that the air end of the governor is all right and that the trouble must be in the steam end. Something is preventing the piston from seating the steam valve.

Q. If this trouble is experienced on a day when the weather is very cold, where would we usually find the trouble?

A. The drain or waste pipe is probably frozen up.

Q. Is that the only defect that could cause such a trouble?

A. No; a blind gasket in this pipe, or the pipe clogged with dirt or gum or otherwise closed, would cause it. This allows the steam that may leak by the stem of the steam valve to accumulate under the piston, holding it up against the air pressure above it.

Q. Sometimes a governor that has been working propperly will develop a continual blow from the vent port. What would be defective in this case?

A. The diaphragm valve would be unseated in this case, probably due to dirt or foreign matter on its seat.

Q. Should the vent port be plugged to prevent the loss of air?

A. No; to do so would probably cause the governor to stop the pump. As the diaphragm valve would continue to leak, and as there would be no outlet for the air, it would accumulate above the piston until there was sufficient to drive it down, which would stop the pump.

Q. If the governor stops the pump properly, but fails to start it again when the pressure is slightly reduced, what may cause the trouble?

A. The diaphragm valve being rigid, instead of having the proper amount of side play, a partly or entirely stopped-up vent port, or the piston packing ring being a very tight fit and stuck in the lower end of the cylinder.

Q. How does the rigid diaphragm valve cause such trouble?

A. By not seating properly it allows air pressure to feed down on top of the piston holding it down.

Q. How should the packing ring fit the cylinder?

A. It should be a neat working fit and as near air tight as possible, as leakage by this ring would be a waste of air, and would have a similar effect as an enlarged vent port.

Q. Some governors are observed to have a heavy flow of steam from the waste pipe at all times. What would cause this?

A. The piston stem being a very loose fit, and the upper side of the steam valve not making a very good joint.

Q. What is the standard main reservoir pressure on grades less than one and one-half per cent? On grades of one and one-half per cent and over?

A. Ninety pounds and 110 pounds.

Q. Where duplex governors are used, what should be the difference in adjustment of the two heads as regards pressure?

A. Twenty pounds.

Q. What is the allowable variation of the governor in controlling pump?

A. Theoretically there should be no variation.

GAUGES.

Q. What is the purpose of the different air gauges used on the engine?

A. To properly indicate the air pressures in the different parts of the brake system.

Q. What pressure does the red hand on the duplex gauge indicate? What pressure does the black hand indicate?

A. Red hand—main reservoir; black hand—chamber "D" pressure.

Q. Where duplex gauge is used on brake cylinder, as with No. 6 E T equipment, what does red hand indicate? What does black hand indicate?

A. Gauge No. 1. Red hand, main reservoir pressure; black hand, equalizing reservoir pressure.

Q. What pressures are indicated by Gauge No. 2?

A. Red hand, brake cylinder pressure; black hand, brake pipe pressure.

Q. Which gauge hand shows the amount of reduction being made during a service application of the brakes?

A. Black hand, Gauge No. 1.

Q. Why, then, is the black hand of Gauge No. 2 necessary?

A. To show brake pipe pressure when engine is second in double-heading or a helper.

Q. What pressure is indicated by the red hand of Gauge No. 2 when operating the automatic or independent brake valve?

A. Brake cylinder pressure.

Q. How can you test principal air gauge to prove probable correctness?

A. By means of a test gauge attached to train pipe-hose on tender. Place brake valve in full release for the red hand, and in running position for the black hand.

THE WESTINGHOUSE 8½-INCH CROSS-COMPOUND AIR COMPRESSOR.

Q. What are the principal advantages of this compressor as compared with all other types of locomotive air compressors?

A. Economy in steam consumption and great air compressing capacity.

Q. Explain in a general way the design of the 8½-inch cross-compound compressor as compared to the 9½-inch and 11-inch Westinghouse compressors.

A. It has two steam and two air cylinders placed side by side, the steam cylinders vertically above the air cylinders and joined by a suitable center piece.

Q. How are the steam cylinders designated?

A. High and low pressure steam cylinders.

Q. How are the air cylinders designated?

A. High and low pressure air cylinders.

Q. What are the dimensions of the steam cylinders?

A. The high pressure steam cylinder is 8½x12 inches, the low pressure steam cylinder, 14½x12 inches.

Q. What are the dimensions of the air cylinders?

A. The low pressure cylinder is 14½x12 inches; the high pressure air cylinder, 9x12 inches.

Q. Why do the high pressure cylinders vary in diameter, while the low pressure cylinders are of the same size?

A. In view of the boiler pressure being greater than the maximum air pressure desired, it does not require a high pressure steam cylinder as large in diameter as the high pressure air cylinder. This permits of greater economy in steam consumption and more uniformly balances the steam and air forces acting on the various pistons.

Q. How are the cylinders relatively located?

A. The low pressure air cylinder is under the high pressure steam cylinder; the high pressure air cylinder is under the low pressure steam cylinder.

Q. How are the high pressure steam piston and low pressure air piston joined?

A. By a hollow piston rod, the same as those in 9½ and 11-inch compressors.

Q. How are the low pressure steam piston and the high pressure air piston joined?

A. By a solid piston rod.

Q. Have the low pressure steam piston and the high pressure air piston and rod any mechanical connection to the valve gear?

A. No; they are simply floating pistons.

Q. How many inlet valves has the low pressure air cylinder?

A. Four.

Q. Where are they located?

A. Two each in the top and bottom heads of the cylinder.

Q. How many intermediate valves?

A. Four.

Q. What is the purpose of the intermediate valves?

A. They perform the same duties between the low and high pressure air cylinders as the discharge valves do between the high pressure air cylinder and the main reservoir.

Q. Where are they located?

A. Two each in the top and bottom heads of the low pressure air cylinder.

Q. How many discharge valves has the high pressure air cylinder?

A. Two.

Q. Where are they located?

A. Outside of and near the top and bottom of the high pressure air cylinder.

Q. Where is the steam valve gear located?

A. In the top head of the high pressure steam cylinder.

Q. Does a single valve mechanism serve to operate the entire compressor?

A. Yes.

Q. What are the operative parts of the valve gear?

A. A piston valve, reversing valve and reversing valve rod.

Q. How many pistons has the piston valve?

A. Five.

Q. What are the purposes of the five pistons?

A. The two outer or differential pistons perform the same duties, and in the same way, as the main valve pistons of the 9½-inch compressor. The three intermediate pistons, all of equal diameter, govern the flow of steam through the admission and exhaust ports of the steam cylinders, thus corresponding to the main (slide) valve of the 9½-inch compressor.

Q. How many steam ports are there in the piston valve seat?

A. Five.

Q. To what do they connect?

A. Beginning at the right-hand port, the ports connect to the steam cylinders as follows: the top of high pressure cylinder; top of low pressure cylinder; exhaust; bottom of low pressure cylinder, and bottom of high pressure cylinder respectively.

Q. Name the operating parts of the compressor.

A. The reversing valve and the reversing valve rod; the piston valve, which performs the same duties as the differential pistons and slide valve of the 9½-inch compressor; the inlet valves, the intermediate valves, in the pasages connecting the high and low pressure air cylinders; the discharge valves; the high pressure steam piston and its rod; the low pressure steam piston and its rod; the low pressure air piston, and the high pressure air piston.

Q. How does the piston valve perform the same duties as the differential pistons and main (slide) valve of the 9½-inch compressor?

A. The five pistons are so arranged that the two outer (differential pistons) when moved actuate or move with them the three intermediate ones over the ports in their seat, permitting the passage of steam to and from the cylinder ports in a similar way to that accomplished with the slide valve.

Q. Where is the steam pipe connection to the compressor?

A. At the steam inlet, at the right of the high pressure steam cylinder.

Operation, Steam Portion.

Q. Where does steam enter the compressor?

A. Through the passage leading to the top head to main valve chambers; also through the port into the chamber containing reversing valve.

Q. What is the duty of the reversing valve?

A. To admit and exhaust steam from the chamber, at the right of the piston valve.

Q. When the high pressure steam piston is at the bottom of its stroke, what position will the reversing valve be in?

A. Down.

Q. In what position is the low pressure steam piston at this time?

A. Up.

Q. Do the high and low pressure pistons always move in opposite directions and at the same time?

A. Yes.

Q. With the reversing valve down, what takes place?

A. The chamber at the right of the piston valve is open to the exhaust through a port, and cavity in reversing valve, and exhaust port. The larger piston of the piston valve having a greater area exposed to the pressure in the chamber than the smaller piston at the opposite end of the piston valve, moves the piston valve to the right.

Q. With the piston valve in the position just described, what takes place in the steam cylinders?

A. With steam pressure from the boiler always present in the main valve chambers, steam is admitted to the bottom end of the high pressure steam cylinder, from the chamber on the left, carrying its piston upward; at the same moment the steam in the top end of the high pressure cylinder is expanding into the top end of the low pressure cylinder, forcing its piston downward. During the down stroke of this piston, the bottom end of the low pressure cylinder is open to the exhaust.

Q. Upon completion of the piston stroke just described, what takes place?

A. As the high pressure piston approaches the upper end of its stroke, the reversing plate strikes the shoulder on the reversing valve rod, forcing it and reversing valve upward. This movement closes the port to the exhaust and uncovers another port, allowing steam to flow to the chamber at the right of the larger piston valve. Since live steam is always in the top chambers, and exerts its pressure against the inner surfaces of the largest and smallest of the piston valve pistons, and since now the larger piston has full steam pressure on its outer face, the resulting pressure on it will be balanced, while the small piston has steam on its inner face, and the chamber on its outer face is open to the exhaust, there is an unbalanced pressure on the right of the small piston so that it will be forced to the left.

Q. What follows the movement of the piston valve to the position just described?

A. Steam is admitted to the top end of the high pressure cylinder from the chamber on the right, driving its piston downward. At the same time, the steam under the high pressure piston expands into the bottom end of the low pressure cylinder, carrying its piston upward. The top end of the low pressure cylinder is now open to the exhaust

Operation, Air Compressor Portion.

Q. How is the air taken into the bottom end of the low pressure air cylinder?

A. When the high pressure steam piston is moved upward, the low pressure air piston, being connected to the same piston rod, is also carried upward, and air is drawn in through the lower strainer into the lower passage; the lower inlet valves lift and the air passes into the cylinder through inlet ports.

Q. While this is going on, what is taking place in the top end of the low pressure air cylinder?

A. Air above the piston is being compressed during its upward movement and forced past the upper intermediate valves, through a passage into the top end of the high pressure air cylinder, the piston of which is meanwhile traveling downward.

Q. What takes place in the bottom end of the low pressure cylinder when the piston reaches the upper end of its stroke?

A. When the piston starts downward, the inlet valves are forced to their seats, and the air below the piston is compressed until it can raise the lower intermediate valves against the air pressure in the high pressure cylinder acting on their upper side, when it is forced through ports to the lower end of the high pressure air cylinder, the piston, in the meantime, being drawn upward by steam pressure under the low pressure steam piston.

Q. What takes place in the top end of the low pressure air cylinder at this time?

A. The upper intermediate valves drop to their seats and prevent back flow of air from the top end of the high pressure air cylinder, and air is drawn through the upper air strainer into a passage past the upper inlet valves—and through a port into the top end of the low pressure air cylinder. At the same time the high pressure air piston is moving upward (compressing the air admitted from the top end of the low pressure air cylinder to the top part of the high pressure air cylinder), until its pressure in the passage is sufficient to lift the upper discharge valve against the main reservoir pressure holding it to its seat, and air then flows through passages to the air discharge and the main reservoir.

Q. What takes place when the low pressure air piston reaches the lower limit of its stroke and starts upward?

A. The lower intermediate valves drop to their seats so that air from the high pressure air cylinder cannot flow back into the low pressure air cylinder; at the same time the high pressure piston is forced downward by the low pressure steam piston, compressing the air (that has been forced into the high pressure air cylinder from the low pressure side), lifting the discharge valve, when it will be forced through port and passage to the air discharge and main reservoir.

Q. It has been stated that the high pressure piston is forced downward by the low pressure steam piston. Is there any additional force exerted on the piston at this time?

A. Yes. During the time the high pressure air piston is moving down the low pressure air piston is moving up and compressing the air into the upper end of the high pressure air cylinder. The gradual increase of air pressure on top of the piston exerts a downward force on the piston the same as does the steam above the low pressure steam piston. When the compressor mechanism is reversed, the action is simply a repetition of that just described.

Q. What pressures are exerted on the pistons as they reach the lower end of the stroke?

A. Steam piston has from 25 to 40 pounds of steam pressure per square inch (dependent upon boiler pressure) and air piston about 40 pounds of air pressure.

Q. What is the intermediate air pressure on the under side of the high pressure air piston as it starts on its downward stroke?

A. About 40 pounds.

Q. What is the pressure on the piston when it starts on its upward stroke?

A. The same; about 40 pounds.

Q. In how many stages is the air compressed?

A. Two.

Q. What is meant by "two stages"?

A. The final pressure at which the air leaves the compressor is obtained by two separate compressions. The first "stage" is when air, at atmospheric pressure, in the low pressure air cylinder is compressed and delivered to the high pressure air cylinder at the "intermediate" pressure. The second stage is when the air at the intermediate pressure in the high pressure air cylinder is compressed, and delivered to the main reservoir at the final or high pressure.

Q. What type of air valves are used in the 8½-inch cross-compound compressor?

A. Inlet valves and discharge valves are of the 11-inch compressor standard. Intermediate valves are of the 9½-inch compressor standard.

Q. What is the lift of all air valves?

A. $\frac{3}{32}$ inch.

Q. How can the air inlet valves be removed?

A. Top valve is accessible by removing cap nuts, and bottom one by removing the valve cages.

Q. How are the upper intermediate valves removed?

A. By taking out the cap nuts.

Q. How are the lower intermediate valves removed?

A. By unscrewing valve cages.

Q. How are the discharge valves removed?

A. By removing cap nut and by taking out valve cage.

Q. What provision is made for lubricating the piston rods of the compressor?

A. Swabs, which should be kept well lubricated with oil.

Q. How many oil cups has the compressor, and where are they located?

A. Two; located on the high pressure steam cylinder head.

Q. What do they lubricate?

A. One the high pressure air cylinder; the other the low pressure air cylinder.

Q. How many drain cocks has the compressor, and where are they located?

A. Four; located in the steam cylinders.

Q. What is their purpose?

A. The ¼-inch cock drains the steam inlet chamber; the other cocks drain the top and bottom ends of the low pressure steam cylinder and the bottom end of the high pressure steam cylinder.

Q. When should these drain cocks be open?

A. At all times when the compressor is not running, to prevent condensation from accumulating in the cylinders and passages, and when starting it.

Q. In general, how should this compressor be operated?

A. The same as the older standard Westinghouse compressors.

Q. What decided advantages has the cross-compound as compared to other types of locomotive air compressors?

A. (a) Economy in steam consumption.

(b) Great air compressing capacity at comparatively low speed.

(c) The compressor is less susceptible to pounding and strains incident thereto.

(d) Less packing ring leakage in both the steam and air cylinders.

Q. What contributes largely to the steam economy?

A. Compounding the steam, and less low packing ring leakage.

Q. What contributes largely to air capacity?

A. A low maximum pressure in the low pressure air cylinder; less differential pressure on opposite sides of the pistons, as compared to older types of air compressors, and full stroke of high pressure steam and low pressure air pistons, and valve gear, regardless of high or low main reservoir pressure.

Q. Why is the packing ring leakage less in the low pressure air cylinder?

A. Because, as already explained, the pressure in this cylinder never exceeds 40 pounds.

Q. Why is the packing ring leakage less in the high pressure air cylinder?

A. As the air is compressed to main reservoir pressure on one side of the piston, it is being built up to about 40 pounds on the other side (a result of compressing the air from the low pressure to the high pressure air cylinder), hence the differential is 40 pounds less than would be the case with simple compressors having one side of the piston exposed to main reservoir pressure and the other to atmospheric pressure.

Q. Why is the packing ring leakage less in the high pressure steam cylinder?

A. While steam is exerting its force on one side of the high pressure piston, the other side is subjected to such back pressure as obtains from expansion into the low pressure steam cylinder.

Q. Why is the packing ring leakage less in the low pressure steam cylinder?

A. Because while the exhaust side of the piston is open to the atmosphere, the steam pressure on the opposite side of the piston is, as the name of the cylinder implies, comparatively low.

Q. Why cannot the results as stated in the four preceding questions be accomplished with simple compressors?

A. Because with such type of compressors there is a high differential pressure on opposite sides of the pistons. In the steam cylinder the piston has high steam pressure on one side and is open to the atmosphere on the other, while one side of the air piston is working against main reservoir pressure and the other is exposed to atmospheric pressure.

Q. In what way does full stroke of the low pressure air piston increase the capacity of the compressor?

A. As the maximum air pressure in this cylinder never exceeds 40 pounds, the air occupying the clearance space when the piston starts on its return stroke, quickly expands down to atmospheric pressure, permitting the taking in of free air more promptly and with much less piston movement than is possible when main reservoir pressure in the cylinder must expand to that of the atmosphere.

Q. In what way does this low pressure affect the operation of the valve gear?

A. Against this low pressure the high pressure steam and low pressure air pistons always make their intended and full traverse, thus insuring full movement of the valve gear regardless of the high main reservoir pressure.

Q. Is the stroke of the low pressure steam, and high pressure air pistons affected by high and low main reservoir pressure?

A. Yes, to some extent, though such is of little importance, as it can in no wise interfere with the valve gear or govern the quantity of free air taken into the compressor.

Q. What is the comparative air compressing capacity of the 8½-inch cross-compound and 9½-inch compressors?

A. Under the same operative conditions the cross-compound has a little more than three times the capacity of the 9½-inch compressor.

Q. What is the steam consumption of the 8½-inch cross-compound compressor when supplying the same volume of air as the 9½-inch compressor when working at its maximum capacity?

A. The 8½-inch cross-compound uses about one-third the amount of steam required by the 9½-inch compressor.

Q. How should the air compressor be started?

A. Slowly to allow the condensation to escape from the steam cylinders.

Q. What else should be done at the same time that the steam throttle to the compressor is opened?

A. The lubricator should be started feeding freely at first, until the cylinders have received eight or ten drops of oil; the feed should then be reduced to an amount sufficient to properly lubricate the compressor.

Q. What kind of oil should be used?

A. A good quality of valve oil.

Q. When should the air cylinders be lubricated and what kind of oil should be used?

A. The air cylinders should be lubricated with a small amount of valve oil at occasional intervals.

Q. Why should valve oil be used?

A. Because it has a good body and will stand the temperature of the air cylinders.

Q. Describe the construction and operation of the oil cup.

A. The cup has an air-tight fitting cover and plug cock or key, which is operated by the handle, the key having a recess or cavity in one side. When the handle is in a vertical position, the cavity fills with oil. When the handle is horizontal, the oil flows from the cavity into the oil pipe and finds its way to the air cylinder.

Q. Should oil ever be introduced through the air inlets or strainers?

A. No; such oiling has a tendency to gum up the air valves, passages or strainers, which, in time, may restrict the flow of air sufficiently to reduce the capacity of the compressor.

Q. How tight should the piston rods be packed?

A. Just tight enough to prevent leakage.

Q. What benefit is derived from well-oiled swabs on the piston rods?

A. They keep the piston rods lubricated and assist in oiling the cylinders.

Compressor Disorders and Remedies.

Q. What is the cause if, when starting the compressor, it short strokes or "dances"?

A. Low pressure on the reversing valve allowing it to drop of its own weight; too much lubrication or a bent reversing valve rod.

Q. What could be the trouble if the compressor begins to pound badly after running rapidly for some time?

A. The compressor may be lacking in lubrication. It may also have worked the bolts loose that fasten it to its bracket. If the bracket is weak or loose on the boiler, it would cause the same trouble.

Q. Are there any other causes for the compressor pounding?

A. Yes; too much lift of the air valves; tight packing rings in the piston valve, or loose nuts on the piston rods in the air cylinders.

Q. If the compressor stops in service, from an unknown cause, what might be the trouble?

A. Loose nuts on the piston rod in the low pressure air cylinder; a bent or broken reversing valve rod; the rod disengaged from the reversing valve plate; a loose reversing valve plate; bad packing rings on the main valve, or a dry compressor.

Q. What method should first be tried to start the compressor?

A. Close the compressor throttle for a short time, then open it quickly.

Q. If this fails to start the compressor, what other method might be tried?

A. Tap the steam cylinder head lightly.

Q. What should first be examined if the compressor fails to start?

A. The nuts on the piston rod of the low pressure air cylinder, which can be done by removing the plug in the center of the lower cylinder head. If the trouble is not located, next examine the reversing valve rod, by removing the reversing valve cap.

Q. In the case of loose nuts on the piston rods in the low, or high pressure air cylinders, how should the trouble be remedied?

A. In all cases where possible the compressor should be removed from the locomotive and proper repairs made in the air brake room. Very poor results are liable to be obtained when this work is done without removing the compressor from the locomotive. Using a hammer and chisel to tighten up these nuts is very bad practice, as it does not draw them tight, and often fractures the end of the rod.

Q. What will cause a blow in the cross-compound compressor?

A. Loose rings on the low pressure piston, or on either of the pistons of the piston valve; reversing valve not having a good bearing on its seat; reversing valve rod not fitting snugly in the reversing valve bushing; reversing valve, or piston valve bushing not fitting neatly; or top head gasket leaking between the ports.

Q. If, in handling a long train, the compressor gets hot, what should cause the trouble?

A. Unusually high main reservoir pressure; bad packing rings on the air pistons, the packing in the stuffing boxes being too tight; too little lift of, or stuck air valves; the ports and passages being badly gummed or clogged up, or clogged up air strainers. Any or all of these troubles would produce the effect mentioned. If the compressor and its air pipes are in good condition, it should not run hotter than that caused by the natural heat of compression.

Q. Should the compressor run hot, what should be done?

A. First reduce its speed, then put a small quantity of good oil in the air cylinders, and continue to run the compressor slowly until it cools down.

Q. How can bad packing rings on the low pressure air piston be determined?

A. By noticing the suction at the air inlets. The suction should be good nearly the entire stroke if the packing rings are in proper condition.

Q. If the low pressure air piston packing rings are found in good condition, what should next be done?

A. Ascertain if the air valves have the proper lift ($\frac{3}{32}$ inch).

Q. In fitting new air valves, what rules should be followed?

A. The valve should have a good bearing on the seat, but not too wide. In removing the top of the valve to give the required lift, it should be filed squarely, that it may have a full bearing where it strikes the stop.

Q. What will result from bad packing rings in the high pressure air cylinder?

A. If the leakage is serious, it will have a tendency to slightly slow up the speed of the compressor.

Q. If the packing rings are found to be defective, how should new rings be fitted to the cylinder?

A. The rings should be filed or scraped, to a good bearing all the way around the cylinder. The ends should be filed off so that the ring will fit the smallest part of the cylinder, the ends coming as close together as possible and work free. They should also be a neat fit in the piston grooves.

Q. Is it poor practice to fit rings to a cylinder that is slightly out of round, or not of the same diameter its entire length?

A. Yes.

Q. What should be done if the cylinder is found, from wear, to be smaller in one part than another?

A. It should be re-bored. If this is not done, the rings will permit the air to churn from one end of the cylinder to the other, greatly reducing the efficiency of the compressor, and at the same time contribute largely to excessive heating.

Q. If the air ports or passages are gummed up, how may they be cleaned out?

A. By working a strong, hot solution of lye, or potash, and water through the air cylinders. If the engine is to remain in the round house long enough, the air cylinders and ports may be filled with this solution and allowed to stand until it has cut the gum. If the time will not permit of this, then the solution should be worked through the compressor by running it slowly, to the main reservoir; then worked through the compressor a second time, after which a quantity of fresh water sufficient to thoroughly rinse the compressor should be worked through it. The piston rods should then be repacked (unless metallic packing is used) and the pipe joints tightened. Kerosene or coal oil must not be used, as it frequently explodes under pressure, and at best does not do the work thoroughly.

Q. If the compressor makes irregular strokes or "goes lame," where would the trouble be?

A. Probably with the air valves.

Q. What would be the trouble?

A. A valve may be stuck or broken.

Q. If an inlet valve was stuck open or broken, what would result?

A. Air would be drawn into the low pressure cylinder and on the return stroke of the piston, blown back to the atmosphere.

Q. If an inlet valve were stuck closed, what effect would it have?

A. No serious effect. As there are two inlet valves at each end of the low pressure air cylinder the valve still in good condition would permit the cylinder to be supplied with air.

Q. If an intermediate valve was stuck open or broken, what would result?

A. Air would churn back and forth between the high and low pressure air cylinders, and no air would be taken in at the inlet valves at the end of the low pressure cylinder having the stuck or broken intermediate valve.

Q. If an intermediate valve was stuck closed, what effect would it have?

A. Little, if any effect. There being two intermediate valves at each end of the air cylinders, the valve still in good condition would answer the requirements.

Q. What would be the effect if the upper discharge valve was stuck or broken?

A. Main reservoir pressure would always be on top of the high pressure air piston and cause the compressor to work slowly.

Q. What would be the effect if the lower discharge valve was stuck or broken?

A. Main reservoir pressure would always be under the high pressure air piston, causing the compressor to work slowly.

Q. What could be done out on the road to get the compressor to work regularly?

A. If a valve is stuck, tapping lightly on the outside of the compressor will often dislodge it. If the valve continues to stick, it should be removed, and the foreign matter cleaned off. Though the trouble may be remedied it should be reported upon arrival at the terminal, and the compressor thoroughly cleaned, as gummed-up valves indicate a bad condition of the air cylinders.

Q. If a compressor is in good condition, yet is slow in pumping up air pressure, where might the trouble be?

A. The air strainers may be partially clogged up, which in most cases is the source of this trouble, as it will not permit the low pressure cylinder to be filled with air at each stroke of the piston. Strainers are at times deceiving in external appearance as they may be polished bright and appear to be clean and yet the small perforations may be partially clogged up with dirt.

Q. In the event of the low pressure steam piston or high pressure air piston becoming disabled, can the compressor still supply air?

A. Yes—as under such conditions the compressor becomes single-acting, the same as the 9½-inch compressor.

Q. How would the compressor then operate?

A. Air would be taken into the low pressure air cylinder in the usual manner and forced through the high pressure cylinder to the main reservoir.

Q. What main reservoir pressure could be obtained in this way?

A. 40 to 50 pounds.

Main Reservoir.

Q. What is the function of the main reservoir?

A. To receive and store the compressed air delivered by the air pump.

Q. Does the size of the main reservoir affect the operation of the brakes?

A. It does. It should be large enough to contain a sufficient volume of air to promptly charge up the train pipe and auxiliaries when empty.

Q. What is the minimum size reservoir permissible for freight and passenger engines?

A. A capacity of 40,000 cubic inches for freight and 20,000 cubic inches for passenger.

Q. Are there any freight engines equipped with reservoirs of a capacity greater than 40,000 cubic inches?

A. Yes; many of the leading railroads are equipping their heavy freight engines with reservoirs of 50,000 and 60,000 cubic inches capacity, and are getting good results from the increased volume.

Q. Why is a reservoir of large capacity desirable?

A. It permits of carrying a large volume of air with which to promptly charge up an empty train, or to recharge the train pipe and auxiliary reservoirs after an application of the brakes.

Q. Are there any other benefits received from the use of a large main reservoir?

A. Yes; it acts as a cooling or radiating chamber for the air after it leaves the pump, thereby reducing the temperature of the air and allowing it to pass through the brake valve into the train pipe at a moderate temperature.

Q. What benefit is received by cooling the air before it leaves the main reservoir?

A. It separates the moisture from the compressed air and causes it to settle in the reservoir, whence it can be readily drained out.

Q. What might be the result if this water is not caught in the main reservoir, but goes back through the brake valve into the train pipe?

A. Water passing into the train pipe is very detrimental, as it causes the pipes to rust, and in getting into the triple valves it destroys the lubrication. In the winter time, water in the train pipe is very dangerous, as it is liable to result in a stopped-up train pipe.

Q. Why do freight engines require a larger main reservoir volume than passenger engines?

A. This is owing to the longer trains handled and greater number of auxiliary reservoirs to recharge after an application of the brakes.

Q. Why cannot air be pumped direct into the train pipe, and thus release the brakes?

A. The process is too slow, and on a long train many of the brakes would fail to release; another objection is that the pump would be required to do a great amount of work in a very short time, which would probably cause it to run hot.

Q. How much main reservoir pressure is carried?

A. Ordinarily 90 pounds, although local conditions, and the use of special equipments govern the amount carried.

Q. Is not main reservoir pressure sometimes called excess pressure?

A. Yes; the amount of pressure in the main reservoir above that in the train pipe is called excess pressure.

Q. What is excess pressure used for?

A. To insure a prompt release of brakes and recharging of the auxiliary reservoirs; also, to supply the various air operated devices on the engine without affecting the train pipe pressure.

Q. Where is the starting and ending point of the main reservoir pressure in the brake system?

A. It starts at the discharge valves of the pump and ends at the engineer's brake valve.

Q. What effect does water have in the main reservoir?

A. It occupies space that should be filled with air, and in doing so reduces the capacity of the reservoir.

Q. How often should the main reservoir be drained?

A. At the end of each trip. In suburban or switching service, every 24 hours.

Q. Where does the water come from that is found in the main reservoir?

A. From the atmosphere. Atmospheric air always carries in suspension more or less moisture, which is delivered into the main reservoir with the compressed air, and is condensed into water.

Q. Does leakage at the pump stuffing box affect the amount of water collected in the main reservoir?

A. But very little, as experiments have proven that the amount received through the stuffing box is very small.

THE ENGINEER'S BRAKE VALVE.

The engineer's brake valve is the device on the engine by means of which the engineer is enabled to charge up, and keep charged, the trainpipe and auxiliaries; apply the brakes, and keep them applied, release the brakes and keep them released, and to do these several things he has either to place the main reservoir in communication with the train pipe, or open the train pipe to the atmosphere, or shut off all communication, as the case may be, according to whether he is applying or releasing the brakes, keeping them set, or running along.

There are just four things that constitute the essential parts to a modern Westinghouse brake valve, and they are: the rotary valve, the handle that controls the rotary, the equalizing discharge valve, and the feed valve attachment, or train pipe governor. Of course there are gaskets, springs, packing rings, the equalizing reservoir, etc., but they are matters of detail.

There are five positions in which the handle of the brake valve can be placed.

The first, or extreme left position is full release, and is the position the handle should always be in when releasing brakes, or when it becomes necessary to charge up quickly, for in this position the air from the main reservoir flows through the largest ports in the rotary, direct to the trainpipe.

The second position is called running position, because the handle should be carried in this position while running along, for the reason that in this position the rotary valve is placed so that all the air that passes from the main reservoir into the trainpipe must go through the feed valve attachment, and this attachment will only allow seventy pounds of air to get into the trainpipe (if set correctly, and unless the high-speed apparatus is being used), it enables the pump to maintain an excess pressure in the main reservoir, for if the pump governor is set at ninety pounds, and the feed valve set at seventy, there will naturally be twenty pounds greater pressure in the main reservoir than in the trainpipe before the pump is stopped by the governor.

Another reason why the handle must always be carried in running position while the train is running along, is because whenever the pressure in the trainpipe leaks down below the standard of seventy pounds, the feed valve will open automatically and allow the main reservoir pressure to again flow into the trainpipe until that pressure is restored, when it will automatically close itself, and allow the pump to again create the "excess" in the main reservoir.

The third position of the brake valve is lap, and when the handle is in this position all ports are closed, so that no air can pass either into the trainpipe or out of it. After applying the brakes, the handle should be brought to lap carefully, and held there until it is desired to further reduce the trainpipe pressure or release the brakes, as the case may be, and when releasing the brakes the handle must be placed on full release position for a few seconds, according to the length of train and the amount of excess carried before it is allowed to rest on running position.

The fourth position is called service application position because in this position the air is allowed to escape gradually from the train pipe. In this position the air on top of the equalizing discharge valve is allowed to escape through the small preliminary exhaust port in the seat of the rotary so gradually that a sudden reduction on the trainpipe is prevented, for as the pressure on top of the discharge valve is allowed to escape, the trainpipe pressure below gradually forces it from its seat and thereby opens the trainpipe exhaust. If the handle is left in service position until ten pounds is drawn from the top of the discharge valve and then placed on lap, the valve will not seat until a fraction over ten pounds has escaped from the trainpipe, when the pressure on top will then be the greatest and force the discharge valve back to its seat, and thereby close the trainpipe exhaust.

The fifth position is called emergency application position, because when the handle is in this position the rotary connects the main trainpipe supply port with the main exhaust port and the air is allowed to escape from the trainpipe, direct to the atmosphere, regardless of the equalizing discharge valve, and this sudden reduction of trainpipe pressure allows the triples to be forced to their full stroke, and thus causes the quick action, or emergency application. Emergency position should never be used except in case of danger.

In applying the brakes with the quick-action triple, it is not only necessary to reduce the train-pipe pressure lower than that in the auxiliary, but it is absolutely necessary that the reduction be made gradually to prevent the emergency action.

The old-style brake valve, or three-way cock, Fig. 21, has only three positions, viz: application, lap and release. The passage ways through the plug of the valve are designated by the marks on the plug. When the handle is turned to the right, communication is established between the main reservoir and the brake pipe to the brake cylinders. When the handle is reversed (turned to the

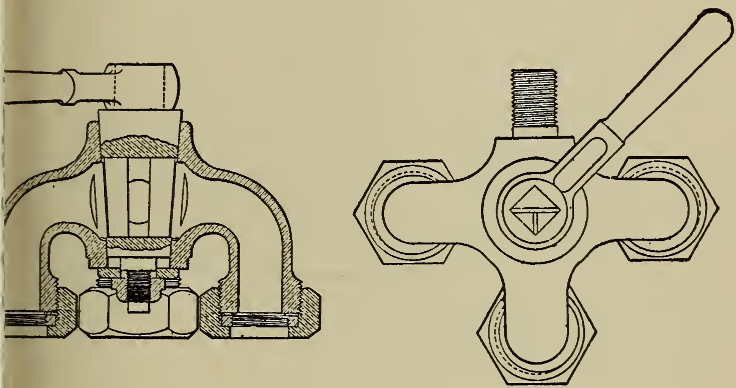


Fig. 21—Three-Way Cock Form of Brake Valve.

left), the former communication is cut off and a new one made, establishing communication between the brake cylinders and brake pipe to the atmosphere.

D-8 Brake Valve.—As the D-8 brake valve is now largely superseded by the F-6 and G-6 it will not be necessary to enter into details in describing it, except to point out the differences between the two types of brake valves.

The D-8 brake valve uses the pump governor to control the train pipe pressure of seventy pounds, and the connection is made at V, Fig. 22, the excess is controlled by what is known as the excess pressure valve (19, Sec. 3, of Fig. 22).

When the handle of the D-8 brake valve is in full release position the pump will shut off at seventy pounds,

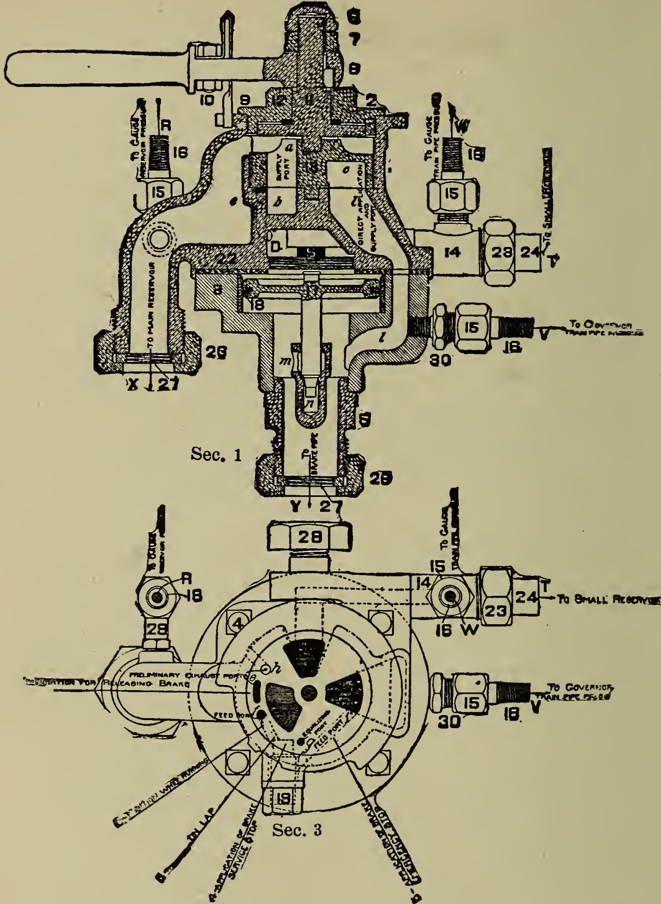


Fig. 22—D-8 Brake Valve.

and the pressure in the main reservoir and train pipe would be the same, but if the handle is in running position the excess pressure valve will not open to admit air into the train pipe until there is twenty pounds in the main reservoir, and as it requires twenty pounds to hold this valve open, the train pipe will get a pressure of seventy pounds before the pump will shut off, thus leaving an excess pressure of twenty pounds in the main reservoir.

If the handle is placed on lap while the train pipe pressure is below seventy pounds, the pump will run the main reservoir pressure up to boiler pressure, for the governor cannot shut the pump off unless there is seventy pounds in the train pipe; on the other hand, if the handle is in running position no air can get into the train pipe until there is twenty pounds of excess in the main reservoir, and as a consequence the many leaks that commonly occur in the main reservoir and train pipe connections cause the brakes to creep on before the pressure can be restored to keep them off.

It is mainly on this account that the F-6 brake valve was invented, for with this valve the pump governor is controlled by the main reservoir pressure, and will stop the pump at ninety pounds in the main reservoir, no matter in what position the handle is, and, as the train pipe pressure is controlled by the feed valve, whenever that pressure falls below the standard of seventy pounds, if the handle is in running position the feed valve will open and let the main reservoir pressure in, and thus keep the brakes from dragging.

Another difference between the two kinds of brake valves is that with the D-8 valve, when making a service application, the air from cavity D over the equalizing discharge valve, 17, is exhausted to the atmopshere through a separate little port in the casing, marked h in Sec. 2 of Fig. 23, whereas the preliminary exhaust h, in the F-6 valve, is connected with the main or emergency exhaust, marked k in Sec. 2 of Fig. 25, thus mak-

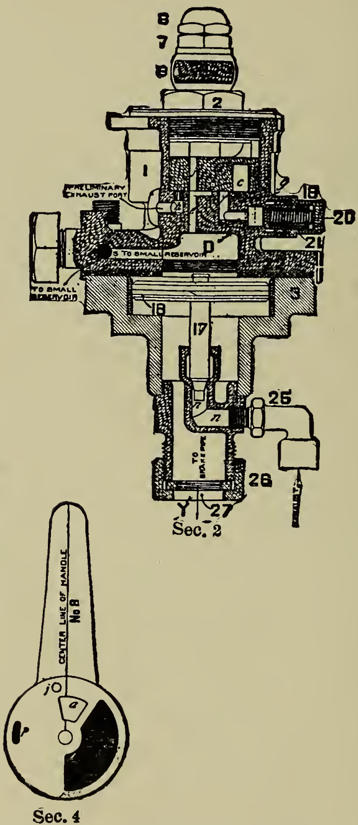


Fig. 23—D-8 Brake Valve and Rotary.

ing one port less through the casing of the F-6 brake valve.

Therefore there are the following differences between the D-8 and the F-6 brake valves: 1st, with the D-8 valve the excess pressure is gotten before the train pipe begins to charge, if the handle is in running position; 2nd, with the D-8 valve the train pipe pressure is controlled by

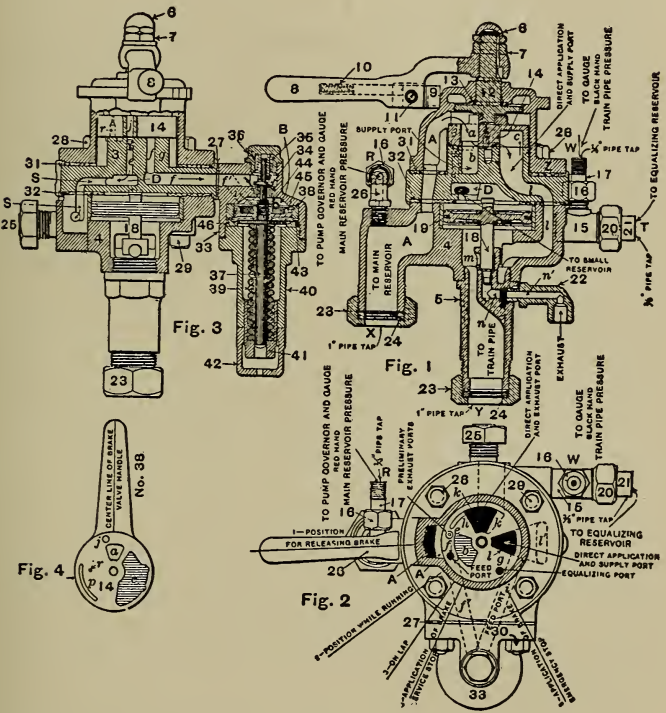


Fig. 24—Engineers' Brake Valve, F-6 Type.

the pump governor, instead of the feed valve attachment, as it is with the F-6; 3rd, with the D-8 valve, if the handle is left in either lap, service or emergency position, the pump will run the main reservoir pressure up to boiler pressure, or will shut off when there is only seventy pounds in the main reservoir if the handle is left in full release from the starting of the pump, whereas with the F-6 valve, the pump will be shut off by the governor, if properly set, when the main reservoir reaches ninety pounds, no matter what position the handle of the valve is in; 4th, with the F-6 valve the excess pressure is gotten after the train pipe pressure is pumped up; 5th, with the D-8 valve, if the excess pressure valve should happen to be in bad order, and it usually is, if the handle was left on lap for any considerable length of time after making a service application, the main reservoir pressure would be raised so high that, with a short train, when the handle was thrown to release position the auxiliaries would be overcharged, and the wheels slid on the next application, unless the engineer was very careful, whereas with the F-6 valve the most that could get in the auxiliaries, if the governor was correct, would be ninety pounds; 6th, when an emergency application is made with the D-8 valve, the black hand on the gauge will rise instead of fall, because in this position the equalizing port to cavity D is open to the main reservoir pressure. The construction of the D-8 valve, with these differences, is the same as the F-6 or G-6, except that the D-8 has an excess pressure valve, while the F-6 or G-6 has a feed valve attachment, which will be explained in regular order.

F-6 Brake Valve.—The parts of the F-6 brake valve are as follows: the handle, which controls the rotary, is marked 8, in Sec. 1, Fig. 24. The lug, 9, is forced out by a spring, 10, so that the handle may be stopped in any desired position, and when placing the handle in any of the positions be sure that the lug in the handle is right up against the lug on the brake valve, for the reason that the rotary valve is moved in exact accord with the handle. If either lug is worn the movement of the rotary will be correspondingly changed when the lugs are against each other; 12 is the stem to one end of which the handle is fastened by nuts 6 and 7, and the other is dove-tailed or keyed into the top of the rotary, so that whatever way the handle is turned the rotary has to turn with it; 13 is a small leather gasket for the purpose of preventing any air from leaking out around the stem, as main reservoir pressure is always on top of the rotary and under the shoulder of stem 12, forcing it up against the casing. This gasket sometimes gets gummed up so badly that it causes the handle to move very hard; 14 is the rotary valve, and 3 is the rotary valve seat; 18 is the equalizing discharge valve, which controls the train pipe exhaust m and n. The action of the discharge valve has already been explained under the head of service application position.

As cavity D above the discharge valve is very small, it is necessary to have a greater volume of air to control it than the cavity alone will contain, and this greater volume is supplied by a little drum, or equalizing reservoir, which holds about 500 cubic inches of air, and is located, usually, under the footboard of the cab. It is connected to the brake valve at T (Sec. 1), and from T to cavity D there is a connecting passage, as shown by s in Sec. 3, and as the little drum is always charged equally with cavity D, whenever the pressure in cavity D is reduced it is also reduced in the little drum. This greater volume is needed above the discharge valve to compensate for the volume in the train pipe.

When the handle of the brake valve is placed in service position the rotary shuts off the main reservoir and also cavity D from the train pipe, and allows the air to escape from cavity D by way of port e, groove p and preliminary exhaust port h to the atmosphere through the main ex-

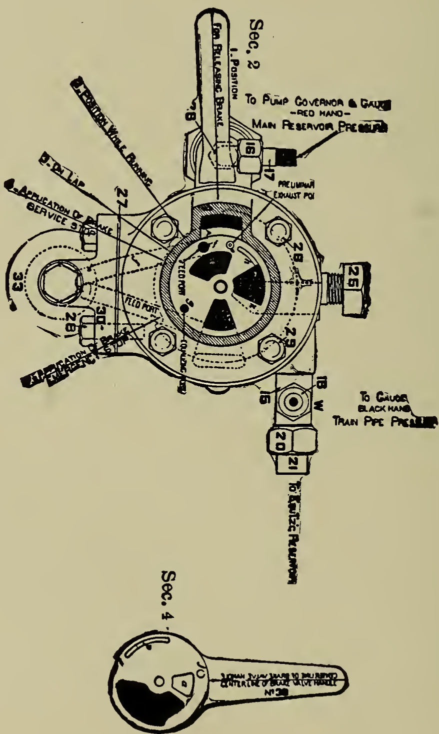


Fig. 25—F-6 Brake Valve—Rotary and Seat.

haust k, and when the handle is moved to lap it closes the preliminary exhaust, and thus holds the little drum pressure at whatever it was reduced to, as shown by the black hand of the gauge, and when the train pipe has exhausted until it becomes less than the pressure in cavity D the discharge valve is forced to its seat by the pressure in the little drum, and stops any further flow of air from the train pipe.

Nos. 34 to 46 in Sec. 3 of Fig. 24 all refer to the old style feed valve attachment as used on the F-6 brake valve. The essential parts are the supply valve, 34, valve spring, 35, diaphragm piston, 37, regulating spring, 39, regulating nut, 41.

When the rotary is in running position, the operation of the feed valve is as follows: the regulating spring being set at seventy pounds tension, it forces the piston up against the stem of the supply valve and raises it off its seat, causing the main reservoir pressure to flow from the top of the rotary down through port j in the rotary Sec. 4, Fig. 25, and through port f in the rotary seat Sec. 3, Fig. 24, through a passage, f, and under the supply valve to the top of the diaphragm piston, then through a port (shown by dotted lines, and marked i,) Sec. 2, Fig. 25, which leads off the top of the piston into the train pipe by way of the main supply port, as shown by dotted lines in Sec. 2. As the rotary is now in position so that the large cavity, c, as shown in Sec. 4, Fig. 24, connects the main supply port with the equalizing port g (which passes through the rotary seat into cavity D), the air that is passing from the top of the rotary through the feed valve into the train pipe, is also filling cavity D, and the little drum, by way of ports g and s, as shown in Sec. 3, Fig. 24.

While Fig. 24 shows full release position, still ports s and g are fully shown, and if the handle is moved to running position the port through the rotary that registers with port e in Sec. 3, would be in register with port f; port g is indicated by dotted lines.

In running position, when the train pipe and little drum are charged up to seventy pounds, there is also seventy pounds on top of the diaphragm piston, and as the regulating spring is set at a fraction less than seventy, the air pressure forces it down and allows the supply valve to seat and shut off the main reservoir from the train pipe. But as soon as the pressure in the train pipe falls below seventy, the piston is again forced up by the regulating spring and keeps the supply valve open until the pressure is again restored in the train pipe.

The feed valve attachment is in operation only, when the handle of the brake valve is in running position.

The course of the air through the brake valve in full release position is as follows.: the return pipe from the main reservoir is connected to the brake valve at X, and passes directly to the top of the rotary through passage A, then through port a in the rotary into cavity b in the rotary seat and under a bridge in the rotary (which now stands midway over cavity b), and on over the seat of the rotary, through large cavity c, direct into the main supply port, 1, to the train pipe. In passing over the rotary seat the air also passes down through the equalizing port g, into cavity D, and from cavity D through port s into the little drum; and as the feed valve is cut out when the handle is in full release, both the little drum and train pipe pressure would charge up to main reservoir pressure if the rotary was left in full release. In full release position, port j in the rotary registers with port c in the seat, so that cavity D charges faster in full release than in running position.

The little drum is simply an enlargement of cavity D and the same pressure is in both.

The Warning Port, through which the air is heard escaping as long as the handle remains in full release, is a small port through the rotary about the size of a pin, which allows the main reservoir air to whistle through it to warn the engineer that he is liable to overcharge his train pipe. It should always be kept clean.

The black hand of the gauge is piped to the little drum at W, Sec. 1, Fig. 24, as stud 17 is tapped into pipe 15 which connects the little drum with cavity D by way of port s.

The red hand of the gauge, and also the pump governor are piped to the main reservoir pressure at R.

To make an emergency application the handle must be moved to the extreme right, when the large cavity, c, in the rotary will connect the main supply port, l, of the train pipe with the main exhaust port, k, and allow the air in the train pipe to exhaust directly into the atmosphere.

G-6 Brake Valve and New Slide Valve Feed Valve.— The G-6 brake valve is identical with the F-6, with the exception of the feed valve. In the new slide valve feed valve the only material change is that a slide valve controls the flow of air from the main reservoir into the train pipe, which allows the pressure to be raised much quicker than it can be with the old style feed valve.

The working parts of the new slide valve feed valve are as follows: all of the essential parts of the old style feed valve are retained, see Fig. 27, with slight modification, for 64 is the diaphragm piston, which, instead of having a rubber diaphragm has two sheet-brass diaphragms, 57, on the piston head, supported by a ring, 63;

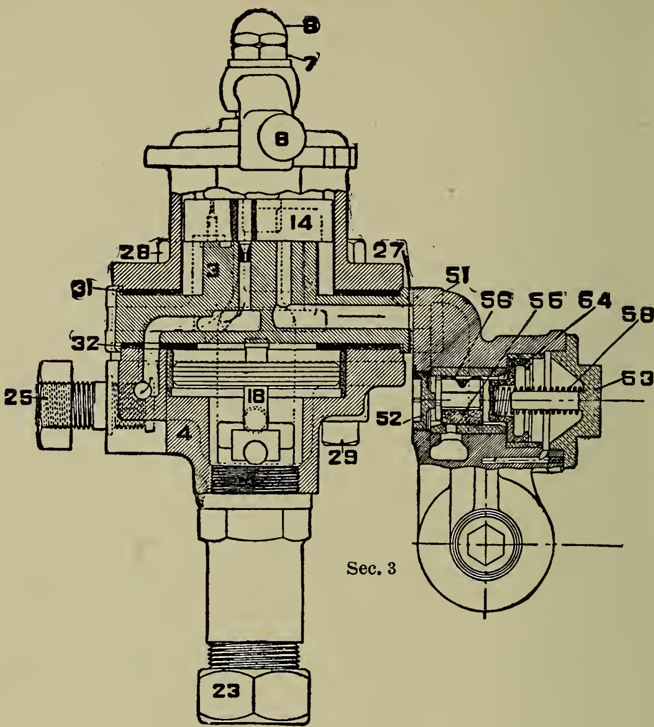


Fig. 26—G-6 Brake Valve.

67 is the regulating spring; 65 the regulating nut; 59 a small valve corresponding exactly with supply valve 34 in the old style feed valve, and 60 is the spring which controls valve 59.

By reference to Fig. 26, Sec. 3, it will be seen that there is a slide valve, 55, attached to a piston, 54, and this piston is forced forward by a spring, 58.

The action of the new slide valve feed valve is as follows: When the handle of the rotary is in running position, main reservoir pressure drives the slide valve and piston back, which uncovers a port in the slide valve seat that connects with feed port i, and as the slide valve does not move until the train pipe is fully charged, it causes the pressure to be restored very quickly after it has been reduced from any cause.

The reason the slide valve does not move until the pressure is restored is because the piston has no packing rings, and the air is allowed to circulate by it through a small passage that leads to the supply valve chamber,

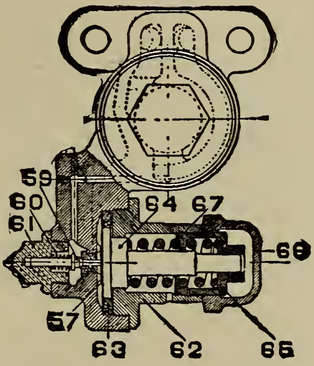


Fig. 27—Slide Valve Feed Valve.

from which it passes under the cut-off valve across the diaphragm into feed port i, and when there is a pressure of seventy pounds on the diaphragm it moves away from the supply valve and allows it to seat, when the circulation by the piston is stopped, causing the pressure to equalize on both sides of the slide valve piston, when spring 58 moves the slide valve and closes communication between the main reservoir and the train pipe. Whenever train pipe pressure falls below seventy the diaphragm forces valve 59 off its seat and the same action is repeated as before.

The H-6 automatic brake valve, and the S-6 independent brake valve will be discussed in the section devoted to the No. 6 E. T. Equipment.

WESTINGHOUSE ENGINEER'S BRAKE VALVE.

Q. What is the engineer's brake valve for?

A. For the purpose of enabling the engineer to properly charge, set and release brakes, and control the flow of main reservoir and train pipe pressure.

Q. What style of brake valve is now in general use?

A. The equalizing discharge type.

Q. What advantage is gained by its use?

A. It permits the engineer to make light, uniform reductions throughout long trains, sufficiently fast to cover all leakage grooves, yet not fast enough to obtain quick action; and automatically closes off the discharge gradually, thereby preventing the release of the head brakes of the train.

Q. What are the essential parts of the engineer's brake valve?

A. The rotary valve and the handle which controls it, the equalizing discharge valve, the feed valve attachment, or train pipe governor, and the equalizing reservoir.

Q. What is the purpose of the rotary valve?

A. To open and close the ports in the brake valve.

Q. What is the handle of the brake valve for?

A. To control the movement of the rotary valve.

Q. What is the equalizing discharge valve for?

A. To open and close the train pipe exhaust port according to the pressure above or below it.

Q. What is the equalizing reservoir intended for?

A. To maintain a large volume of air on the upper side of the equalizing discharge valve, in order to compensate for the volume of air in the train pipe, which is on the under side of the equalizing discharge valve.

Q. How many positions are there for the brake valve handle to be placed in?

A. Five; as follows: 1, full release position; 2, running position; 3, lap position; 4, service application; 5, emergency.

Q. Name the different types of Westinghouse engineer's brake valves now in use.

A. The D-8, the F-6, the G-6, the H-6 automatic, and the S-6 independent.

D-8 BRAKE VALVE.

Q. In what respect does the D-8 valve differ from the F-6 or G-6 type of brake valve herein described?

A. The principal difference is in the train pipe controlling device. With the D-8 valve an excess pressure valve is used, while the F-6 and G-6 have a feed valve device to control the train pipe pressure.

Q. Are the positions of the brake valve handle of this valve the same as with the F-6 or G-6 pattern?

A. Yes.

Q. Are the ports in the rotary valve and seat the same in this valve as with the F-6 or G-6?

A. Yes; practically the same, although slight modifications have been made in the general arrangement of the F-6 and G-6 valves to permit of better wearing surfaces.

Q. What is the object of the excess pressure valve?

A. To permit excess pressure to accumulate in the main reservoir, and to allow air to feed into the train pipe after the excess pressure has been attained.

Q. In what position of the brake valve does the excess pressure valve operate?

A. Running position.

Q. How much excess pressure does this valve maintain?

A. Ordinarily 20 pounds, this being governed by the tension of the spring on the back of the valve.

Q. With the brake valve in running position, will air pass to the train pipe until the excess pressure is obtained?

A. No; in order for air to pass to the train pipe, it must unseat the excess pressure valve; therefore, it cannot pass through unless the air pressure exceeds the tension of the valve spring.

Q. With the D-8 type of brake valve, what volume of air is the pump governor connected to?

A. To the train pipe volume.

Q. If the handle of the D-8 brake valve is placed on lap position while the train pipe pressure is below 70 lbs., what will be the result?

A. The pump will run main reservoir pressure up to boiler pressure.

Q. Why is this?

A. Because the governor cannot shut the pump off unless there is 70 lbs. pressure in the train pipe.

F-6 BRAKE VALVE.

Q. Name the different pipe connections to the F-6 valve.

A. 1, Main reservoir; 2, train pipe; 3, equalizing reservoir; 4, pump governor and red hand of air gauge; 5, black hand of gauge.

Q. How many positions are there in which air is admitted to the train pipe, and what are they?

A. Two. Full release and running position.

Q. How many positions are there in which the train pipe pressure can be discharged? Name them.

A. Two. Service application and emergency position.

Q. What is lap position?

A. Lap position is the position in which all ports in the brake valve are closed.

Q. What is lap position used for?

A. To hold the brakes on after an application, or to prevent main reservoir pressure from passing into the train pipe when the train has parted, or the conductor has applied the brakes with the conductor's valve; also, when coupling to air brake cars.

Q. In what respect does the F-6 brake valve differ from the D-8 type?

A. Principally in the use of the feed valve attachment, in place of the excess pressure valve, although a number of general mechanical improvements have been made in the valve.

Q. What improvement is the feed valve attachment over the excess pressure valve?

A. The feed valve is a device which controls the train pipe pressure, maintaining the standard amount regardless of the excess pressure in the main reservoir, which the excess pressure valve would not do. It is also more sensitive in its action and permits of a convenient method of adjustment; also, is broader in the limits of adjustment.

Q. With the brake valve in running position, is it necessary to accumulate the excess pressure before air can pass to the train pipe, as it is with the D-8 type?

A. No; this is one of the decided advantages of this valve. With excess pressure valve, considerable trouble was had from the brakes creeping on during the time the pump was raising the excess pressure necessary to open the valve.

Q. How many types of feed valves are there?

A. Two known as the poppet type of feed valve and the slide valve feed valve.

Q. What type of feed valve is used with the F-6 brake valve?

A. The poppet type of valve.

Q. What is the difference between the F-6 brake valve and the G-6 valve?

A. Only in the use of the slide valve feed valve, as described in the following pages.

Q. What is full release position of the brake valve used for?

A. To allow main reservoir pressure to flow quickly and directly into the train pipe, thereby insuring a prompt rise of pressure and the prompt release of the brakes and recharging of the auxiliary reservoirs.

Q. Describe the warning port, and its location.

A. It is a small port about the size of a pin, and passes through the rotary.

Q. What is the function of the warning port?

A. By allowing the air to whistle through it warns the engineer when he is liable to overcharge his train pipe. It should always be kept clean.

Q. To what reservoir is the black hand of the gauge piped?

A. To the equalizing reservoir.

Q. What pressure does the red hand of the gauge indicate?

A. Main reservoir pressure.

G-6 BRAKE VALVE.

Q. Describe the passage of the air through the brake valve when in full release position.

A. Air from the main reservoir flows through the largest ports in the rotary, direct to the train pipe.

Q. What volume of air is at all times in the chamber above the equalizing piston?

A. The equalizing reservoir, or little drum, volume.

Q. What is the object of having the equalizing reservoir always connected to the chamber above the equalizing piston?

A. This is to increase the volume of air of the equalizing piston.

Q. Why is this necessary?

A. Without the equalizing reservoir, the volume of air above the equalizing piston would be so small that it would be difficult to reduce the pressure gradually, which is required during service brake applications.

Q. Is it understood that in all cases, when this chamber is being charged, that the equalizing reservoir is also being charged?

A. Yes; they are at all times in direct communication with each other.

Q. What is the cause of the blow from the direct exhaust opening of the brake valve when in full release position?

A. This is due to the warning port being open, in the rotary valve, and which is always open to the direct exhaust when the brake valve handle is in full release position.

Q. What is the object of having this air escape when the handle is in this position?

A. To make a noise and attract the engineer's attention to the fact that the brake valve is in full release position, and that it must be moved to running position to prevent the train pipe from becoming overcharged.

Q. What air pressure is escaping to the atmosphere through the warning port?

A. Main reservoir pressure.

Q. What will happen if the brake valve is left in full release position?

A. The train pipe and main reservoir pressure will equalize, thereby causing the train pipe to become overcharged.

Q. Why would the train pipe be overcharged if it contains the same pressure as the main reservoir?

A. This is owing to the pump governor being connected to the main reservoir volume of air, with this style of brake valve, and which is always adjusted for a pressure above the standard train pipe pressure.

Q. To what position must the brake valve handle be moved to prevent the train pipe from becoming overcharged?

A. Running position.

Q. What are the conditions while the brake valve is in running position?

A. In this position all the air that passes from the main reservoir into the train pipe must pass through the feed valve attachment thus enabling the pump to maintain an excess pressure in the main reservoir.

Q. How many ports in the rotary valve seat are open in running position?

A. Two; one leading to the feed valve attachment, and the other to the chamber above the equalizing piston.

Q. With this attachment what pressure is allowed in the train pipe, and what pressure in main reservoir?

A. Seventy pounds in train pipe, and 90 pounds in main reservoir, unless the high speed apparatus is in use.

Q. Why will the train pipe not become overcharged with the brake valve in running position?

A. Because, in this position all air which enters the train pipe must pass through the feed valve attachment which controls the train pipe pressure, as this valve automatically closes off when the desired pressure is obtained.

Q. What air pressure is always present above the rotary valve?

A. Main reservoir pressure.

Q. When is the running position of the brake valve used?

A. While running over the road when the brakes are not being operated, in order that the feed valve may control the train pipe pressure.

Q. What is lap position used for?

A. To prevent the main reservoir pressure from entering the train pipe, or the train pipe pressure from passing through the valve to the atmosphere.

Q. Are there any ports open to the brake valve on lap?

A. No; all communication through the brake valve is cut off.

Q. After applying the brakes how should the handle be brought to lap?

A. It should be brought to lap carefully, and held there until it is desired to further reduce train pipe pressure, or release the brakes as the case may be.

Q. When releasing the brakes how must the brake valve be handled?

A. The handle should be placed on full release for a few seconds, according to the length of the train and the amount of excess pressure carried, before it is allowed to rest on running position.

Q. Describe the conditions when the brake valve is in service application position.

A. In this position the air on top of the equalizing discharge valve is allowed to escape so gradually that a sudden reduction of train pipe pressure is prevented.

Q. In making a service brake application does it require that the brake valve handle be left in application position any longer to make a 10 pound reduction on 40 cars than it would with 10?

A. No; for in service position the volume of air which is reduced always remains constant, that being the air pressure in the chamber and the equalizing reservoir.

Q. If the brake valve handle is left in service position until 10 pounds is drawn from the top of discharge valve, and then placed on lap, what is the result?

A. The valve will not seat until a fraction over 10 pounds has escaped from the train pipe, when the pressure on top will then be the greatest, and force the discharge valve back to its seat, thereby closing the train pipe exhaust.

Q. When should emergency position be used?

A. Only in case of danger.

Q. What conditions prevail in the brake valve during an emergency application?

A. In this position the rotary connects the main train pipe supply port with the main exhaust port thus allowing the air to escape from the train pipe direct to the atmosphere regardless of the equalizing discharge valve.

Q. What effect does this sudden reduction of train pipe pressure have on the triple valves?

A. It allows them to be forced to their full stroke, thus causing quick action or emergency application.

Q. With the brake valve handle in emergency position, does any air pressure escape from the train pipe at the train pipe exhaust fitting?

A. No; in emergency position of the brake valve the equalizing piston does not move; therefore no air can escape from the train pipe exhaust.

Q. What precautions must be observed in applying brakes with the quick action triple?

A. The reduction in train pipe pressure should be made gradually in order to prevent an emergency application.

Q. Sometimes a very noticeable flash occurs at the train pipe service exhaust when releasing brakes, as though the equalization piston had raised. It is a noticeable fact that this never occurs with a long train, but only with the light engine or a few cars. What causes it?

A. When the valve handle is placed in full release position, the supply to the train pipe is much greater than that to the equalizing reservoir, thus charging the chamber under the equalizing piston faster than the chamber above it. This causes the piston to rise until the pressures equalize.

THE TRIPLE VALVE.

One of the most important parts of the automatic air brake system is the triple valve, so called from the fact that it performs the three-fold function of, (a), charging the auxiliary reservoir located under the car, (b), applying the brake, and (c), releasing the brake. As has been already explained, the automatic air brake requires an auxiliary reservoir under each car, and in this reservoir a sufficient volume of compressed air is stored ready for use in applying the brake. In the brake cylinder is where the air pressure is applied to the piston acting upon the brake levers and rods, but the triple valve operates or controls the passage of the compressed air from the auxiliary reservoir, near which it is located, into the brake cylinder during the application of the brake; and it also releases the pressure from the brake cylinder, passing it to the atmosphere locally under each car when the engineer desires to release the brakes. This being done the triple valve again automatically assumes the position in which air passes through it to recharge the auxiliary reservoir, ready for another application.

PLAIN TRIPLE.

Fig. 28 shows a sectional view of the Westinghouse new style plain triple, the parts of which are designated as follows: 23 is called the triple piston; 24 is the slide valve; 25 is the graduating valve; 26 is the graduating

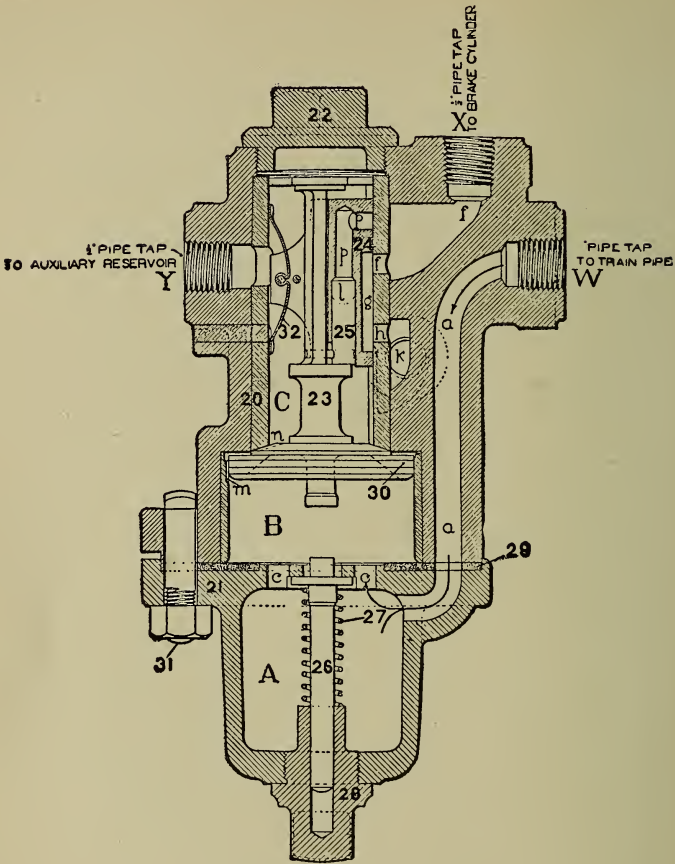


Fig. 28—New Style Plain Triple-Valve.

stem, and 27 is the graduating spring; 32 is the U spring over the slide valve.

The casing is so shaped that one part of it forms a cylinder for the triple piston to move in, and is marked

B, and adjoining it is a chamber having a flat side (called the slide valve seat), for the slide valve to move on, and is marked C.

The flat side of this chamber, which forms the seat on which the slide valve rests, has two ports cut through it; the one marked f leads to the brake cylinder, and the other, marked h, leads to the atmosphere.

In the slide valve there are also two ports, one passes through the valve, as shown by the letters l, p-p, and the other is a groove cut in the bottom of the valve, and marked g, and when the valve is moved toward the left end of Chamber C (in other words, moves down), the port through the valve marked p connects with the port in the seat marked f, so that the air in the auxiliary can pass through the valve, and valve seat and on through pipe connection X directly into the brake cylinder; and when the slide valve is in the opposite end of Chamber C the groove g in the bottom of the slide valve connects the two ports f and h together, so that one end of the groove rests directly over the port leading to the brake cylinder, and the other end rests over the port leading to the atmosphere, thus forming a direct opening between the brake cylinder and the atmosphere; therefore, as the triple is so connected to the auxiliary by pipe connection Y that the auxiliary pressure is always in direct communication with chamber C, in which the slide valve moves, and as the port in the seat marked f is the only way for the air to get in or out of the brake cylinder, with this kind of a triple, it is very evident that when the slide valve is moved along on its seat until the port in the valve marked p-p comes opposite the port in the seat marked f, the air in the auxiliary is free to pass into the brake cylinder, and apply the brake. And when the slide valve is forced back again to its original position, as shown in Fig. 28, the air in the brake cylinder is free to pass out to the atmosphere through ports f, g, h and exhaust port k, and thereby release the brakes. Therefore, as the flow of air from the auxiliary to the brake cylinder, and from the brake cylinder to the atmosphere is dependent upon the movement of the slide valve, it is necessary to understand how this movement is accomplished.

The stem of the triple piston extends into chamber C, in which the slide valve moves, and the valve is hung on this stem; there is a packing ring, 30, around the triple piston, making a tight joint against the walls of cylinder B, and as one end of this cylinder is always open to chamber C (which always contains auxiliary pressure) and the other end of cylinder B is always open to the train pipe, the triple piston stands between the auxiliary and train pipe pressure at all times, and if these pressures are equal, and the piston is in full release position, as shown in Fig. 28, should the pressure on the train pipe side of the piston become lower than that on the slide valve side, the piston would be moved by the auxiliary pressure, and of course draw the slide valve with it, causing the port in the valve marked p to come opposite the port in the seat marked f, and allow the air from the auxiliary to pass into the brake cylinder and set the brake.

To release the brake it is necessary to force the slide valve back to the position it occupied before the brake was set, as shown in Fig. 28.

To do this the pressure stored in the main reservoir is used, because when the engineer places his brake valve in full release position the main reservoir pressure quickly raises the pressure on the train pipe side of the triple piston and forces it back to the position shown in Fig. 28, and, as the slide valve has to go back with it, the groove g in the bottom of the valve is placed so that one end of it rests over the port marked f in the valve seat, and the other end rests over the port marked h in the valve seat, consequently the air in the brake cylinder is free to pass out to the atmosphere through ports f, g, h and through a passage around the casing to the triple exhaust marked k. The air having thus escaped from the brake cylinder the heavy spring in the cylinder, marked 9, in Fig. 33, drives the brake piston back from the levers, which allows the brake shoes to drop away from the wheels and the brake is released.

The whistling noise heard when the brakes are releasing on passenger cars is caused by the air escaping through the small ports in the triple (on freight cars the air exhausts through the pressure-retaining valve on top of the car), and if this whistling is weak, when releasing after a full application has been made, it indicates that either a portion of the air has already escaped from from the cylinder through a bad packing leather around the brake piston, or there is too much piston travel, which allowed the air to expand in the cylinder more than it should have done; in other words, a high pressure will rush out quicker than a low pressure.

Having set the brakes and released them, it now becomes necessary to recharge the auxiliary reservoir, to be ready for the next application.

The brake cylinder gets its power from the auxiliary, and the latter must always be kept charged ready to meet all demands made upon it by the cylinder. If the auxiliary is only partly charged, the force with which the brakes set will be correspondingly weak.

It should be borne in mind that just as soon as the slide valve moves to let the air out of the brake cylinder it opens the feed groove between the train pipe and auxiliary to admit air again into the auxiliary.

Reference to Fig. 28 will show the course of the air from the train pipe through the triple to the auxiliary.

Beginning at the point indicated by W, the air travels through a passage a-a, in the casing, to a chamber indicated by A, and from this chamber there are two openings, c, c, which allow the air to pass into the cylinder in which the triple piston moves, as indicated by B. As the air passes from chamber A it strikes the plain side of the triple piston, and forces it to the extreme end of cylinder B, and as the piston is supposed to be a tight fit in cylinder B, the only chance the air has to get into the chamber C is by passing through a small groove cut in the wall of cylinder B, as indicated by m. This is called the "feed groove." As this groove m is only as long as the head of the piston is thick, it will be seen at once that the piston must be all the way back before the air can enter this groove. It will be noticed, also, that the piston forms a seat only about half way from its center to its outer edge; in other words, there is a shoulder on the slide valve side of the piston, and this necessitates another groove to be cut in this shoulder, which is shown by the letter n. The air can now pass from cylinder B by way of the feed grooves, m and n, into chamber C, and over the top of the slide valve through the pipe connection Y into the auxiliary.

Owing to the smallness of the feed groove in the triple through which the air passes to get into the auxiliary, the train pipe will naturally fill quicker than the auxiliary, and cause the pump to stop temporarily, but as soon as the train pipe pressure is again lowered by the air passing through the feed grooves into the auxiliary, the pump will again start, and continue to compress air until every bit of space is filled to seventy pounds.

If the main reservoir, train pipe or auxiliary reservoir leaks, while the brake valve is in the position just described, the pump will not stop at all, and a great many leaks will very soon wear a pump out.

A few important things to remember when charging up a train are: first, leaks of any kind will prevent getting the required pressure in the time it should be gotten, and bad leaks will prevent it entirely.

Second, the strainer and feed grooves in the triple must be kept clean to allow the air to pass freely.

Third, the packing ring around the triple piston must be a good fit to prevent the auxiliary charging too rapidly, and to insure against charging too quickly is the reason for having a shoulder on the slide valve side of the piston, for if any air leaks around the packing ring it cannot enter the auxiliary except through the second feed groove, as shown by n in Fig. 28, unless the shoulder on the piston has a bad seat.

A still greater reason for having the packing ring, 30, tight, is to insure the brake against "sticking," as it will if the train pipe pressure equalizes with the auxiliary without moving the slide valve.

The reason for having the feed grooves so small in the triples is to allow all the auxiliaries on the train to charge as nearly together as possible, and also to assist in making the triple sensitive to the slightest reduction of train pipe pressure, for, if the feed groove was large, when the air was drawn from the train pipe a considerable amount of air from the auxiliary would flow back into the train pipe before the piston moved; but, as it is, the feed groove is so small and so short that it requires less than a two pound reduction to cause the triple piston to move and shut off communication between the auxiliary and train pipe.

For the same reason (sensitiveness) the piston packing ring must have a good fit, or else the auxiliary and train pipe pressures will equalize, and thereby fail to move the piston when desired in setting or releasing the brakes. This is especially true on long trains. (See "K" triple valve.)

If everything was tight, and all the parts working as they should, and train pipe pressure was kept constantly at seventy pounds, a one hundred car train could be charged as quickly as could one car, as under such perfect condition the air will pass through the feed grooves at the rate of one pound a second, but as this is never the case in actual practice, it ordinarily takes about five minutes to charge up a short train of ten cars, and about twelve to fifteen minutes for a train of thirty or forty cars, with comparatively no train pipe leaks, and where there are leaks it, of course, takes much longer.

Train pipe leaks should be carefully guarded against. There are three kinds of applications, as follows: "full service," "partial service" and "emergency." The method of making a full service application has just been described. Partial service application is made possible by means of the graduating valve, 25, see Fig. 28, as for instance if a reduction of 10 pounds is made on the train pipe the triple will automatically lap itself as soon as a fraction over 10 pounds has left the auxiliary.

This is done as follows: when the train pipe pressure is reduced below that in the auxiliary the triple piston moves and carries with it the graduating valve, which, as will be seen by reference to Fig. 28, is connected directly to the stem of the triple piston by a small pin, as shown by the dotted lines, and, when the piston moves, the graduating valve is carried from its seat in the slide valve and opens port p, so that when the slide valve is in service position the auxiliary air can pass through the slide valve by way of ports l and p, then through port f in the seat of the slide valve and on through pipe connection X direct into the brake cylinder. As only ten pounds are drawn from the train pipe, just as soon as a fraction over ten pounds flows from the auxiliary, the train pipe pressure being now the strongest forces the triple piston towards the auxiliary end of its cylinder, but it can only force it a very short distance, for the reason that the distance between the end of the slide valve and the shoulder on the stem of the piston is only three-sixteenths of an inch, and when the piston has moved this distance it is stopped by the slide valve, because the auxiliary pressure, aided by the U spring, is firmly holding the slide valve, on account of the friction being greater on the slide valve seat than it is around the edge of the triple piston, and when the piston is thus stopped by the slide valve, the graduating valve is now back on its seat, and no more air can flow from the auxiliary into the brake cylinder, until the train pipe pressure is again reduced and the graduating valve again unseated by the movement of the triple piston.

The slide valve does not move when the second reduction is made, but stands in the same position it assumed on the first reduction. Consequently, as soon as the graduating valve is unseated the air will again flow into the brake cylinder; but when the air in the brake cylinder finally becomes as strong as it is in the auxiliary (or equalizes) the pressure in the auxiliary no longer falls below that in the train pipe, and therefore the graduating valve remains off its seat, because the triple piston does not now move back as it did when the first reduction was made, as the pressure in the train pipe is now as low or lower than it is in the auxiliary, and the brakes are now fully applied.

Hence a full service application can be made without the graduating valve, but in making a "partial service application," this valve is a very important factor.

If the engineer simply wants to slow his train up, but does not want to come to a full stop, he can draw off any amount of air from the train pipe he desires, and when he laps his brake valve, the triple valve will, by means of the graduating valve, let a corresponding amount of air from the auxiliary into the brake cylinder and automatically lap ports l-p-p in the slide valve, but if the engineer should draw his train pipe pressure down below the point at which the auxiliary and brake cylinder equalize, he would not only be wasting the train pipe pressure, but would have trouble when it came time for him to release his brakes, as will be explained later on.

As has already been mentioned, the third kind of an application is called the "emergency." When this kind of application is made it is only in case of danger, and therefore it is desired that the air in the auxiliary should be passed into the brake cylinder as quickly as possible, and in order to do this it is necessary to have the slide valve entirely clear the port in the seat through which the air has to pass.

In making ordinary stops this very quick action is not required, and in order to prevent the slide valve making the full stroke, there is a projection on the train pipe side of the triple piston which strikes against the graduating stem, 26, and as this stem is held to its seat by the graduating spring, 27, the strength of this spring combined with the pressure in the train pipe causes the triple piston to stop, and in doing so the slide valve is held in such a position that port p is in register with port f, and of course the brakes are applied gradually.

But if the pressure in the train pipe is reduced suddenly, the auxiliary pressure causes the triple piston to strike the graduating stem a hammer blow and overcomes the tension of the spring so that the slide valve entirely clears the port in the seat, and the auxiliary pressure immediately equalizes with the brake cylinder. (This refers to the plain triple. The emergency action of the quick-action triple will be described later on, and also the action of the "K" triple.)

The U spring, 32, is placed over the slide valve for the reason that if the brake is applied and all the air is let out of the train pipe, and the car cut off from the engine, the brake could not be "bled" off by the release valve on the auxiliary if the slide valve could not be lifted off its seat by the brake cylinder pressure, but as there is a slight lift to the slide valve for this purpose, the U spring is required to reseat the valve, so that when the auxiliary is again recharged no air can get under the slide valve and pass out to the atmosphere through port h in the valve seat.

If there is a great deal of oil on the slide valve seat it will prevent the slide valve from being forced up by brake cylinder pressure, when a single car is being "bled off," and the brake cannot be released at all until the air finally leaks out around the packing leather in the cylinder. In such a case the release signal is very handy.

THE WESTINGHOUSE QUICK ACTION TRIPLE VALVE.

Fig. 29 shows this valve in release and charging position, and the parts are numbered as follows:

A. Train pipe connection.

B. Auxiliary reservoir connection.

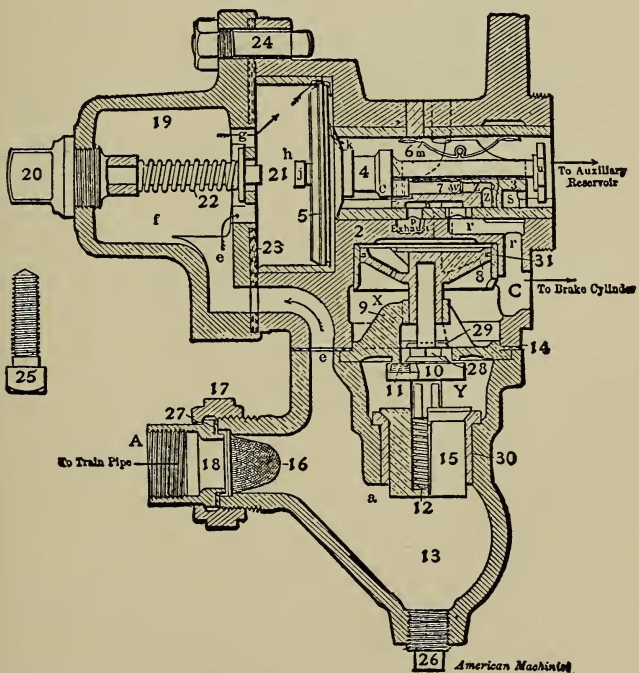


Fig. 29—Quick-Action Triple in Release and Charging Position.

C. Cylinder connection.
3. Slide valve.
4. Triple piston and stem.
5. Triple piston packing ring.
6. U or slide valve spring.
7. Graduating valve.
8. Emergency valve piston.
9. Emergency valve seat and guide.
10. Rubber seated emergency valve.
12. Check valve spring.
14. Check gasket.
15. Check valve.
21. Graduating stem.
22. Graduating spring.
23. Triple gasket.

The air passages and ports are described in the text. The feed groove, i, is now open.

The parts contained in the quick-action triple which are not in the plain triple are shown in Figs. 29, 30, 31 and 32, and are indicated as follows: The emergency piston is marked 8; the guide for this piston, which also forms a seat for the emergency valve, is marked 9; the emergency valve is 10; the check-valve spring is 12; the check valve is 15, the gasket which separates chamber X from chamber Y is marked 14. This gasket, it will be noted, extends clear across the triple, but a portion of it is cut away just over the emergency valve, so that when that valve is unseated, as it is in an emergency application, the air in chamber Y can pass into chamber X and the brake cylinder, and another hole is cut in this same gasket at e, so that the train pipe pressure, which enters the triple at A, can pass freely into chambers f and h.

RELEASE AND CHARGING.

The quick-action triple has five positions: release, charging, service, lap and emergency.

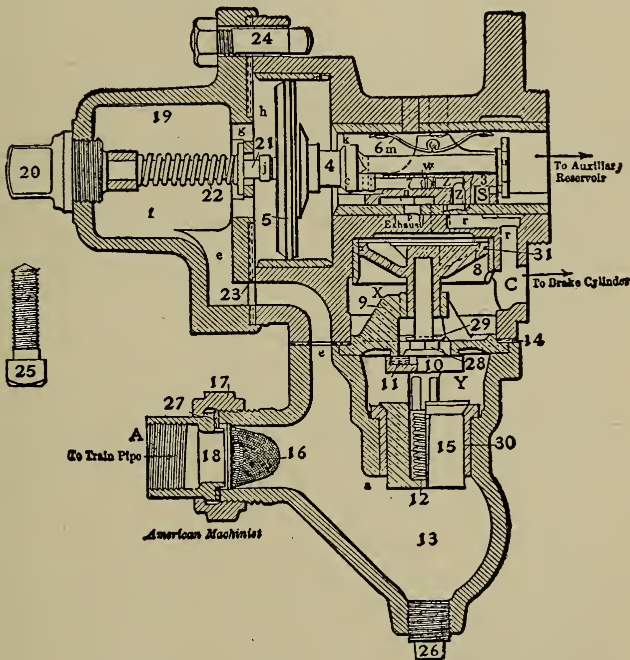


Fig. 30—Quick-Action Triple in Service Position.

Release and charging positions are really one and the same, and are shown in Fig. 29. While the air is being released from the brake cylinder by way of the ports in the slide valve seat, etc., as previously illustrated in Fig.

28, the auxiliary is being charged by way of the feed grooves described in Fig. 28 as m and n, but in Fig. 29 they are marked i and k.

By referring to Fig. 29, and following the course of the arrows it will be seen that after the air enters the triple at A it passes through a passage in the casing, to a chamber having two openings into the cylinder containing the triple piston, and from this cylinder the air passes through the two feed grooves marked i and k, on into the slide-valve chamber, and instead of entering the auxiliary at the pipe connection Y, as in Fig. 28, it passes right on through the slide-valve chamber into the auxiliary, so that whether it is a plain or quick-action triple the auxiliary pressure is always on the slide-valve side of the triple piston, and train pipe pressure is on the opposite side.

SERVICE POSITION.

In this position, shown in Fig. 30, it will be seen that the triple piston has moved in its cylinder until the projection j strikes against the graduating stem, which stops it, and in making this movement the stem of the piston has drawn the slide valve to a position which places the port marked w, z-z in register with the port in the seat marked r, thus allowing the auxiliary pressure to pass into the brake cylinder through pipe connection C and set the brake.

LAP POSITION.

Lap position, Fig. 31, means that all ports are closed, and the reason why the triple automatically laps itself is due to the fact that when the slide valve is moved to service position the graduating valve is held off its seat at w by the triple piston and when the pressure in the auxiliary becomes slightly less than train pipe pressure the piston is forced back by the train pipe pressure until the graduating valve strikes its seat in the slide

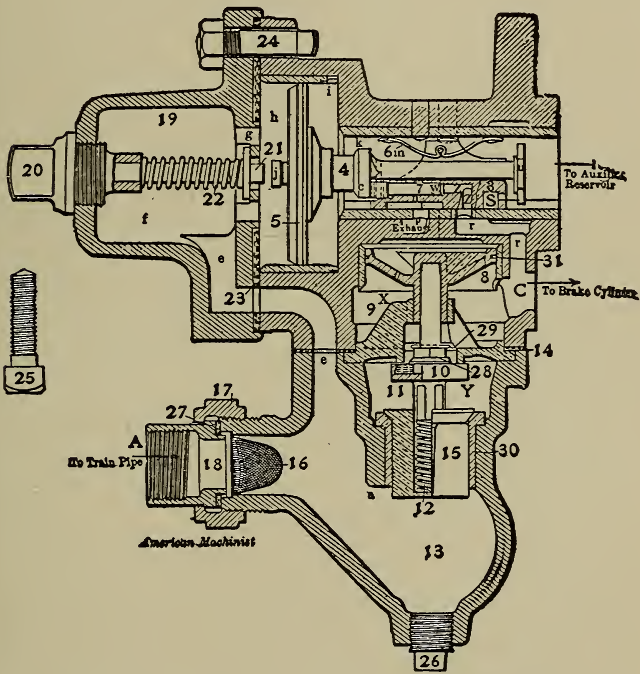


Fig. 31—Quick-Action Triple in Lap Position.

valve, and stops the flow of the auxiliary air into the brake cylinder.

The reason the slide valve is not moved when the graduating valve moves is because the auxiliary and train pipe pressure are so nearly equal that the friction of the slide-valve seat, combined with the tension of the slide valve spring (marked 6), prevents it, and as this keeps the exhaust port closed, and the position of the triple piston keeps feed groove i closed, all ports are now closed and the valve is said to be on lap.

The triple will not lap itself unless the auxiliary pressure has a chance to get lower than train pipe pressure, which means that if an engineer reduces his train pipe pressure below the point at which the auxiliary and brake cylinder pressures equalize, the only means of holding the air in the brake cylinder (aside from the packing leather around the brake piston and the closing of the triple exhaust) is the check valve, 15, or the packing ring, 30, of the triple piston, for while it is true that the piston would seat against gasket 23, still this gasket so soon becomes hard that it cannot be relied upon to stop the auxiliary pressure from flowing back into the train pipe.

The reason the check valve has to be depended upon to keep the brake cylinder pressure from flowing back into the train pipe, after an extra heavy reduction has been made, is because the air in chamber Y will reduce as fast as the train pipe pressure is reduced, on account of the volume in Y being so small that the slightest possible leak in the seat of the check valve will let it out, and after the train pipe pressure has been drawn down sufficient to allow the auxiliary and brake cylinder to equalize, the leak from chamber Y is supplied by the brake cylinder, for whenever the pressure in Y becomes less than that in the brake cylinder the emergency valve, 10, is forced off its seat by the brake cylinder pressure until it equalizes again with chamber Y, when the spring, 12, reseats valve 10, which is done very quickly, consequently if the train pipe pressure was entirely exhausted and the check valve leaked very badly the brake cylinder would very quickly be robbed of its pressure and let the brake off. It is, therefore, very bad practice to ever reduce the train pipe pressure below the point at which the auxiliary and brake cylinder equalizes, except in an emergency.

EMERGENCY POSITION.

A sudden reduction of train pipe pressure is necessary to cause the triple to assume emergency position.

When a sudden reduction is made it causes the triple pistion, 4, to strike the graduating stem, 21, such a hammer blow that the graduating spring, 22, is unable to stop it from making its full stroke, and as it has now traveled further than it did in service position, the slide valve has also been moved a correspondingly greater distance on its seat, which brings a big slot, or in some triples, a removed corner (not shown) in the slide valve over a port in the seat (indicated by dotted lines behind port Z), and allows the auxiliary pressure to fall on the emergency piston, 8, which strikes the stem of valve 10 and forces it from its seat (which is kept closed by spring 12 and the train pipe pressure in Y), and valve 10 being thus unseated, the air from Y rushes into the brake cylinder.

As all this is done so very quickly that the train pipe pressure has as yet reduced but very little, the remaining train pipe pressure forces the check valve up and also rushes into the brake cylinder until it equalizes with what is left in the train pipe, when spring 12 reseats the check valve, preventing the air in the brake cylinder from flowing back into the train pipe.

At the same time that the big slot in the back of the slide valve reached its position over the port in the seat leading to the emergency piston, another small port in the slide valve, marked S in Fig. 31, is placed in register

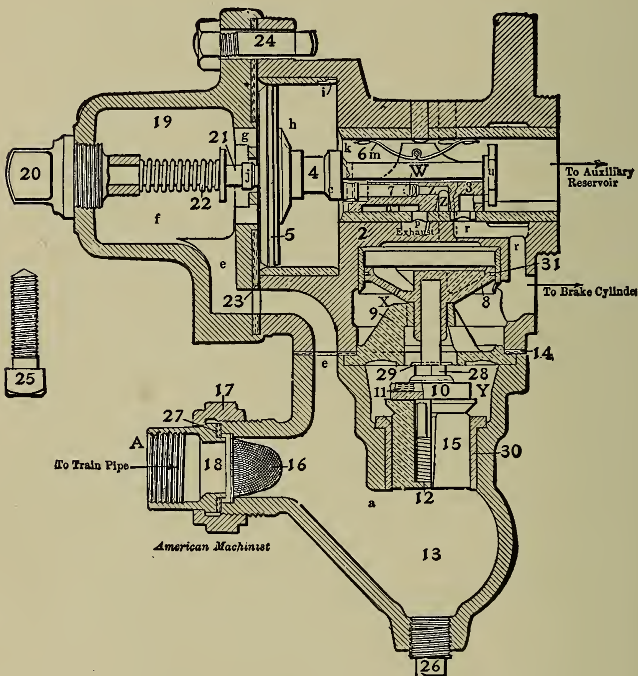


Fig. 32—Quick-Action Triple in Emergency Position.

with port r in the valve seat, taking the place of port Z, which allows the auxiliary pressure to flow into the brake cylinder on top of what went in from the train pipe.

The opening around the emergency valve is so much larger than port S in the slide valve that virtually no air enters the brake cylinder from the auxiliary until the check valve closes on the charge received from the train pipe.

It is this air from the train pipe that gives the added percentage of brake power after an emergency application; for the air which enters the brake cylinder from the train pipe has the same effect as shortening the piston travel, because it forces the auxiliary pressure to equalize just that much higher than it would if the brake cylinder was empty when the auxiliary pressure started to flow into it.

On account of the train pipe pressure having two outlets (one by way of the brake valve, and the other by way of valve 10) when an emergency application is made, it is reduced so suddenly that the next triple is thrown into quick action, because the pressure that was holding that triple to release position immediately rushes back into the empty space just created in the train pipe by the first reduction, and the triple is left without sufficient train pipe pressure to hold it, when the pressure on the auxiliary side of that triple piston drives it to emergency position, which in turn creates a vacancy in the train pipe on that car which the next car tries to fill, and so on, till all the brakes on the entire train are set in emergency.

The new passenger triple valve, style L, now being made by the Westinghouse Air Brake Company, is arranged to operate with two auxiliary reservoirs for the purpose of enabling the engineer to gradually release and quickly re-apply the car brakes.

TRIPLE VALVE, AUXILIARY RESERVOIR AND BRAKE CYLINDER COMBINED.

Figure 33 illustrates a freight equipment. The brake cylinder, 2, is bolted directly to the auxiliary reservoir, 10, and while the supply pipe, b, runs through the auxiliary and into the cylinder, still the air in the auxiliary cannot get into the cylinder except by way of the ports in the triple, as previously described, for the left end of pipe b is connected with the triple at C, as shown in Fig. 31.

The gasket between the auxiliary and brake cylinder is not for the purpose of separating them, but is to make the cylinder air-tight at that end, and when the brakes are set, the other end of the cylinder is made air-tight by the packing leather, 7, around the piston head, 3, which is held to its place by the expansion ring, 8, and follower, 6. Spring 6 is to force the piston back when the air is let out of the cylinder.

To prevent the brakes from setting on account of train-pipe leaks, there is a small leakage groove, a, cut in the wall of the cylinder for about three inches from the extreme left end, or pressure head, so that any small amount of air that might be let into the cylinder through the triple, from any cause, would escape to the atmosphere, instead of pushing the piston out, by passing through the leakage groove by the piston head, and out around piston 3.

The Release Valve 17 or "bleeder," is for the purpose of drawing the air from the auxiliary, and when a car is set out, and *especially* when a brake is cut out, the release valve should be held open until all the air in the auxiliary has escaped, for if any air is left in it the

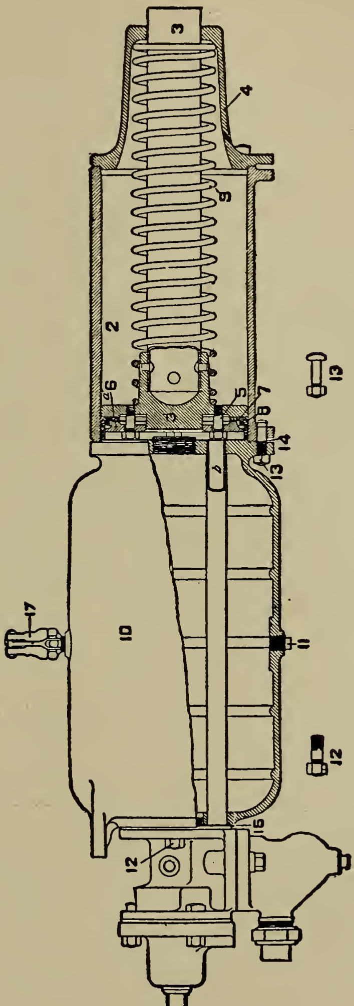


Fig. 33—Triple Valve Auxiliary Reservoir and Brake Cylinder Combined.

brake will again set whenever the trainpipe pressure is reduced lower than that in the auxiliary. Whenever a brake cannot be released from the engine, but has to be "bled off," either at the auxiliary, or by the release signal valve inside the car, always cut that brake out at the first opportunity and *drain* the auxiliary.

Where cars are equipped with the new release signal the brakeman can keep a brake off that is inclined to stick, until the train is in a safe position to allow him to get down and cut the brake out.

If the auxiliary release valve leaks and it cannot be stopped by one or two quick jerks, to dislodge the dirt that is causing it to leak, cut the brake out, as no air can accumulate in the auxiliary, making that brake worthless, and the leak is drawing air from the trainpipe, which affects the rest of the brakes. Should the release valve become clogged so that no air could be drawn through it, remove the drain plug 11 in the under side of the auxiliary. This plug will not have to be removed, of course, where a car is equipped with the release signal as the brake cylinder can be emptied independent of the action of the triple, by simply opening the valve of the release signal.

Pressure Retaining Valve.

This device illustrated by Fig. 34, is for the purpose of retaining a certain amount of pressure in the brake cylinder after the triple valve has been moved to release position. It is attached as follows:

Into the triple exhaust a small pipe is connected and extends from the triple to the top of the car at the end where the hand-brake staff is, and onto this pipe is attached the retaining valve at the connection marked X.

The handle 5 controls a plug 6 similar to the cutout plug 13 in the plain triple. When the handle is turned as shown in Fig 34, port c through the plug is in register with port b-b, and the air which comes from the triple

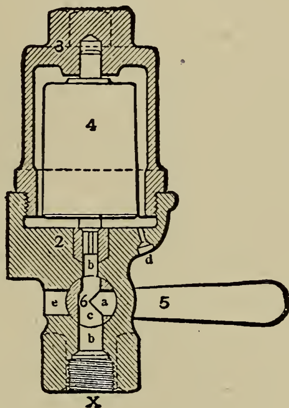


Fig. 34—Pressure-Retaining Valve in Retaining Position.

X. Triple exhaust connection. 5 Handle.
4. Retaining valve weight. 6. Cut-out plug.

exhaust is forced against the seat of the valve 4, which raises and allows the pressure to escape to the atmosphere through port d. As port d is controlled by valve 4, the air will exhaust only while this valve is up, and as the weight of the valve, combined with the size of the ports, requires a pressure of fifteen pounds to keep it up, just as soon as the pressure in the brake cylinder has been reduced to a fraction less than fifteen pounds to the square inch, the valve will seat and retain the remaining pressure in the brake cylinder until the handle is turned down. When the handle is turned down it brings port a in register with the lower part of b, and port c is turned to register with port e, and thereby allows all the air in the brake cylinder to escape to the atmosphere.

Therefore if the handle of the retainer is kept turned down the engineer can release the brakes from the en-

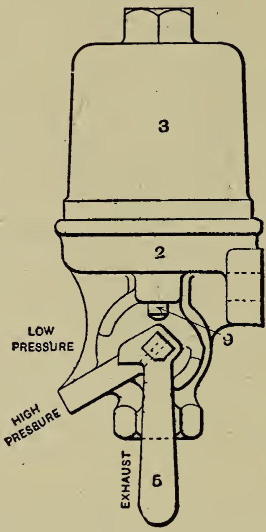


Fig. 34*a*—Three-Position Retaining Valve for Heavy Freight Cars.

gine, but if the handle is turned up (unless the brake leaks off) it will stay set until the handle is turned down.

Retainers were formerly made to hold only ten pounds in the brake cylinder, but are now made to hold fifteen or fifty pounds.

With the retainer handle turned up, the second application of the brakes will give a much higher brake-cylinder pressure, if the auxiliary has been allowed time enough to recharge, because the pressure that is already in the cylinder will force the auxiliary to equalize much higher than it would if the cylinder was empty to start with (in the same manner that the emergency application causes an added pressure on account of the train pipe pressure entering the cylinder before the auxiliary pressure has a chance to get in). For this reason it is best to apply the brakes and recharge the auxiliaries as soon as possible after passing the summit of a mountain grade, and besides it gives an increased reserve of brake power.

THE "K" TYPE FREIGHT TRIPLE VALVE.

The Westinghouse Air Brake Company at frequent intervals, adds new and improved apparatus to its air brake equipment, after having first subjected the new device to the most rigid, and severe test in the workshop. In view of the fact that air brake construction, like all other branches of the useful arts, is continually advancing it is plainly evident that the man whose daily duties require him to care for, and operate the air brake, must study if he would keep pace with the march of progress. One of the most important of these recent additions is the device known as the "K" triple valve.

The "K" type triple valve differs from the standard quick action triple valve in three particulars: First, it allows a small amount of train pipe pressure to be vented into the brake cylinder when a service application is made, regardless of the location of the triple in the train. Second, it automatically retards the release of the brake cylinder pressure when the K triple is located within thirty cars from the engine. Third, it retards the charging of the auxiliary reservoir when the K triple is located within thirty cars from the engine.

By venting a small amount of train pipe pressure into the brake cylinder during a service application, it produces a much higher braking power than is produced by the standard quick action triple, and this feature is primarily intended to cause the brakes throughout the train to be applied as nearly uniform as possible. The uniformity of application and release was the point in view when this triple was made and the increased brake power was merely incidental, in fact, in view of the many old style quick action triples which are now in use, it would be preferable if the uniform application could be secured without having to apply the brakes harder in service with this triple than with the old style quick action triple.

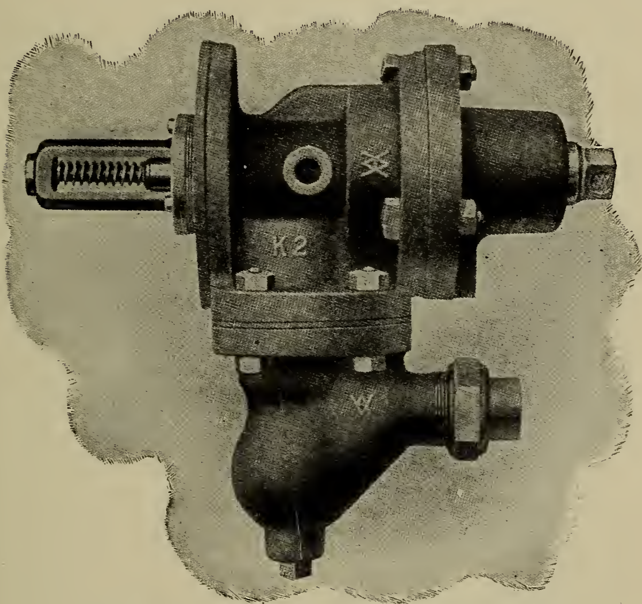


Fig. 35—The Type "K" Freight Triple Valve.

The retarding of the brake cylinder pressure is produced by holding the brakes applied on the head end of the train until the rear end brakes have had a chance to release, and as the force of the train pipe pressure would be materially decreased if the auxiliary feed groove in the triples on the head end of the train were wide open, it was therefore necessary to temporarily choke the feed groove on the head cars so that the trainpipe pressure instead of rushing into the auxiliary will have to keep moving toward the rear end of the train, thereby driving those triple pistons to release position before the pressure in the trainpipe has had a chance to expand into the auxiliary reservoir.

The choking of the triple feed groove on the head cars is produced by the trainpipe pressure overcoming the retarding spring in the triple, thereby moving the piston beyond the normal position, which closes the regular feed groove and allows the auxiliary to receive trainpipe pressure by way of a restricted opening through the slide valve. The latest type of K triple has a restricted feed groove on the back of the piston, doing away with port 1.

The importance of this restricting of the feed groove will be easily understood when it is remembered that with the ordinary Westinghouse Automatic Engine Equipment on a 50-car train with a 50,000 cubic inch main reservoir, a 9½-inch pump carrying a 70-pound train line pressure and a 100-pound main reservoir pressure, after a trainpipe reduction of 20 pounds, when the handle of the brake valve is thrown to full release position it will raise the trainpipe pressure in ten seconds to about 78 pounds on the first car, 57 pounds on the 25th car and only 53 pounds on the last car. Consequently if the head brakes were allowed to release immediately when the handle was thrown to release position, the result would be that the rear brakes would either give the train a fearful shock or else pull it in two.

The new valve is at present manufactured in two sizes, the "K-1" for use with 8-inch freight-car brake cylinders, corresponding with the H-1 (F-36), and the "K-2" with 10-inch freight-car brake cylinders, corresponding with the H-2 (H-49). The K-1 will bolt to the same reservoir as the F-36, and the K-2 as the H-49. Each valve is marked with its designation on the side of the valve body, and the K-2 may be distinguished from the K-1 by the fact that it has *three*, as compared with *two*, bolt holes in the reservoir flange. Also, in order to distinguish the type K valves from the old standard type, their exterior being similar when they are attached to the auxiliary reservoir, a lug is cast on the top of the valve body, as shown in Fig. 35. This enables anyone to locate them at once. With the K-2-A triple the retarding Spring is contained inside of triple casing, thereby avoiding the danger of having it broken off.

Figure 36 is a vertical cross section of the K-2 triple valve, and the names of the various parts are as follows:

2, Valve Body; 3, Slide Valve; 4, Piston; 5, Piston-Packing Ring; 6, Slide-Valve Spring; 7, Graduating Valve; 8, Emergency Piston; 9, Emergency-Valve Seat; 10, Emergency Valve; 11, Emergency-Valve Rubber Seat; 12, Check-Valve Spring; 13, Check-Valve Case; 14, Check-Valve-Case Gasket; 15, Check Valve; 16, Air Strainer; 17, Union Nut; 18, Union Swivel; 19, Cylinder Cap; 20, Graduating-Stem Nut; 21, Graduating Stem; 22, Graduating Spring; 23, Cylinder-Cap Gasket; 24, Bolt and Nut; 25, Triple-Valve Cap Screw; 26, Drain Plug; 27, Union Gasket; 28, Emergency-Valve Nut; 29, Retarding-Device Bracket; 30, Retarding-Device Screw; 31, Retarding-Device Stem; 32, Retarding-Device Washer; 33, Retarding-Device Spring; 34, Retarding-Device-Stem Pin; 35, Graduating-Valve Spring.

Figure 37 shows the relative position of the ports and cavities in the slide valve, graduating valve, and slide-valve seat of the K-2 Triple Valve. As it is difficult to show all of these in a single section, diagrammatic cuts of the valve in each of the principal positions have been used, all ports and passages having been so arranged as to place them in one plane. In preparing these cuts, the actual proportion and mechanical construction of the valve has been disregarded for the purpose of making the connections of ports, and operation, more easily understood.

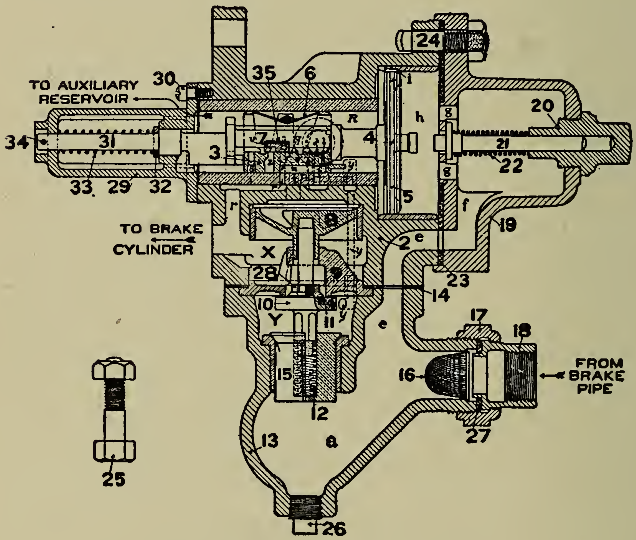


Fig. 36—The K-2 Triple Valve.

The retarding groove in the exhaust cavity of the slide valve has now been changed to a round port, in order to insure the opening of that port when the triple is in Retarded Release position.

EXPLANATION OF FIGS. 36 AND 37.

Referring to Fig. 36, the branch from the brake pipe connects at union swivel 18. The retarding-device bracket 29 projects into the auxiliary reservoir, and by its construction free communication exists between the auxiliary reservoir and chamber R, in which the slide-valve 3 and graduating valve 7 operate. The retarding-device stem 31, through its extension into chamber R, and the action of its spring 33, forms the stop against which the stem of piston 4 strikes when it moves to the release position (from right to left in the cut, it being shown in full-release position).

The opening marked "To Brake Cylinder" comes opposite one end of the tube which leads through the auxiliary reservoir to the brake cylinder, when the valve is bolted in place on the end of the auxiliary reservoir. This opening in the triple valve leads to chamber X over the emergency valve 10, and under the emergency piston 8. Also, it leads through port *r* to the seat under slide valve 3 (Fig. 37). The emergency piston 8 and the parts below it are the same as in the older quick-action freight triple valve. Port *y* (shown by dotted lines) connects chamber Y, between check valve 12 and emergency valve 10, with port *y* in the valve seat (Fig. 37).

Port *t* connects the slide-valve seat with the chamber above emergency piston 8. Port *p* is the exhaust port to the atmosphere. Port *j* in the slide valve begins at the face, as shown by the top view, Fig. 37, and passes around other ports in the valve to a smaller opening in the top. (NOTE:—This port *j* does not exist in the K-1 Triple Valve, as will be explained later.) Port *o* is sim-

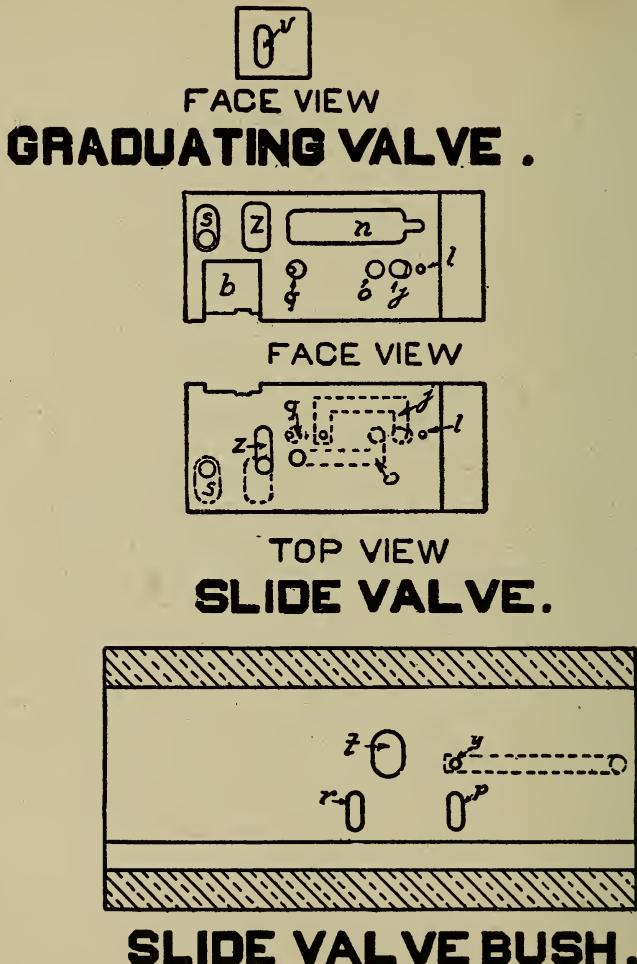


Fig 37—Slide Valve, Graduating Valve and Slide-Valve Seat of K-2 Triple Valve.

NOTE.—The latest type K triple does not have port 1, but has a groove on the back of the piston as a feed groove for retarded charge-up.

ilarly arranged, except that openings in top and bottom are alike in size. Port *q* runs directly through the slide valve, but is smaller at the top than at the face of the valve, and the smaller part is out of center with the larger part. Ports *s* and *z* run through the valve and connect with cavities in the face; port *z* also has a cavity at the top.

The face view of the graduating valve shows that it has a small cavity *v*. This valve is of the slide-valve type, and it seats on the top of the slide valve, where it controls the upper ends of ports *z*, *q*, *o*, and *j*. The purpose of the cavity *v* is to connect the upper ends of ports *o* and *q* in a service application, as explained in detail later.

As shown by the face view of the slide valve, *n* is a long cavity having a narrow extension at the right hand end. This cavity connects the ports through which the air escapes from the brake cylinder in releasing. Port *b* is cut diagonally from the face till it just cuts into edge, at the top of the slide valve. It admits auxiliary-reservoir pressure to port *t* in an emergency application.

With this explanation, and by occasional reference from the diagrammatic views to those in Fig. 37, the same ports being lettered alike, a clear understanding will be obtained of both the operation and actual arrangement of ports of the triple valves.

FULL RELEASE AND CHARGING POSITION.

Fig 38 is a diagrammatic view of the triple valve in this position Air from the trainpipe flows through passage *e*, cylinder cap *f*, and ports *g* to chamber *h*; thence through feed groove *i*, now open, to chamber R above the slide valve, which is always in free communication with the auxiliary reservoir. The feed groove *i* is of the same dimension as that of the old standard H-1 (F 36) triple valve, which is designed to properly charge the auxiliary reservoir of an 8-inch brake cylinder, and prevent any appreciable amount of air from feeding back into the trainpipe from the auxiliary reservoir during an application. For this reason, the feed groove of the

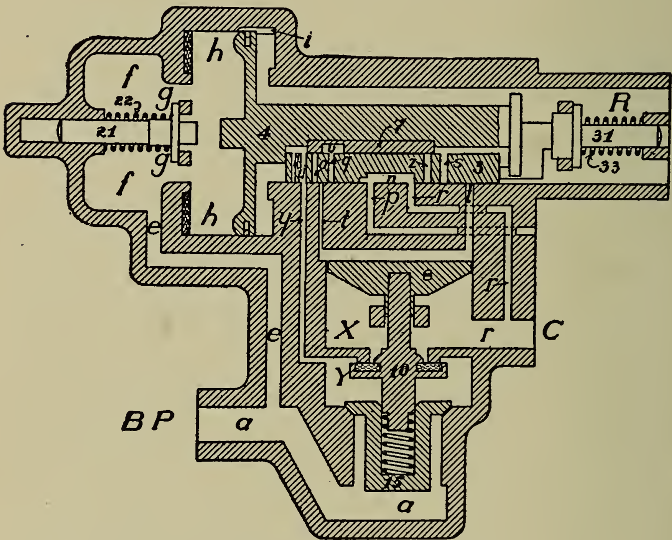


Fig. 38—K-2 Triple—Full-Release and Charging Position.

K-2 triple valve is made the same size as the K-1, so that it is necessary in the K-2 triple to increase the charging port area, through which the air can feed into the auxiliary reservoir, sufficiently to enable it to handle the greater volume of the auxiliary reservoir of a 10-inch brake cylinder. In order to do this, the small port *j* is added to the slide valve of the K-2 triple valve only; this port registers with port *y* in the slide-valve seat, when in the full release position. Air then passes from chamber Y, through ports *y* and *j* to chamber R, and the auxiliary reservoir. Trainpipe air in *a* raises check valve 15 and supplies chamber Y with air as fast as it is required. Port *j* is so proportioned that the rate of charging the auxiliary reservoir of a 10-inch brake cylinder is made practically the same as that of the 8-inch, which in full release is fed through the feed groove *i* only. In the following description, the K-2 triple valve only is referred to; the operation of the K-1 is exactly the same except for the absence of port *j*.

Air flows from the trainpipe to the auxiliary reservoir until their pressures become equal, when the latter is then fully charged.

QUICK-SERVICE POSITION.

To make a service application of the brakes, air pressure is gradually reduced in the trainpipe, and thereby in chamber *h*. As soon as the remaining pressure in the auxiliary reservoir and chamber R becomes enough greater than that in chamber *h*, to overcome the friction of the piston 4 and graduating valve 7, these two move to the left until the shoulder on the end of the piston stem strikes against the right-hand end of the slide valve, when it also is moved to the left until the piston strikes the graduating stem, 21, which is held in its place by the compression of the graduating spring, 22. The parts of the valve are then in position shown in Fig. 39. The first movement of the piston closes the feed groove *i*, preventing air from feeding back into the trainpipe from the auxiliary reservoir, and also opens the upper end of port *z* in the slide valve, while the movement of the latter closes the connection between port *r* and the exhaust port *p*, and brings port *z* into partial registration with port *r*, in the slide valve seat. Auxiliary reservoir pressure then flows through port *z* in the slide valve and port *r* in the seat to the brake cylinder.

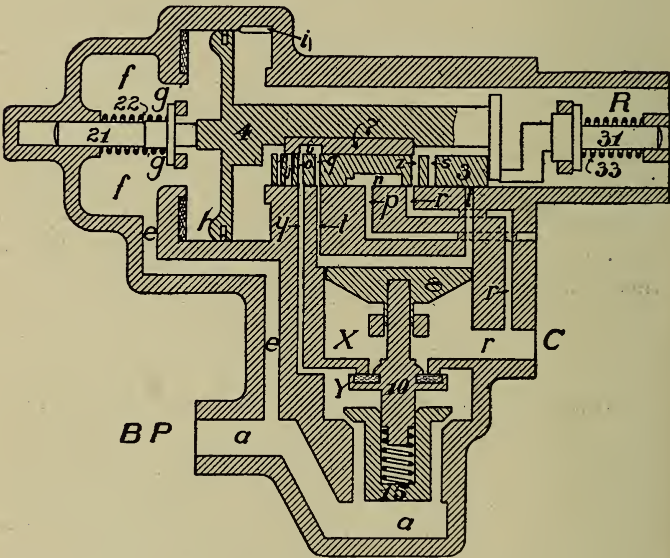


Fig. 39—K-2 Triple—Quick Service Position.

At the same time, the first movement of the graduating valve connected the two ports *o* and *q* in the slide valve, by the cavity *v* in the graduating valve, and the movement of the slide valve brought port *o* to register with port *y* in the slide valve seat, and port *q* with port *t*. Consequently the air pressure in chamber Y flows through ports *y*, *o*, *v*, *q* and *t*, thence around the emergency piston 8, which fits loosely in its cylinder, to chamber X and the brake cylinder. When the pressure in chamber Y has reduced below the trainpipe pressure remaining in *a*, the check valve raises and allows trainpipe air to flow by the check valve and through the ports above mentioned to the brake cylinders. The size of these ports is so proportioned that the flow of air from the trainpipe to the top of emergency piston 8, is not sufficient to force the latter downward and thus cause an emergency application, but at the same time takes considerable air from the trainpipe, thus increasing the rapidity with which the trainpipe reduction travels through the train.

With the ordinary quick action triple valve in a service application, all of the trainpipe reduction has to be made at the brake valve, and the resulting drop in pressure passes back through the train at a rate depending on its length, size of trainpipe, number of bends and corners, etc., which cause friction and resistance; also a much heavier application of head than of rear brakes is caused at the beginning of the application, thereby running the slack in, which is liable at low speeds to be followed by the slack running out suddenly when the rear brakes do apply, causing loss of time and difficulty in making quick slow downs and accurate stops, and, with very long trains, results in such serious losses through leakage grooves and feed grooves as to lose much braking power and even prevent some brakes from applying. With this new triple valve, only a small part of the reduction is made at the brake valve, while each triple acts momentarily as a brake valve to increase the reduction under each car, thereby rendering the resistance and friction in the trainpipe of much less effect, and hastening the application throughout the train.

This is called the "Quick-Service" feature, and by means of it the rapidity of a full service application on a 50-car train is increased about fifty per cent. The rapid reduction of trainpipe pressure moves the main piston 4 quickly to the service position and cuts off any flow back from the auxiliary reservoir through the feed groove to the trainpipe; it rapidly drives the brake-cylinder piston beyond the leakage groove, and prevents loss of air through it; and yet permits applying with as moderate a brake force as desired. It also greatly reduces the trainpipe reduction necessary at the brake valve for a certain brake-cylinder pressure, due to the fact (1) that part of the reduction takes place at each triple valve and (2) that the air taken from the trainpipe into the brake cylinder gives a little higher pressure than if the auxiliary-reservoir pressure alone were admitted, thus requiring a smaller trainpipe reduction for the same cylinder pressure.

FULL-SERVICE POSITION

With short trains, the trainpipe volume, being comparatively small, will reduce more rapidly for a certain reduction at the brake valve than with long trains. Under such circumstances the added reduction at each triple valve by the quick-service feature, might bring about so rapid a trainpipe reduction as to cause quick action and an emergency application, when only a light application was intended. (The emergency application is explained later.) But this is automatically prevented by the triple valve itself. By Fig. 39, it will be noted that in the quick-service position, port *z* in the slide valve and port *r* in the seat do not fully register. Nevertheless, the opening is sufficient to allow the air to flow from the auxiliary reservoir to the brake-cylinder with sufficient rapidity to reduce the pressure in the auxiliary reservoir as fast as the pressure is reducing in the train-pipe, when the train is of considerable length. But if the trainpipe reduction is more rapid than that of the auxiliary, the difference in pressures on the two sides of piston 4 soon becomes sufficient to slightly compress the

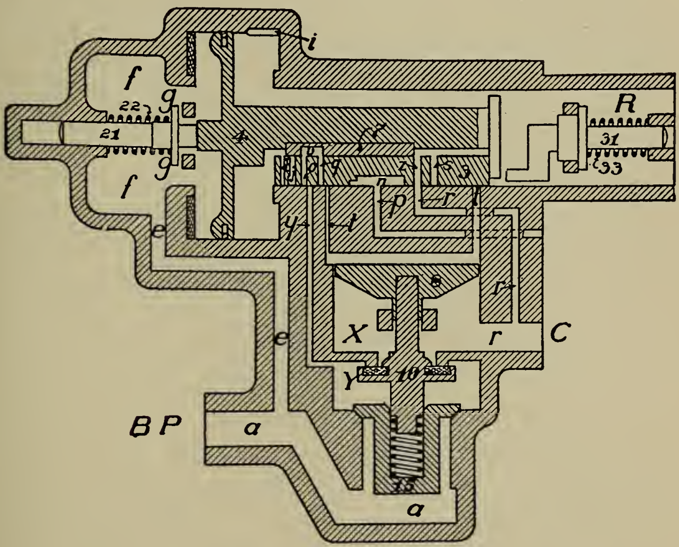


Fig. 40—K-2 Triple—Full Service Position.

graduating spring, and move the slide valve to the position shown in Fig. 40, called *"Full Service."* In this position, quick service port *y* is closed, so that no air flows from the trainpipe to the brake cylinder; the trainpipe reduction being sufficiently rapid, there is no need of the additional quick-service reduction, so the triple valve cuts it out. Also, ports *z* and *r* are fully open, and allow the auxiliary-reservoir pressure to reduce more rapidly, so as to keep pace with the more rapid train-pipe reduction.

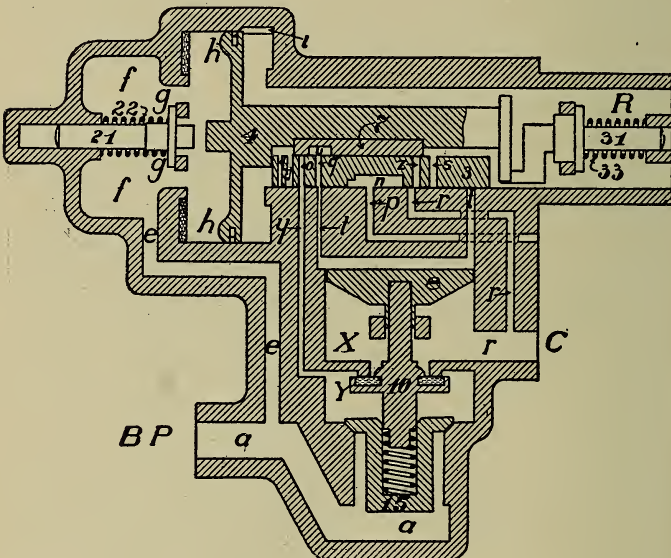


Fig. 41—K-2 Triple—Lap Position.

LAP POSITION

When the trainpipe reduction ceases, air continues to flow from the auxiliary reservoir through ports *z* and *r* to the brake cylinder, until the pressure in the chamber R becomes enough less than that of the trainpipe to cause piston 4 and graduating valve 7 to move to the right until the shoulder on the piston stem strikes the left-hand end of slide valve 3. As the friction of piston and graduating valve is much less than that of the slide valve, the difference in pressure which will move the piston and the graduating valve, will not be sufficient to move all three; consequently, the piston stops in the position shown in Fig. 41. This movement has caused the graduating valve to close port *z*, thus cutting off any further flow of air from the auxiliary reservoir to the brake cylinder. Consequently, no further change in air pressures can occur, and this position is called "Lap," because all ports are *lapped,*—that is, closed.

If it is desired to make a heavier application, a further reduction of the trainpipe pressure is made, and the operation described above repeated, until the auxiliary reservoir and brake cylinder pressures become equal, after which any further trainpipe reduction is only a waste of air. About twenty pounds trainpipe reduction will give this equalization.

RETARDED RELEASE AND CHARGING POSITION.

The K triple valve has two release positions, full-release and retarded-release. Which one its parts will move to when the train brakes are released, depends upon how the trainpipe pressure is increased; if slowly, it will be full release, and if quickly and considerably, if the triple is located within 30 cars from the engine, it will be retarded-release. It is well known that in a freight train, when the engineer releases the brakes, that the rapidity with which the trainpipe pressure increases on any car depends on the position of the car in the train. Those cars towards the front, receiving the air first will have their trainpipe pressure raised more rapidly than those in the rear. With the old standard apparatus, this is due to two things: (1) the friction in the trainpipe; (2) the fact that the auxiliary reservoirs in the front at once begin to recharge, thus tending to reduce the pressure head by absorbing a quantity of air and holding back the flow from front to rear of the train. The retarded-release feature of this new triple valve overcomes the second point mentioned, taking advantage of the first while doing so. The friction of the trainpipe causes the pressure in chamber *h* to build up more rapidly on triple valves towards the front than those in the rear. As soon as its pressure is enough greater than the auxiliary-reservoir pressure, remaining in chamber R after the application above described, to overcome the friction of piston, graduating valve, and slide valve, all three are moved toward the right until the piston stem strikes the retarding-device stem, 31. The latter is held in position by the retarding-device spring, 33. If the rate of increase of the trainpipe pressure is small, as, for example, when the car is near the rear of the train, the triple valve parts will remain in this position, as shown in Fig. 38, the brakes will release and the auxiliary reservoirs recharge as described under "FULL RELEASE AND CHARGING." If, however, the triple valve is near the head of the train, and the trainpipe pressure builds up more rapidly than the auxiliary reservoir can recharge, the excessive pressure in chamber *h* will cause the piston to compress retarding-device spring, 33, and move the triple-valve parts to the position shown in Fig. 42.

Exhaust cavity *n* in the slide valve now connects port *r* leading to the brake cylinder, with port *p* to the atmosphere, and the brake will release; but as the small extension of cavity *n* (see Fig. 37) is over port *p*, discharge of air from the brake cylinder to the atmosphere is quite slow. In this way the brakes on the front end of the train require a longer time to release than those on the rear. This feature is called the "Retarded Release," and although the triple valves near the locomotive commence to release before those in the rear, as is the

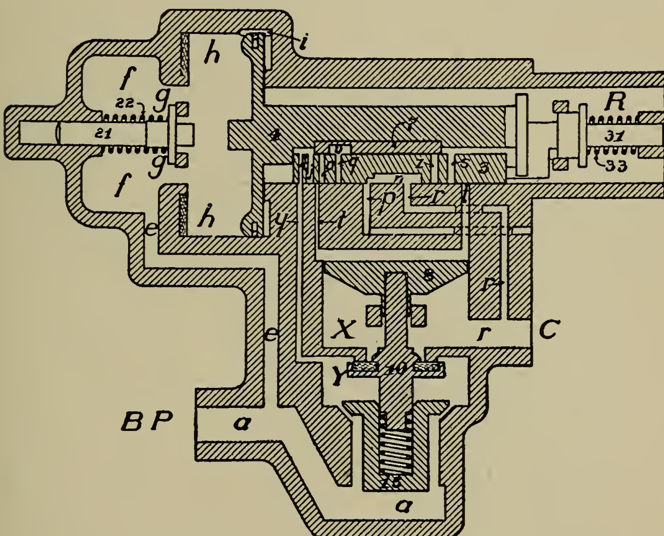


Fig. 42—K-2 Triple—Retarded-Release Position.

case with the H-triple valve, yet the exhaust of brake-cylinder pressure in retarded-release position is sufficiently slow to allow the rear brakes to release first. This permits of releasing the brakes on very long trains at low speeds with less danger of a severe shock or break in two than with old style triples.

At the same time, the back of the piston is in contact with the end of the slide-valve bush and, as these two surfaces are ground to an accurate fit, their contact effectually cuts off communication between chambers *h* and R through feed groove *i*, preventing air from feeding through from the trainpipe to the auxiliary reservoir by this path. Also, port *l* in the slide valve registers with port *y* in the slide valve seat, and pressure in chamber Y can flow through ports *y* and *l* to the chamber R and the auxiliary reservoir. Chamber Y is supplied with air under these circumstances by the check valve 15 raising and allowing trainpipe air to flow past it. The area of port *l* is about half that of feed grove *i*, so that the rate that the auxiliary reservoir will recharge is much less than when the triple valve is in full-release. The groove on the back of the piston now takes the place of port 1.

As the auxiliary-reservoir pressure rises, and the pressures on the two sides of piston 4 become nearly equal, retarding-device spring 31 forces the piston, slide valve, graduating valve, and retarding device stem back to the full release position shown in Fig. 38, when the remainder of the release and recharging will take place as described above under "Full Release and Charging."

These features of the new valve are always available, even when in trains with the old standard triple, the beneficial results being in proportion to the number of new valves present in the front end of train.

EMERGENCY POSITION.

Emergency Position is the same with the K triple valve as with the H type. Quick action is caused by a sudden and considerable reduction in trainpipe pressure, no matter how caused. This fall in trainpipe pressure causes the difference in pressures on the two sides of piston 4 to increase very rapidly, so that the friction of the piston, slide valve and graduating valve is quickly and greatly overcome, and they move to the left with such force that when the piston strikes the graduating stem, it compresses graduating spring 22, forcing back the stem and spring, until the piston seats firmly against

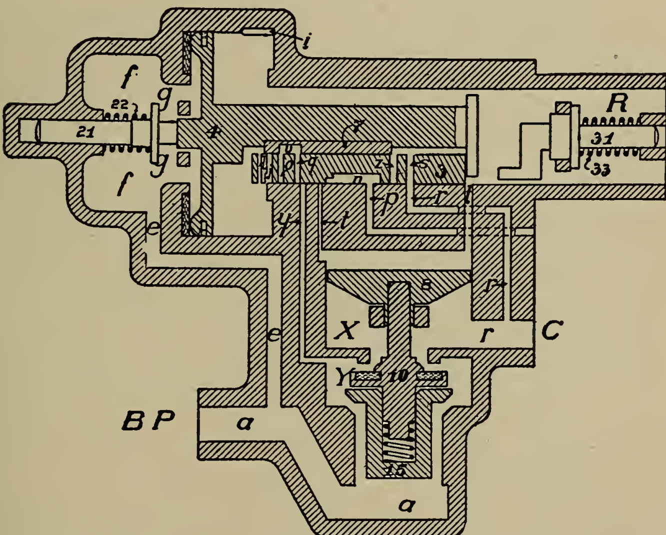


Fig. 43—K-2 Triple—Emergency Position.

the gasket 23, as shown in Fig. 43. The movement of the slide valve opens port *t* in the slide-valve seat, and allows auxiliary reservoir pressure to flow to the top of emergency piston 8, forcing the latter downward and opening emergency valve 10. The pressure in chamber Y being instantly relieved, allows trainpipe air to raise the check valve 15 and flow rapidly through chambers Y and X to the brake cylinder, until brake-cylinder and trainpipe pressures equalize, when both check valve and emergency valve are forced to their seats by the spring in the former, preventing the air in the cylinders from escaping back into the trainpipe again. At the same time port *s* in the slide valve registers with port *r* in the slide-valve seat, and allows auxiliary-reservoir pressure to flow to the brake cylinder. But the size of ports *s* and *r* is such that very little air gets through them before the trainpipe has stopped venting into the brake cylinder. This sudden discharge of trainpipe air into the brake cylinder has the same effect on the next triple valve as would be caused by a similar discharge of trainpipe air to the atmosphere. In this way each triple valve applies the next, thus giving the quick and full application of all brakes, made heavier than full service application through the greater amount of trainpipe air admitted to the brake cylinders.

The rapidity with which the brakes apply throughout the train is so much increased that in a 50-car train it requires less than three seconds; the brake-cylinder pressure is also increased approximately twenty per cent with 8 inch brake cylinders.

The release after an emergency is effected in exactly the same manner as after a service application, but requires a longer time, owing to the higher brake-cylinder pressures and lower trainpipe pressures.

To change a standard type H triple valve to the type K, it is necessary to add the retarded-release feature and to make the necessary changes in the controlling valves, body, and check-valve case.

MANIPULATION.

No special instructions are required by the engineers to handle trains partially or wholly fitted with the K triple valve. The automatic brake valve should be handled as good practice requires with the H triple valve. Some of the most important details are as follows:

Make the terminal brake tests, and check the results indicated by noting how well the brakes hold in the first running application, and be governed accordingly in subsequent applications.

Before attempting to release have an ample excess pressure for the length of train, and in releasing leave the handle of the automatic brake valve in release position until the rear brakes have had time to release.

As return to running position will cause triple valves in retarded-release position to change to full-release position, the brake-valve handle should not be moved from release too soon. However, with short trains the usual early return to running position will prevent unnecessary retardation of release.

THE AUTOMATIC SLACK ADJUSTER.

The question of correct piston-travel is of the highest importance, and the automatic slack adjuster is for the purpose of keeping it as nearly uniform as possible, which should be eight inches when running.

SLACK ADJUSTER COMPLETE.

Fig. 44 shows how the adjuster is attached to the pressure head of the brake cylinder. One end of cylinder lever (5) is bolted to a cross head, which moves in a guide (4) that is bolted to the pressure head of the cylinder. The cross head is held to its place by a threaded rod (1), which has a ratchet nut where its opposite end extends through the adjuster body (3), and when it is desired to reduce the piston travel, it is done by moving the cross head *away* from the cylinder head a distance equal to the amount of slack to be taken up; and to increase the travel move the cross head *toward* the cylinder.

When no air is in the cylinder the threaded rod can be turned either way with a wrench, and four turns of the rod will equal one inch of piston travel.

In running along, whenever the piston travel exceeds eight inches the adjuster automatically takes up one thirty-second of an inch every time the brake is released, and therefore whenever new shoes are put on (which necessitates letting the adjuster well back), the brake should be fully applied and whatever travel the piston shows *over* 6½ inches should be taken up by turning the ratchet nut, as the running piston travel is from one to two inches greater than it is when the car is standing still.

Don't try to turn the ratchet nut while the brake is set, and never alter the dead levers or bottom rods unless, with all adjuster slack out, the piston-travel is less than 5½ inches, or when the adjuster has been taken up to its limit and the travel is too long, and not then in the latter case if any brake shoes need renewing.

Fig. 45 illustrates the adjuster in cross section. 27 is the ratchet nut which is attached to the threaded rod;

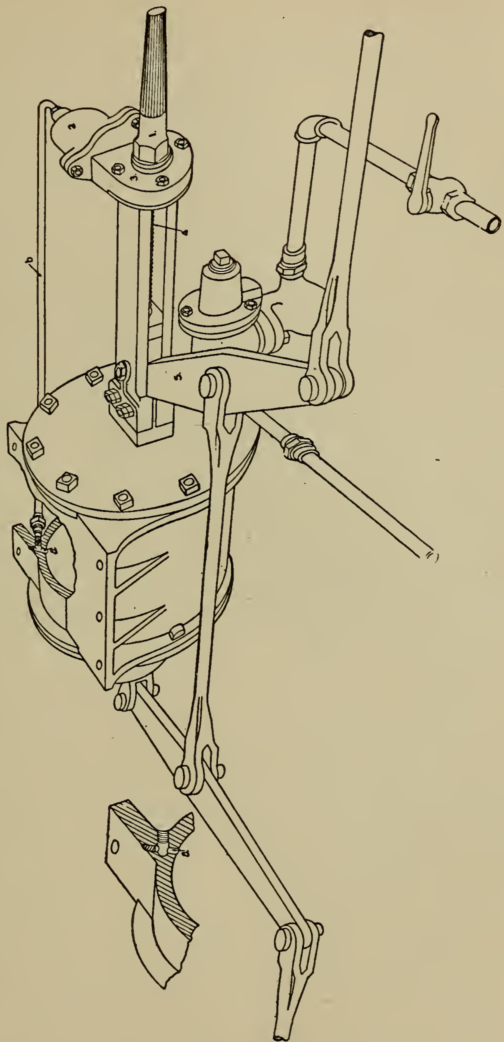


Fig. 44—Automatic Slack Adjuster Complete.

DESCRIPTION OF FIG. 44.

5. Cylinder lever.
1. Threaded rod.
3. Ratchet-nut wheel casing.
2. Adjuster cylinder.

a and *b*. Pipe connection between brake cylinder and adjuster cylinder.

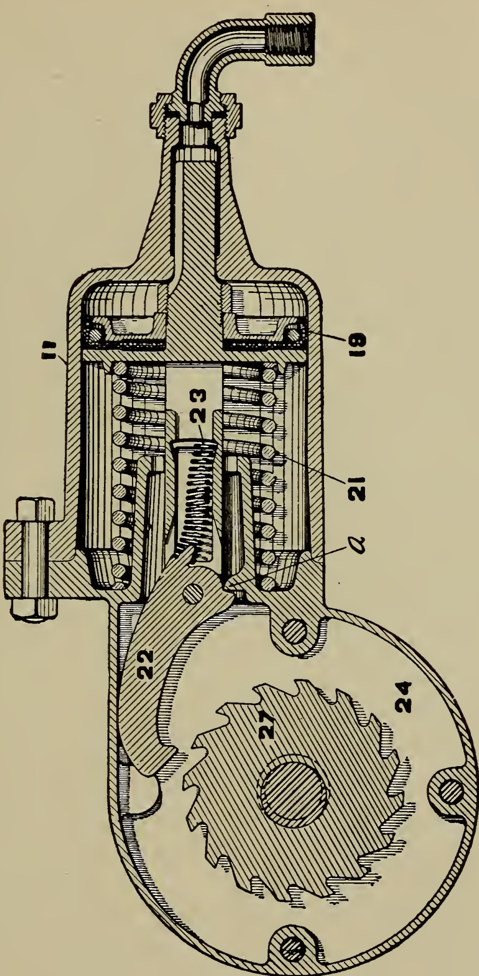


Fig. 45—Automatic Slack Adjuster.

DESCRIPTION OF FIG. 45.

27. Ratchet-nut wheel.
22. Pawl.
a. Projection for lifting pawl.
23. Piston.
21. Release spring.

22 is the pawl which moves the ratchet nut; 23 is the piston, to which the pawl is attached, and 21 is the spring which drives the piston back after the cylinder pressure has escaped from in front of it, and as the adjuster cylinder is connected to the brake cylinder by a small pipe, whenever the air in the brake cylinder forces the brake piston out eight inches, brake-cylinder pressure is admitted against piston 23, which forces the pawl back so that it engages the ratchet-nut wheel, and when the air is released from the brake cylinder the air in the adjuster cylinder (11) escapes through the non-pressure end of the brake cylinder, and spring 21 pushes the piston and pawl forward, thus turning the ratchet-nut wheel the distance of two teeth, which takes up one thirty-second of an inch of piston-travel. The pawl is released by striking a projection (a), which keeps it up.

Fig. 46 illustrates the degree of angularity at which the port in the brake cylinder should be tapped according to the size of the cylinder. As this port is only one-eighth of an inch, it may easily become clogged, so that if the adjuster fails to work you should at once ascertain if the air passages are open between the brake and adjuster cylinders by loosening the union swivel on the adjuster cylinder connection.

Whenever the adjuster has operated to the limit of the screw and the pawl fails to release, so that the ratchet-nut cannot be started back with a wrench, if it be the old style adjuster, remove the ratchet-nut cover and carefully pry the piston outward until the pawl can be raised, then slack back the nut about a turn, which will let the piston return to the end of its cylinder and keep the pawl free from the ratchet nut as before.

An improvement has lately been added by inserting a

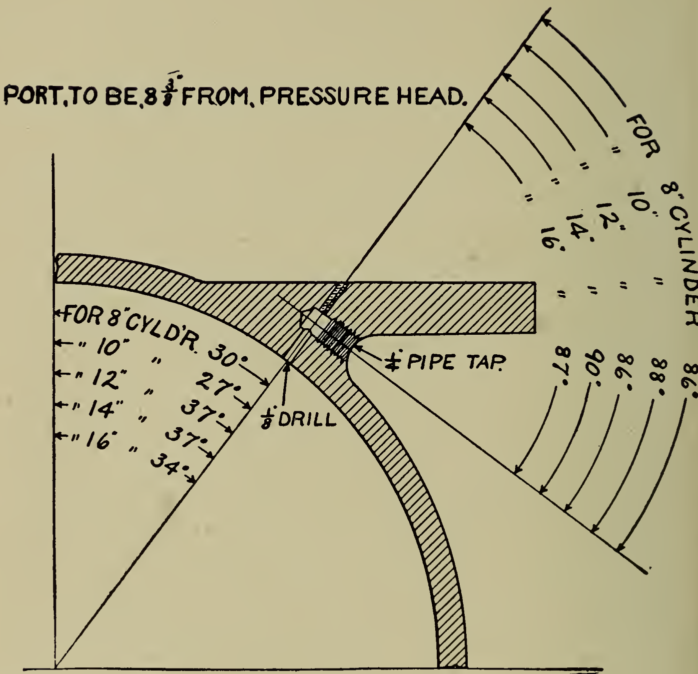


Fig. 46—Automatic Slack Adjuster—Size of Cylinder Port.

DESCRIPTION OF FIG. 46.

The illustration shows the angularity at which the brake-cylinder port should be drilled for the different sized cylinders.

stop screw next to the ratchet-nut casing, which holds the threaded rod a short distance from its extreme travel, so that in case the pawl sticks it is only necessary to back out the stop screw, when the pawl will release itself automatically. The adjuster cylinder should be cleaned and oiled every time the brake cylinder is oiled.

THE CONDUCTOR'S VALVE.

The conductor's valve is an additional stop cock attached to the trainpipe of each passenger car.

There is a branch pipe running from the trainpipe up through the body of the coach, usually in the toilet room, and on this branch pipe is a stop cock, or valve, so that in case the conductor is unable to signal the engineer, or an emergency arises making it necessary to stop the train as quick as possible, the conductor can let the air out of the trainpipe by simply opening this valve.

If he wishes to make a gradual stop he has only to open the valve gradually, but if he wishes to stop quick, he must open the valve quick, and also must hold it open until the train is stopped, for if the engineer should fail to lap his brake valve, as soon as the conductor's valve was closed the brakes would release, on account of the main reservoir pressure driving the triples to release position.

TYPE L TRIPLE VALVE.

This triple valve has the usual brake-pipe auxiliary reservoir, and brake-cylinder connections, also an additional connection for a supplementary reservoir. Fig 47 shows a view of the type L triple valve, with the safety valve in place. In order that trains mav be controlled easily and smoothly when running at either high or low speeds, and that stops may be made quickly and with the least liability of wheel sliding, the brake apparatus must provide the following essential features of operation:

A small brake-pipe reduction must give a moderate brake-cylinder pressure and a moderate but uniform retardation on the train as a whole.

It must be possible to make a heavy service reduction quickly, but without liability of quick action.

It must be possible to graduate the release as well as the application of the brakes.

To insure the ability to obtain brake applications in rapid succession, and to full power, a quick recharging of the auxiliary reservoirs is necessary. This feature also enables the engineer to handle long trains in heavy grade work with a much greater factor of safety than heretofore, and eliminates the need for retaining valves.

For high-speed trains, a high brake-cylinder pressure available for emergency applications is imperative, in order to provide a maximum braking power, when the shortest possible stop is required to save life or to avoid sudden danger.

The Westinghouse Air Brake Co. claim that they have met the above requirements by the development of the type L triple valve. This triple valve is of the quick-action, automatic, "pipeless" type, and is intended for use only in high-speed passenger service. The L valve

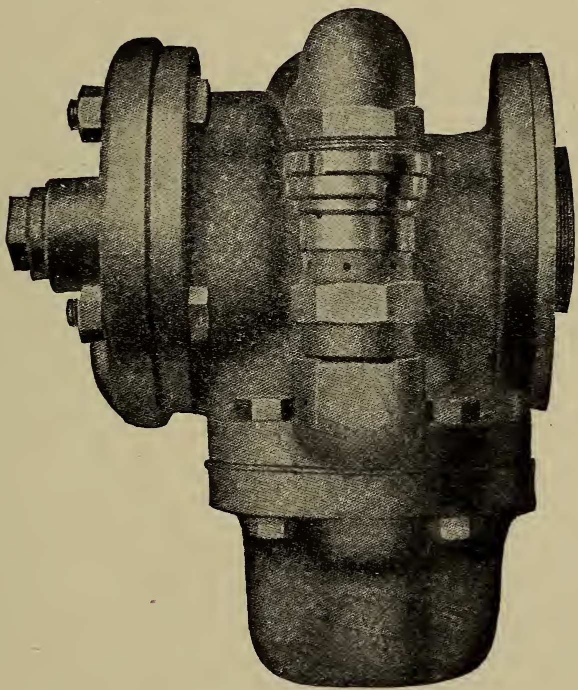


Fig. 47—The Type L Triple Valve.

forms a part of the LN Passenger Car Equipment, which is designed throughout to meet the service conditions outlined above. Being of the quick action type it possesses the following important features:

1st. Quick Recharge (of auxiliary reservoirs), by which a rapid recharging of the brake system is secured, thus making it possible to obtain full braking power immediately after a release has been made and permitting as many applications and releases in quick succession as may be desired, without materially depleting the system.

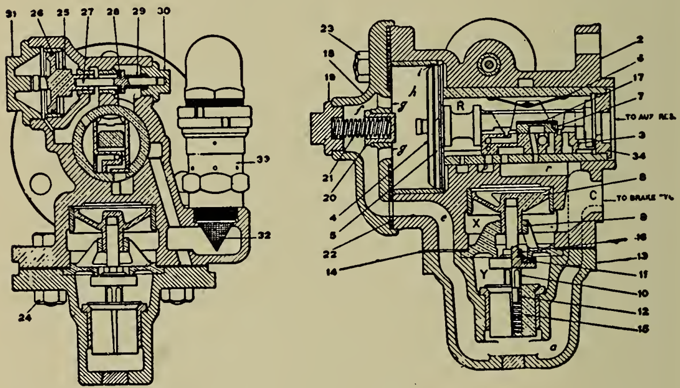


Fig. 48—The Type L Triple Valve.

2nd. Quick Service, by which a very quick serial *service* action of the brakes throughout the train is secured, similar to that in emergency applications, but less in degree. This makes certain the prompt and uniform application of all the brakes in the train, correspondingly increasing the rapidity and effectiveness of any given brake-pipe reduction, and thereby practically eliminating the need for the harsher emergency application, except in cases of actual danger.

3rd. Graduated Release, which permits of partially or entirely releasing the brakes on the entire train at will.

4th. High Emergency Cylinder Pressure, which greatly increases the available braking power in emergency applications over the maximum obtainable with a full service reduction. With this, as with all quick-action triple valves, a portion of the air contained in the brake pipe is vented to the brake cylinder in emergency applications, thus providing for the quick serial operation of the brakes in the usual way. This, in itself increases the brake cylinder pressure thus obtained, considerably above the maximum pressure, possible in ordinary service applications.

The high emergency pressure feature referred to still further increases this emergency pressure, and the high cylinder pressure thus obtained, is retained without reduction, until released.

This is accomplished by the use of a supplementary reservoir in addition to the ordinary auxiliary reservoir. The supplementary reservoir is approximately double the size of the auxiliary reservoirs. Its function is to assist in obtaining the graduated release of the brakes, and the high emergency cylinder pressure, and the way in which this is accomplished will be explained later on. This feature makes it possible to use the equipment as a high speed brake, when carrying 90 lbs. brake pipe pressure, and obtain better results than when using 110 lbs. pressure with the old standard equipment in steam road service. Fig. 48 shows a vertical cross section of the valve, and the names of its various parts are as follows:

2, Valve Body; 3, Slide Valve; 4, Piston; 5, Piston Ring; 6, Slide Valve Spring; 7, Graduating Valve; 8, Emergency-Valve Piston; 9, Emergency-Valve Seat; 10, Emergency-Valve; 11, Rubber Seat for Emergency-Valve; 12, Check-Valve Spring; 13, Check-Valve Case; 14, Check-Valve Case Gasket; 15, Check Valve; 16, Emergency Valve Nut; 17, Graduating-Valve Spring; 18, Cylinder Cap; 19, Graduating-Spring Nut; 20, Graduating Sleeve; 21, Graduating Spring; 22, Cylinder Cap Gas-

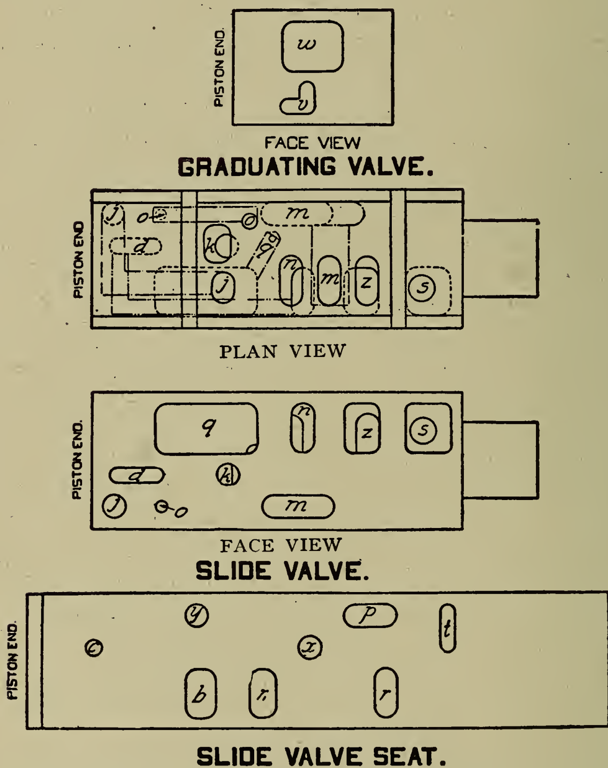


Fig. 49—Graduating Valve, Slide Valve, and Slide-Valve Seat. Type L Triple Valve.

ket; 23, Bolt and Nut for Cylinder Cap; 24, Bolt and Nut for Check-Valve Case; 25, By-Pass Piston; 26, By-Pass Piston Ring; 27, By-Pass-Valve; 28, By-Pass-Valve

Seat; 29, By-Pass-Valve Spring; 30, By-Pass Valve Cap; 31, By-Pass-Piston Cap; 32, Strainer; 33, E-7 Safety Valve.

Figure 49 illustrates the actual arrangement of ports, and cavities, in the graduating valve, slide valve, and slide valve seat, of the type L triple valve. Owing to the impossibility of showing all of the ports and con-

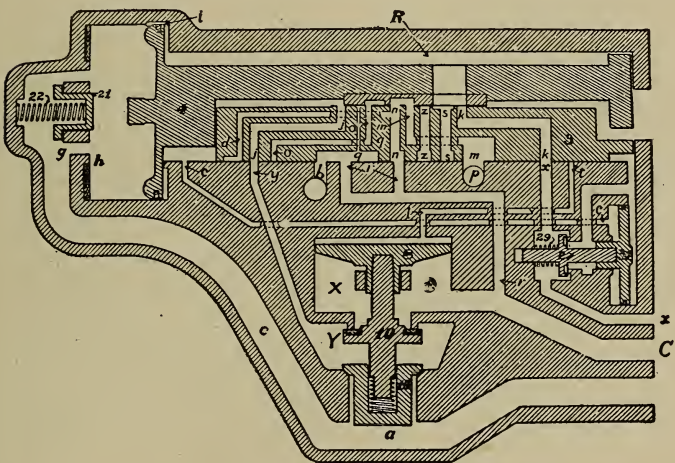


Fig. 50—Full-Release and Charging Position.

necting passageways in any single illustration, figures 51, 52, 53, 54 and 55, are presented, and each shows in a diagrammatic way, the relations of the various parts to each other, for the different positions of the triple-valve piston.

The actual proportions and mechanical construction of the parts have been disregarded, in order to make the connections, and operation more intelligible to the student. The letters designating the ports and passages appear-ing on Figures 48 to 55 inclusive, correspond throughout, but the reference numbers on Fig. 48 do not exactly correspond with those on the diagrammatic views. The various connections shown in Fig. 48, and the ports in Fig. 49 will, however, be made clear, by comparison with the diagrammatic views shown in Figures 50 to 55. Referring to Fig. 49, it will be noticed that the

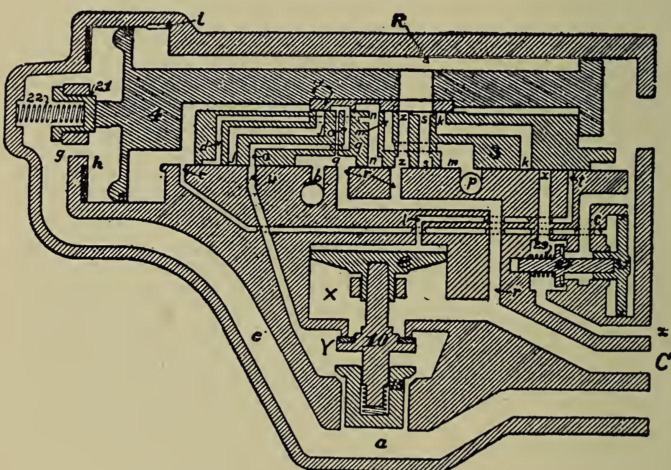


Fig. 51—Quick-Service Position.

ports in the plain view of the slide valve seat are as follows: r leads to the brake cylinder; t, to the top of the emergency piston; p, to exhaust; x, to the supplementary reservoir; y, to the check valve case and chamber Y; b, to the safety valve, and c, to the space behind the by-pass piston.

The registration of the parts is most readily followed, and understood, by reference to, and comparison with the diagrammatic drawings, Figures 50 to 55, in which the connections to the triple valve are as follows:

a—Brake Pipe.
x—Supplementary Reservoir.
C—Brake Cylinder.
p—Exhaust.
b—Safety Valve.
R—Auxiliary Reservoir.

OPERATION OF THE TYPE L TRIPLE VALVE.

CHARGING.

Referring to Figures 48 and 50, air from the brake pipe enters the triple valve through the passages a, e, g, and h, to the face of the triple valve piston (which is then forced to release position as shown), thence through the feed groove *i* to chamber R and auxiliary reservoir. Brake-pipe air in passage *a* also raises the check valve 15, and entering chamber Y flows thence through the ports *y* and *j* into chamber R and the auxiliary reservoir. This check valve then prevents any back flow of air from the auxiliary reservoir to the brake pipe. At the same time, port *k* registers with port *x* and the air in chamber R also flows through these ports into the supplementary reservoir. Both the auxiliary and supplementary reservoirs are thus charged at the same time and to the same pressure from the brake pipe through the two different channels already mentioned. When in this position, air from the brake cylinder, entering the triple valve at C, flows through passage *r*, port *n*, large cavity W (Fig. 49), in graduating valve, and ports *m*, and *p*, to the atmosphere, thus releasing the brakes.

SERVICE APPLICATION.

The ports of the triple valve being in release, and charging as shown in Fig. 50, a service reduction in brake-pipe pressure, reduces the pressure in chamber *h*, and on the face of the triple valve piston, below that in the auxiliary reservoir on the opposite side of the piston. The higher auxiliary reservoir pressure therefore forces the piston in the direction of the lower brake-pipe pressure, carrying with it the attached graduating valve. The first movement of the piston closes the ports *j*, *m* and *k*, thus shutting off communication between the brake pipe, and the auxiliary and supplementary reservoirs, and closing the exhaust passage from the brake cylinder to the atmosphere. The same movement opens port *z* and connects ports *q* and *o*, in the main slide valve through the small cavity *v* in Fig. 49 in the graduating valve. The spider or lugs on the end of the piston stem, then engage the end of the main slide valve, which is carried along with the piston, and graduating valve, as the reduction continues. This brings the parts into quick service position shown in Fig. 51.

Service port *z* in the slide valve, registers with brake cylinder port *r*, in the seat, thus allowing the air in the auxiliary reservoir to flow to the brake cylinder, and apply the brakes. At the same time the quick service ports, *o* and *q*, and the small cavity *v*, in the graduating valve, connect passage *y*, leading from chamber Y in the check valve case with passage *r* leading to the brake cylinder. This allows air from the brake pipe to lift the check valve, and flow through the above mentioned ports to the brake cylinder. This constitutes the quick service action of the triple valve, in that it causes a slight, but definite reduction in brake pipe pressure locally, at each valve. The effect of a reduction in brake-pipe pressure, made at the brake valve, is thus quickly and uniformly transmitted from car to car throughout the train. The amount of air vented from the brake pipe to the quick service ports is not great for two reasons; first, because the ports and the passage ways are small; second, because in the movement of the slide valve 3 to full

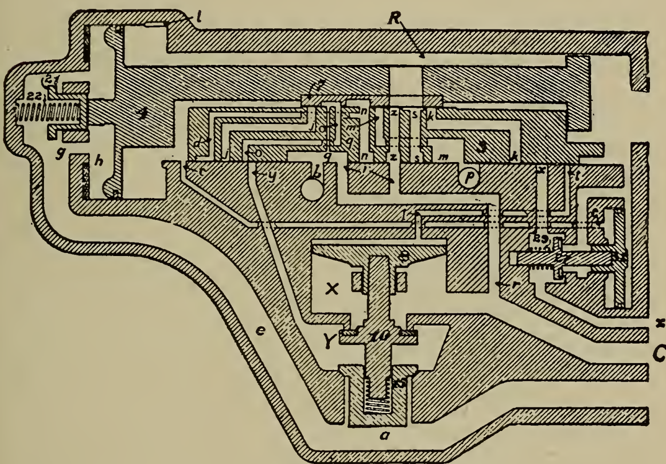


Fig. 52—Full-Service Position.

service position, the quick service port *y* is restricted as it approaches this position and completely closed just before service port *z* is fully open, as shown in Fig. 52.

The amount of opening given the service port in any case, depends upon the rate of reduction in brake pipe pressure as compared with that of the auxiliary reservoir.

If the former is at first rapid, as compared with the latter, which would be the case with short trains, the higher auxiliary pressure moves the piston at once to Full-Service Position, Fig. 52, thus automatically cutting out the quick-service feature where it is not needed. When in Full-Service Position, Fig. 52, the service port *z* is fully open, and the quick-service port *o* is closed. This stops the flow of air from the brake pipe to the cylinder and the quick-service action ceases. As shown in the cut, the graduating spring is compressed slightly when the piston is in full service position. In any case where the brake pipe reduction is so rapid, that the quick service feature is of no advantage, the difference of pressure on the two sides of the triple valve piston becomes at the same time sufficient to compress the graduating spring, and automatically close the quick service port as explained above. But if the brake pipe reduction is less rapid, or slow, as in the case of long trains, or moderate service reductions, a partial opening only of the service port is sufficient to preserve a balance between the pressure on the two sides of the triple valve piston. The service port connecting the auxiliary reservoir to the brake cylinder, is much larger than the quick-service port connecting the brake pipe to the brake cylinder. This serves to effectually prevent an emergency application, when only a service application is desired. It also guards against the brake-pipe reduction being continued, due to the quick-service port remaining open, after the reduction has been stopped at the brake valve.

During the time the slide valve 3 remains in Quick or Full-Service Positions, as shown in Figures 51 and 52, the cavity *q* connects the brake-cylinder port *r* with port *b*, leading to the safety valve. This safety valve, known as the E-7 (see Figures 47 and 48), is ordinarily set for 62 lbs. In an emergency application, however, the safety valve is entirely cut off from the cylinder, as explained under the heading "Emergency."

LAP.

After a sufficient brake-pipe reduction has been made, the brake-valve handle is lapped, and further escape of air from the brake pipe is prevented. When the flow

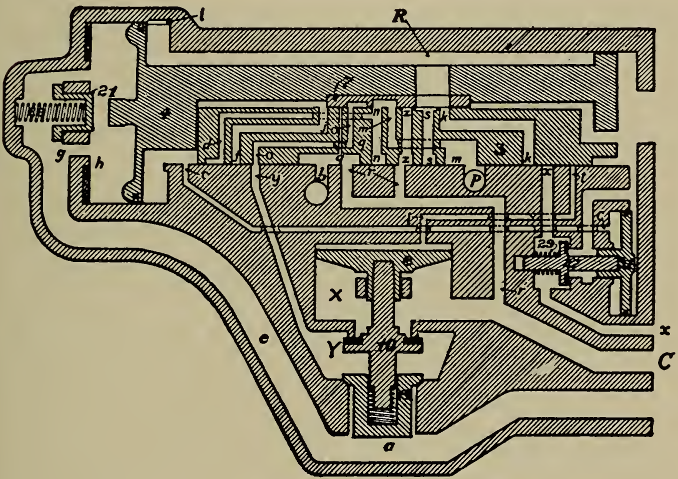


Fig. 53—Service-Lap Position.

of air from the auxiliary reservoir to the brake cylinder has reduced the pressure on the reservoir side of the triple-valve piston slightly below that remaining on the brake-pipe side, the pressure in the brake pipe, assisted by the graduating spring, will move the piston, and graduating valve to service-lap position, shown in Fig. 53. In this position all of the ports are blanked by the graduating valve, and the flow of air to the brake cylinder is stopped. Further movement is prevented by the shoulder of the piston stem striking the end of the slide valve 3, as shown in the cut. The slight difference of pressure which was sufficient to move the piston and small graduating valve is unable to overcome the added resistance of the slide valve, and the parts remain in the position shown.

It should be noted that the slide valve 3 remains in Service Position, a movement of the piston and graduating valve being all that is required to lap the valve. Consequently, when in this position, only a slight reduction in brake-pipe pressure is required to again bring the piston and graduating valve into Service Position. It is evident that the exact position of the main slide valve in Lap Position depends upon whether its previous position was that of quick service (Fig. 51), or full service (Fig. 52). If the former, the lap position assumed would be that of quick-service lap (Fig. 53). If, however, the valve had moved to full service, the position would be that of full-service lap. The main piston being in service-lap position (Fig. 53), the pressure on both sides of it must be equal. If the brake-pipe pressure is increased in order to release the brakes, the higher pressure on that side of the piston causes it to move the graduating and slide valves to the extreme right to release, and recharging position, previously described (see Fig. 50). The air, which was prevented from leaving the supplementary reservoir by the former movement of the slide valve to service position, and which consequently remained at its initial pressure, while the auxiliary reservoir pressure was being reduced, now flows into the auxiliary reservoir and helps to recharge it.

During this operation, as well as while graduating the release of the brakes, described under the next heading, the pressures on the brake pipe and auxiliary reservoir sides of the triple-valve piston are always in balance. This is important, since it insures an immediate response of the brakes to any reduction, or increase in brake-pipe pressure, irrespective of what operation may have occurred just preceding.

If the brake-valve handle is moved to Running Position and left there, the brake-pipe pressure is fully restored and the piston remains in Release Position; the brakes being thereby fully released and the auxiliary and supplementary reservoirs fully recharged.

GRADUATED RELEASE.

Suppose, however, that after the brakes have been applied, only sufficient air is permitted to flow into the brake pipe to move piston 4, with the slide, and graduating valves, to release position (Fig. 50), and the brake-valve handle is returned to lap. Then the flow of air from the supplementary reservoir, through ports x and k, to the auxiliary reservoir, continuing after the rise in brake-pipe pressure has ceased, the pressure on the auxiliary reservoir side of the triple-valve piston will be raised slightly higher than that on the brake-pipe side, and cause the piston, and its attached regulating valve, to move to the left, to graduated release position shown in Fig. 54. In this position the brake is only partially released, and a portion of the air pressure originally in the brake cylinder still remains there. In this way, the brake cylinder pressure may be released in a series of steps, or graduations, and the operation is known as graduated release, and may be repeated as desired, until the brake-pipe pressure has been fully restored, and the exhaust of air from the brake cylinder completed. The amount of reduction in the brake cylinder pressure for any given graduation depends upon the amount of air pressure which has been restored in the brake pipe. The recharge of the brakes is similarly proportioned.

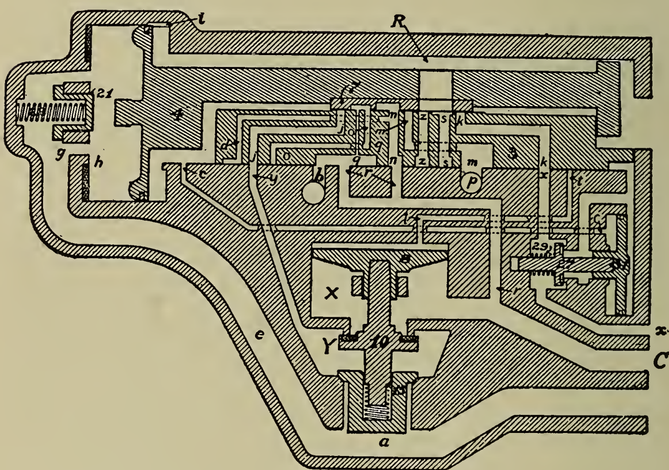


Fig. 54—Graduated-Release-Lap Position.

EMERGENCY.

When the brake-pipe pressure is reduced suddenly, or its reduction continues to be more rapid than that in auxiliary-reservoir pressure, the piston is forced to the extreme left and compresses the graduating spring. The parts are then in Emergency Position, as shown in Fig.

55. In this position air from the auxiliary reservoir enters the brake cylinder passage *r* through the port *s* in the main slide valve, instead of port *z* as in service application. Port *t* in the seat is also uncovered by the end of the main slide valve, thus admitting air from the auxiliary reservoir, through port *t* to the top of the emergency piston.

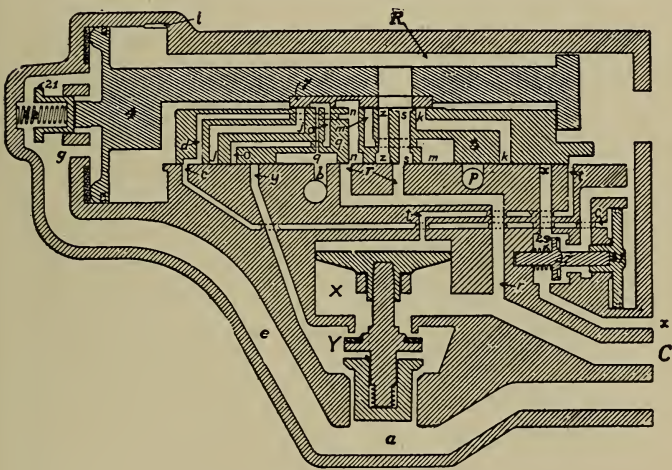


Fig. 55—Emergency Position.

The air pressure thus admitted to the top of this piston, pushes it down and forces the rubber seated emergency valve from its seat. This allows the brake pipe air in passage *a* to lift the emergency check valve, and flow through chambers *y* and *x* to the brake cylinder *C*, in the ordinary way. At the same time port *d*, in the main slide valve, registers with port *c* in the seat. This allows air from behind the by-pass piston to flow through ports *c*, *d* and *n* to *r*, and the brake cylinder. As there is no pressure in the brake cylinder at this instant, the by-pass piston, with its attached by-pass valve is forced to the left by the auxiliary reservoir pressure acting against its opposite face. The air contained in the supplementary reservoir then flows past this valve into the passage way leading to the auxiliary reservoir. It thereby adds to the latter, the volume of the supplementary reservoir.

This gives in effect an auxiliary reservoir pressure volume approximately three times the size of the one that supplies air to the brake cylinder in a service application. Air from the supplementary reservoir continues to flow to the auxiliary reservoir until the pressures in the latter, and in the brake cylinder have risen nearly to that remaining in the supplementary reservoir. Communication between the two reservoirs is then closed by the by-pass valve returning to its seat.

This action of the triple valve in the emergency applications permits the pressure in the brake cylinder to rise to within a few pounds of maximum brake-pipe pressure, a much higher pressure being secured in emergency applications than is possible with the standard quick-action triple valve.

Further more it will be noted by reference to Fig. 55 that cavity *q* has traveled past the brake cylinder port *r*, so that the latter is no longer connected to the safety valve *b*. Hence, there is no escape of air from the brake cylinder after an emergency application of the brakes. Not only, therefore, is the emergency pressure considerably higher than that formerly secured by the use of the old standard High-Speed Brake, but it is held without diminution until the brakes are released.

INSTALLATION AND MAINTENANCE.

The triple valve is usually bolted to the pressure head of the brake cylinder, to which all the pipe connections are permanently made. In removing the valve, no pipes need to be disconnected, the loosening of the three bolts which hold it in place being all that is required. Hence, the name "Pipeless," as applied to this valve. Care should be taken in locating the valve to have it free from obstructions which would render inspection or removal difficult. It should be placed as far as possible above the general level of the piping so that no pockets are formed in the latter. If this point does not receive proper attention, trouble may be experienced in cold weather from the freezing of water in the pipes or valve itself. Under ordinary service conditions, the triple valve should be thoroughly cleaned and lubricated once in three months. The proper interval is best determined for each particular case by a careful inspection and trial. Where conditions are severe and the triple valve exposed to extremes of weather, dirt and so on, more frequent inspections will no doubt be found necessary. Where the valve is protected, and not subjected to hard usage the interval may be lengthened. The use of heavy grease or other lubricants which will "gum" and cause the valve to work stiff, or clog the ports, should be avoided. Too light a lubricant or one that does not possess sufficient "body," is not satisfactory, as it will not thoroughly lubricate the parts or last as long as necessary. Special lubricants made for this purpose will give the best results.

Before installing the triple valve all of the piping should be thoroughly hammered and blown out, in order to loosen and remove all scale and foreign matter. This is especially important in new installations. After the piping is completed all of the joints should be thoroughly tested with soap suds, under pressure, and made air tight. Particular attention should be given to the safety valve and its strainers, in order that no dirt or scale can reach the safety valve seat and prevent it from properly closing. The by-pass piston should also receive attention to insure that it is working freely in its bushing.

Never remove the movable parts of the triple valve while it is on the car. If the valve is not working properly, or needs cleaning and oiling, take it down and replace it by a valve in good condition. All cleaning and oiling should be done at a bench, by a competent man; where the liability of damage to the internal parts of the valve is least. Any attempt to take the triple valve apart while still on the car is almost sure to result in a large percentage of valves being injured by careless handling, or dirt getting inside the pipes, or valve. If repairs are necessary the valves should be sent to the shops, where the facilities for doing the work are best.

The complete LN equipment includes a type L valve triple valve, with safety valve, a supplementary reservoir and a cut-out cock. At times, however, cars equipped with this schedule must be operated in trains with cars having the old standard equipment (P triple valves), as for instance during the transmission period when a change is being made from the old standard to the LN schedule.

During this time the cut-out cock between the triple valve and supplementary reservoir should be closed. The new valves will then work in perfect harmony with the old. In fact, if old and new equipments are to be in service together for any considerable length of time, the cut-out cock and supplementary reservoir may be omitted entirely, as well as the safety valve, furnished with the triple valve. If the equipment is used with 70 pounds brake-pipe pressure, no other change is necessary, and only the addition of the ordinary High-Speed Reducing Valve is required for High-Speed Service (110 pounds brake-pipe pressure). In such cases where the conditions of service demand, there would, of course, be the same necessity for a Pressure-Retaining Valve, as with the Type P Triple Valve.

An improved safety valve is used with the type L triple valve, one size of safety valve being adapted for the different sizes of L triples. The parts of this safety valve, as shown in section in Fig. 56 are, 2, body; 3, cap nut; 4, valve; 5, valve stem; 6, spring; 7, regulating nut; 8, exhaust regulating ring; 9, lock ring.

This safety valve is located on the side of the triple, and connected to the brake cylinder through the triple valve. Its function is to prevent abnormal brake cylinder pressure during service applications of the brake. This safety valve is in connection with the brake cylinder at all times, except during an emergency application. There are two adjustments, maximum and minimum, and its operation is as follows:

As the air from the safety valve port b in the triple valve enters chamber A, of the safety valve, and its pressure becomes sufficient to overcome the tension of spring 6, valve 4 is moved upward, closing the upper end of ports d in the valve bushing and opening chamber B to the atmosphere through ports c in the body, thereby permitting air to flow from chamber A through chamber B and ports c to the atmosphere. (Only one each of ports c and d are shown in the cut.) As the air pressure below valve 4 decreases, the tension of spring 6 forces valve 4 downward, which restricts the opening through ports c to the atmosphere and opens ports d to

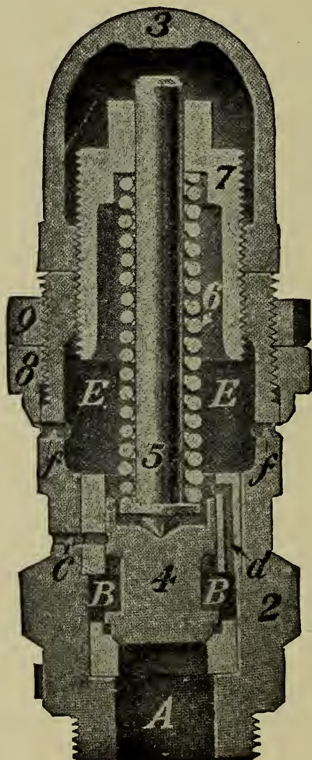


Fig. 56—Safety Valve Used With Type L Triple Valve.

spring chamber E. Air now being permitted to enter chamber E, assists spring 6 in forcing valve 4 to its seat quickly. As chamber E is opened to the atmosphere at all times through ports f in the body, air in chamber E will escape to the atmosphere and again allow the air pressure in chamber A to overcome spring 6 and raise valve 4 from its seat—this action causing the valve to open and close quickly with a pop action.

The function of the exhaust regulating ring 8 is to regulate the size of the opening through ports f, and f, thus controlling the range of opening and closing of valve 4. When this ring has once been placed in proper position it is securely held there by lock ring 9. The valve is adjusted by removing cap nut 3, and screwing regulating nut 7 up or down, after which the cap nut must be replaced and securely tightened in order to hold nut 7, and prevent escape of air from chamber E through the cap nut joint. The safety valve should be adjusted to open at 62 lbs. pressure; and it should close at 58 lbs. As previously explained this range is regulated by means of exhaust regulating ring 8, which can be screwed up or down until ports f have the proper area of opening.

THE TRIPLE VALVE.

Q. What relation does the triple valve bear to the automatic air brake?

A. It is a very important and essential part of the system.

Q. In general, what is the function of the triple valve?

A. It controls the passage of the compressed air from the auxiliary reservoir into the brake cylinder during an application; and it also releases the pressure from the brake cylinder at the will of the engineer. After release, the triple valve again assumes the position in which the air can pass through it to recharge the auxiliary reservoir.

PLAIN TRIPLE.

Q. Name the operative parts of the plain triple valve.

A. This valve consists of a piston, slide valve, graduating valve, graduating stem, graduating stem spring and slide valve spring.

Q. How many positions are there to a plain triple, and what are they?

A. Four; release, service, lap and emergency positions.

RELEASE POSITION.

Q. What is the normal position of the triple valve?

A. Release position.

Q. What is the purpose of release position of the valve?

A. To allow the auxiliary reservoir to be charged, and to exhaust the air from the cylinder to permit the brakes to release.

Q. Explain how the air passes through the triple valve in order to charge the auxiliary reservoir?

A. Air enters from the train pipe connection, passes through a port into graduating stem case, thence through another port to the piston chamber. The piston being in release position, and the feed port in the bushing being open, the air is free to pass through this port, also another port on the piston shoulder to the slide valve chamber, thence through pipe connection to the auxiliary reservoir.

Q. When the auxiliary reservoir is fully charged, how do the pressures stand on the opposite sides of the triple valve piston?

A. Equal; in other words equalized.

SERVICE APPLICATION POSITION.

Q. With the auxiliary reservoir charged and the valve in release position, what must be done to cause the piston to move to service application position?

A. The train pipe pressure must be reduced below that in the auxiliary reservoir.

Q. How much of a train pipe reduction should be made to cause this valve to move to application position?

A. Not less than 5 pounds.

Q. Explain what takes place as the triple valve piston moves to service position?

A. As the piston starts down, the first slight movement causes it to close the feed port and unseat the graduating valve. A shoulder on the end of the triple piston stem, then becomes engaged with the end of the slide valve, causing it to be moved to service position, in which the exhaust cavity is no longer in communication with the brake cylinder port, but a port in the slide valve is now in register with a port in the seat, which leads to the brake cylinder.

Q. As the piston moves toward service position, what resists its movement and prevents it from moving the full length of its cylinder?

A. The graduating stem, with which the knob on the plain side of the triple valve piston becomes engaged, as the piston reaches service position.

Q. What is the duty of the graduating stem and spring?

A. To act as a bumping post for the triple valve piston, which will prevent it from going to the emergency position during service application.

Q. Explain the flow of air through the triple valve in service application position.

A. A port on the slide valve is in register with a port in the seat; therefore, as the graduating valve is unseated, auxiliary reservoir pressure, which always surrounds the slide valve, is free to pass through ports in the slide valve to the graduating valve seat and thence through other ports to the brake cylinder.

Q. If 5 pounds of pressure is reduced from the train pipe, how much will leave the auxiliary reservoir?

A. Just a little more than 5 pounds.

Q. Why will just a little more than 5 pounds leave the auxiliary?

A. Owing to the reservoir pressure expanding into the brake cylinder as long as the graduating valve is open, which eventually will cause the auxiliary pressure to become a little lower than that which remains in the train pipe. The train pipe pressure then being the greater of the two causes the triple valve piston to move forward sufficiently to seat the graduating valve and prevent any further flow of air from the auxiliary reservoir to the brake cylinder.

LAP POSITION.

Q. What is lap position of the triple valve?

A. The position in which the graduating valve is closed.

Q. Does the slide valve move after the first reduction has been made?

A. No; not until the brakes are fully applied or released.

Q. What takes place when the second reduction is made in the train pipe?

A. The triple piston again moves until it reaches the graduating stem, unseating the graduating valve, and allowing auxiliary pressure to pass to the brake cylinder in equal amount to that reduced in the train pipe, when the piston will move forward, and again seat the graduating valve.

Q. Does the triple valve piston move with every reduction that is made in the train pipe?

A. Yes; every considerable reduction, and by so doing it unseats the graduating valve.

Q. How much of a reduction will be required to fully apply the brake in service?

A. About 20 pounds if the piston travel is adjusted properly.

Q. How much pressure will that develop in the brake cylinder?

A. About 50 pounds.

Q. How much pressure will remain in the auxiliary reservoir in this case?

A. About 50 pounds, as the auxiliary reservoir and brake cylinder pressure always stand equal when brakes are fully applied.

Q. How will the triple valve operate if the train pipe pressure is reduced more than the amount required to equalize the auxiliary and brake cylinder pressures?

A. The triple valve piston will drive the graduating stem down, compressing the graduating stem spring, and traveling the full length of its cylinder, until it rests upon the leather gasket.

Q. With the triple valve in application position, what must be done to cause it to move to release position?

A. The train pipe pressure must be made greater than the auxiliary reservoir pressure.

Q. How can this be accomplished?

A. Either by increasing the train pipe pressure until it is greater than the auxiliary reservoir pressure, or the auxiliary reservoir pressure may be reduced below that which is in the train pipe.

EMERGENCY APPLICATION POSITION.

Q. What is the fourth position of the triple valve?

A. Emergency position.

Q. What is the object of the emergency position of the triple valve?

A. To allow the air to pass from the auxiliary reservoir to the brake cylinder quickly.

Q. What must be done to cause the triple valve piston to move to the emergency position?

A. A sudden reduction of air pressure must be made in the train pipe.

Q. Explain the operation of the triple valve as it moves to the emergency position.

A. The quick reduction made in the train pipe causes the auxiliary reservoir pressure to drive the piston down quickly, the knob on the triple valve piston to strike the graduating stem with considerable force, driving it down and compressing the graduating stem spring. This movement of the piston has caused the slide valve to be moved downward until it entirely uncovers a port in the slide valve seat, thereby permitting auxiliary reservoir pressure, which is always present in chamber e, to pass directly to the brake cylinder. This brings about a quick equalization of the auxiliary reservoir and brake cylinder pressures.

Q. Does the emergency action of this triple valve give any greater braking power in the brake cylinder than would be obtained if a full service application were made?

A. No; the only benefit received from the plain triple valve in emergency is that a quicker application of the brake will be had.

Q. Are there any more than one type of plain triple valve?

A. Yes; there are several different types in service, but the two standard types now furnished are the H-24 and F-46.

Q. What is the principal difference in these two types of valves?

A. Only in the sizes of the ports and the various operative parts.

Q. Why must different size ports be used in these different valves?

A. Because they are used with different size cylinders and reservoirs.

Q. What are the dimensions of the graduating spring used in the plain triple valve?

A. Phosphor bronze spring wire, number 14 B. W. G., 83-1000 inch in diameter, 12 coils, 2½ inches, free height, 25-64 inches inside diameter.

WESTINGHOUSE QUICK ACTION TRIPLE VALVE.

Q. How many, and what are the positions of the quick action triple valve?

A. Five; release, charging, service, lap and emergency.

Q. In what respect do the passenger and freight car triple valves differ?

A. With passenger car triple valves, heavier graduating stem springs are used and a different style of emergency valve piston. There is also a difference in the size of the slide valve and various ports throughout the valve.

Q. Name the different parts of the quick action triple valve.

A. Slide valve, triple piston, piston packing ring, slide valve spring, graduating valve, emergency piston, emergency valve, check valve spring, check valve, graduating stem, and graduating stem spring.

Q. How many complete sets of operative parts has the quick action triple valve?

A. Two; the service parts and the emergency parts.

Q. Name the parts of the quick action triple valve that operate during service application?

A. The triple valve piston, the slide valve and graduating valve.

Q. How can the freight car triple valves be distinguished from the passenger car triple valve other than by the lettering on the triple valve body?

A. By the exhaust outlets. All freight car triples have two exhaust outlets, while the passenger car valves have but one.

Q. What are the dimensions of the graduating stem springs used in the passenger car triple valves?

A. With the F-27 and F-29 type of valves, the springs are made of wire 8-100 of an inch in diameter, 13¼ coils, 2⅝ inches free height, and 29-64 inches inside diameter, while with the freight triple valves F-36 and H-49, wire of 49-1000 of an inch in diameter is used, 16 coils and 2¾ inches free height, the inside diameter being 29-64 inches.

Q. Why are heavier graduating springs used on passenger cars than on freight cars?

A. Owing to the shorter train pipe of a passenger train the triple valve pistons move more quickly and require more resistance to stop them in service position.

RELEASE AND CHARGING POSITIONS.

Q. What can be said of these positions?

A. They are really one, and the same.

Q. Explain why.

A. While the air is being released from the brake cylinder by way of the ports in the slide valve seat, the auxiliary is being charged by way of the feed grooves.

Q. What is the time required to charge an auxiliary reservoir from zero to 70 pounds?

A. With triple valve in proper condition and 70 pounds of pressure maintained in the train pipe it will require approximately 1¼ minutes.

Q. What controls the flow of air from the train pipe to the auxiliary reservoir?

A. The feed ports in the triple piston bushing and in the piston seat.

Q. What is the object in making the feed groove so small?

A. In order to permit of a uniform charging of all auxiliary reservoirs in a long train, also to prevent auxiliary reservoir pressure from passing back into the train pipe during service brake application.

Q. As was described, the F-29 triple valves are used in connection with larger reservoirs, the F-27 with smaller. Is it possible to charge both reservoirs in the same length of time?

A. Yes; because the feed ports are made in proportion to the size of the reservoir with which the triple valve is to be used.

Q. What must be done to cause this valve to move to application position?

A. The train pipe pressure must be reduced below that which is in the auxiliary reservoir.

SERVICE APPLICATION POSITION.

Q. Explain the action of this triple valve after a light service application is made.

A. The train pipe pressure being reduced below that in the auxiliary reservoir and chamber m, the greater pressure on the auxiliary side of the piston causes it to move to the left. By so doing, the feed port is closed, cutting off connection between the auxiliary reservoir and train pipe, the graduating valve unseats and the slide valve moves until a port in the slide valve is brought in register with a port in the slide valve seat, which leads to the brake cylinder.

Q. What causes the triple valve piston to stop when it reaches this position in which the ports in the slide valve and the seat are in register?

A. The resistance of the graduating stem and spring with which the knob on the triple valve piston becomes engaged when it reaches this position.

Q. Explain the flow of air through the triple valve in service application position.

A. With the triple valve in service application position, the auxiliary reservoir pressure, which is always present around the slide valve, is free to pass through ports in the side of the slide valve by the graduating valve which is unseated, thence through ports in the slide valve, and the seat, to the brake cylinder.

Q. How much air will pass from the auxiliary reservoir during this service application?

A. Just a trifle more than the amount which was reduced in the train pipe.

Q. With the graduating valve open as shown, why will not the auxiliary pressure continue to flow to the brake cylinder?

A. Because, as the pressure in the auxiliary reservoir expands into the brake cylinder, and becomes a trifle lower than that which remains in the train pipe, train pipe pressure causes the triple piston to move forward sufficiently to seat the graduating valve, thereby stopping any further flow of air from the reservoir to the brake cylinder.

LAP POSITION.

Q. With the triple valve in lap position, what occurs if another light reduction in train pipe pressure is made?

A. The triple piston will again move back until it engages the graduating stem, thus unseating the graduating valve, which will allow auxiliary reservoir pressure to again pass through to the brake cylinder in amount equal to that reduced in the train pipe, when the piston again seats the graduating valve.

Q. Does the slide valve move with every reduction in train pipe pressure?

A. No; the slide valve of the triple valve moves only once with a brake application. The piston and graduating valve, however, move with every reduction.

Q. What is meant by the term "application of an air brake?"

A. From the time the brake is first applied until fully released. This might be made with one or more train pipe reductions.

Q. If, during a service brake application, the pressure in the train pipe is reduced below that at which the auxiliary reservoir and brake cylinders will equalize, how will the triple valve operate?

A. The piston will move to the left until it strikes the body gasket, and will remain in this position as long as the auxiliary reservoir pressure is above that in the train pipe.

Q. Do we get any further braking power by this movement?

A. No; braking power cannot be increased after equalization has once taken place between the auxiliary reservoir and brake cylinder, no matter how much more air may be reduced in the train pipe.

Q. With the triple valve in application position, what must be done to cause the same to move to release position?

A. The pressure in the train pipe must be made greater than that which is in the auxiliary reservoir.

Q. How can this be accomplished?

A. Either by the engineer charging up the train pipe until the pressure exceeds the reservoir pressure, or by the train men reducing the auxiliary reservoir pressure below that in the train pipe.

Q. What two things does the triple valve do when it moves to release position?

A. It opens the feed port in order to again allow the auxiliary reservoir to recharge, and opens the exhaust port from the brake cylinder to the atmosphere, permitting the brakes to release.

Q. Explain how the air escapes from the brake cylinder to the atmosphere when the triple valve is in release position.

A. A cavity in the slide valve connects cylinder port and exhaust port together, thereby permitting the air to leave the brake cylinder and escape.

Q. After having made a brake application and reduced the auxiliary reservoir pressure to 50 pounds, what will be the time required to recharge the auxiliary reservoir again to 70 pounds pressure?

A. Not less than 35 seconds if the train pipe pressure is fully restored to 70 pounds.

EMERGENCY APPLICATION POSITION.

Q. With the auxiliary reservoir fully charged, what must be done to cause the triple valve to operate in emergency?

A. A quick reduction of pressure must be made in the train pipe.

Q. Explain the operation of the triple valve in emergency.

A. A sudden reduction of train pipe pressure causes the triple piston to move out so quickly that the graduating stem spring cannot withstand the impact of the knob on the triple valve piston, but yields, so that the piston moves to the limit of its travel.

In this position, the removed corner of the slide valve uncovers a port in the slide valve seat, which admits air from the slide valve chamber to the chamber above the emergency piston, which results in forcing the emergency piston down and unseats the emergency valve. With the emergency valve unseated, air pressure in the chamber, above the check valve, escapes to the brake cylinder which then permits train pipe pressure to raise the check valve and also pass to the brake cylinder until the train pipe and brake cylinder pressures equalize, when the check valve reseats. A port of the slide valve and another port in the seat are in direct communication, which will, therefore, allow auxiliary reservoir pressure to pass to the brake cylinder until the pressures become equalized.

Q. At what pressure will the auxiliary reservoirs and brake cylinders equalize with an emergency application and proper piston travel?

A. About 60 pounds.

Q. As it is understood that train pipe and auxiliary reservoir pressures both pass to the brake cylinder during an emergency application, what volume of air reaches the cylinder?

A. A small amount of auxiliary reservoir pressure is admitted to the brake cylinder as the service port is passing over the cylinder port, but the air pressure from the train pipe is the first to reach the cylinder in any considerable volume. It will be noted that the port in the slide valve is restricted in size. This is for the purpose of permitting the train pipe pressure to reach the cylinder before any great auxiliary reservoir volume can pass to the brake cylinder.

Q. What advantage is gained by having the triple valve piston make a joint with the graduating cap gasket when in emergency position?

A. This is to prevent auxiliary reservoir pressure from leaking into the train pipe past the triple valve piston packing ring.

Q. In releasing the brake after an emergency application, is a higher train pipe pressure required than would be necessary if the brakes were fully applied in service?

A. Yes; to release brakes after an emergency application, the train pipe pressure must be raised above 60 pounds; whereas, with a full service application, the brakes can be released with a little over 50 pounds train pipe pressure.

THE PRESSURE RETAINING VALVE.

Q. What is the purpose of the pressure retaining valve?

A. Its purpose primarily is to retain a limited, predetermined amount of pressure in the brake cylinders of the train, in heavy grade service, thereby holding the speed of the train in check during the time the auxiliary reservoirs are being charged.

Q. Does it not also perform other useful duties?

A. Yes; it permits of a much safer handling of the train, the maintenance of a more uniform rate of speed down heavy grades, and causes a great saving in air pressure, which means less labor for the air pump. It also gives an increased cylinder pressure and higher braking power, with a lower consumption of air pressure. Likewise, it permits of a greater reserve in stopping power for emergencies.

Q. Briefly describe the construction of the pressure retaining valve?

A. It consists of a weighted valve enclosed in a casing, and seated in a passage way. This valve is screwed on the opposite end of a pipe coupled to the exhaust port of the triple valve.

Q. Describe its operation when the handle is turned down, pointing to the ground.

A. When the handle is pointing downward, pressure escapes from the brake cylinder, through the triple valve, passes through the retaining valve pipe to the retaining valve, where it escapes freely to the atmosphere. In this position the valve is non-operative and performs no useful work.

Q. When the handle of the retaining valve is turned horizontal, how does it operate?

A. When the handle is turned up, pointing in a horizontal line, the direct outlet from the retaining valve pipe is closed, and a passage way is made through the cock to the under side of the weighted valve on its seat. All pressure over 15 pounds will hold the valve lifted from its seat and escape through a small port from the cage enclosing the weighted valve. The weighted valve is so proportioned that it will seat when only 15 pounds pressure is exerted upon it. Thus the last 15 pounds are retained in the brake cylinder, which is sufficient to steady the train while the brakes are being recharged.

Q. The retaining valve then merely performs the useful service of holding 15 pounds in the brake cylinder?

A. Not only this, but the passage way out of the casing to the atmosphere is so small that considerable time is consumed in discharging the entire brake cylinder through the small port. This renders the release of the brake much slower, and exerts a retarding effect which also gives more time for the auxiliary reservoir to recharge.

Q. Is this small escape port in the cap, or cage, the same size for all retaining valves?

A. No; it is 1-16 inch for retaining valves used on 6, 8 and 10-inch cylinders, and ⅛ inch for 12, 14 and 16-inch cylinders. These port sizes give a restriction, which requires about 30 to 60 seconds for the full cylinder pressure to escape down to the amount limited by the weighted valve.

Q. Describe the construction of the three position retaining valve.

A. It has two separate weighted valves, one of the ordinary form, the other being of an inverted cup shape, resting upon the top of the ordinary weight.

Q. How does this valve operate?

A. When the handle points downward, the valve is inoperative, and brake cylinder pressure escapes freely to the atmosphere through the large release port of the valve.

Q. When the handle is turned half way up, at an angle of 45 degrees, how does the valve operate?

A. The large release port is cut off, and both weights now resist the escape of brake cylinder pressure through the retaining valve, and as their combined weights have a resistance equal to 50 pounds of pressure, that amount is retained in the brake cylinder.

Q. Why is it necessary to retain such a high pressure?

A. Experience has proved it desirable, on high capacity steel cars, to hold this amount continuously in the brake cylinders in heavy grade service, on account of the low percentage of braking power on these cars when loaded.

Q When the handle is turned up to horizontal position, how does the valve operate?

A. The heel, or projection, on the handle strikes a pin which, in being forced upward against the inverted cup weight, lifts that weight from the top of the other weight, thus permitting the latter to perform its usual function of retaining 25 pounds in the brake cylinder.

RETAINING VALVE DISORDERS.

Q. Is the retaining valve of any decided advantage in driver brake operation?

A. It would be were it not for the fact that driver brake packings generally leak badly, and the numerous connections in the brake cylinder pipe frequently become loose and cause leakage. With these avenues of escape for pressure, the retaining valve is unable to perform its intended function. The driver brake retaining valve has almost entirely given way to the combined automatic and straight air brake which overcomes this leakage difficulty.

Q. If there is a steady leakage of pressure at the retaining valve exhaust while brakes are released, should the trouble be looked for in the retaining valve?

A. No; the trouble will generally be found in the rubber seated emergency valve in the triple.

Q. If the retaining valve handle has been turned up in operative position, brakes then released, and after a few moments the handle is turned down and no air escapes, is the fault in the retaining valve?

A. No; it is either in a leaky joint or connection in the pipe, or in the brake cylinder packing.

Q. Should air refuse to pass through the retaining valve with handle turned down, and brake remain set, where should the trouble be looked for?

A. At the exhaust port. It may be stopped up by accumulation of dirt, pipe scale, or cuttings. Sometimes insects build and stop up the port.

THE K TRIPLE VALVE.

Q. In what respect does the type K triple valve differ from the standard quick action triple?

A. It has three additional features known as quick service, uniform release and uniform recharge.

Q. Why are these added features necessary?

A. To meet modern conditions of freight service.

Q. Why is the older type (F-36 or H-49) triple valve not satisfactory on trains consisting of more than 50 cars?

A. Being originally designed for trains of not more than 50 cars it is unable to handle the increased volume of air required on longer trains.

Q. How are the F-36 and H-49 triple valves at present designated?

A. The H-1, and H-2 triples.

Q. With the same discharge opening at the brake valve why do the type "K" triple valves apply more promptly and uniformly than the old standard types?

A. The Quick Service feature of the "K" valve makes a supplementary brake pipe reduction at each triple valve.

Q. How is this supplementary or local brake pipe reduction obtained?

A. When a brake pipe reduction is made at the brake valve, the first triple valve moves to quick service position, in which position a port is open from the brake pipe to the brake cylinder, which permits the brake pipe air to flow to the brake cylinder, making a local brake pipe reduction which affects the next valve, causing a rapid serial application throughout the train.

Q. Does air flow from the auxiliary reservoir to the cylinder at the same time it flows from the brake pipe to the cylinder?

A. Yes. The service port from the auxiliary reservoir to the cylinder is open when the quick service port is open.

Q. What controls the opening of the quick service port?

A. The triple valve slide valve, and graduating valve.

Q. Is the quick service feature operative with short trains?

A. No. This feature automatically goes out of service when the brake pipe pressure is being reduced at the proper rate.

Q. What increase of brake cylinder pressure is obtained by use of the quick service feature?

A. About one pound higher equalization under normal conditions of piston travel and cylinder leakage.

Q. What other advantages are obtained from the quick service feature in addition to the higher cylinder pressure?

A. The application of all brakes with light brake pipe reductions; time of application is reduced about one-half; also a uniform application is obtained throughout the train.

Q. Is less air consumed in handling a train equipped with quick service triple valves than would be the case with valves not having this feature?

A. Yes. A considerable portion of the brake pipe air which is ordinarily discharged to the atmosphere enters the brake cylinders, therefore not requiring as heavy brake pipe reductions to obtain the same cylinder pressure as would be the case where auxiliary reservoir air alone enters the cylinder, but chiefly because, for a given train and speed, the same stop can be made with a much lighter brake pipe reduction with the "K" valves, due to uniform application throughout the train.

Q. Is the advantage of the quick service feature obtained where quick service triples are mixed in a train with triple valves not having this feature?

A. Yes. The advantages obtained are in proportion to the number of quick service triple valves in the train.

Q. Will the discharge of air from the brake valve exhaust with a given reduction be as long with a train of quick service triple valves as would be the case if the train was equipped with triple valves not having the quick service feature?

A. No. The time of discharge from the brake valve would be reduced about one-half.

Q. How many service positions has the type "K" triple valve?

A. Two: Quick Service and Full Service positions.

Q. From an external view what distinguishes the type "K" valve from other types?

A. A lug or fin cast on the top of the valve body.

Q. What is the object of the Uniform Release feature of the "K" triple valve?

A. To provide a uniform release of brake cylinder pressure through the entire train and prevent the severe shocks, and possible break-in-twos often experienced with a long train equipped with triple valves not having this feature.

Q. When the brake valve is placed in release position in order to release the train brakes, on what portion of the train do the triple valves move to release position first?

A. On the head end.

Q. Why do the valves on the head end move to release position before those on the rear end?

A. Owing to the prompt rise in brake pipe pressure on the head end when the brake valve is placed in release position and the slow rise of pressure on the rear end.

Q. What prevents the pressure from raising promptly on the rear of a long train if a high pressure exists in the main reservoir at the time the brake valve is moved to release position?

A. The frictional resistance to the flow of air through the long brake pipe combined with its many bends makes it impossible to raise the pressure promptly on the rear end.

Q. How many release positions has the type "K" triple valve?

A. Two: Normal and Retarded Release.

Q. How do these two positions differ, insofar as the release of brake cylinder pressure is concerned?

A. In normal release position, the exhaust opening is large, which permits of a prompt fall of brake cylinder pressure; in retarded release position, the exhaust opening is small, which restricts the fall of brake cylinder pressure.

Q. What controls the movement of the valve to normal or retarded release position?

A. The rate of rise of brake pipe pressure as compared with that in the auxiliary reservoir. If this is slow the valve moves to normal release position; if quick, the valve moves to retarded release position.

Q. Explain briefly the uniform release feature of the "K" triple valve.

A. Connected to the auxiliary end of the triple valve body is a casing in which is a stem and spring so located as to stop the triple piston and slide valve in normal release position when the brake pipe pressure is raised gradually. However, if the rise in brake pipe pressure is sufficiently prompt to increase it materially above the auxiliary reservoir pressure the differential pressure thus set up will be sufficient to move the triple piston and slide valve to retarded release position, compressing the retarding spring.

Q. What difference in pressure between the brake pipe and auxiliary reservoir is required to compress the retarding spring, and cause the valve to move to retarded release position?

A. About three pounds.

Q. In releasing the brakes on a fifty-car train or longer, with the brake valve held in release position, about how far back in the train will the valves move to retarded release position?

A. About thirty cars immediately back of the engine.

Q. Why will the valves beyond this point not go to retarded release position?

A. Because with a long train it is impossible to raise the brake pipe pressure three pounds above the auxiliary reservoir pressure for more than thirty cars back in the train.

Q. If the head triple valves move to release first, why are not the head brakes released first?

A. The restricted exhaust opening of the "K" valve in retarded release position causes the brake cylinder pressure to fall sufficiently slow as to permit the rear triples of a long train to move to normal release position and discharge the brake cylinder pressure to five pounds on the rear in approximately the same time the cylinder pressure on the head end is reduced to five pounds.

What other feature does the "K" triple valve possess that is valuable at the time brakes are being released?

A. The uniform recharge feature.

Q. What is meant by uniform recharge?

A. The recharging of the auxiliary reservoirs on the head, and rear of the train at approximately the same rate.

Q. Why is this necessary?

A. To prevent the reapplication of the head brakes, when the brake valve is moved from release to running position, as would occur, if the head auxiliary reservoirs were overcharged.

Q. If the feed grooves of triple valves in the trains are the same size, why will the head auxiliary reservoirs charge faster than the rear ones?

A. When the brake valve is placed in release position, the brake pipe pressure on the head end is raised promptly above that in the auxiliary reservoirs, whereas the brake pipe pressure on the rear is raised slowly, this difference in brake pressure resulting in the head reservoirs charging more promptly than those on the rear.

Q. How does the "K" triple valve permit a uniform recharge when the brake pipe pressure is higher on the head end than on the rear end?

A. The charging ports and grooves are so arranged that with the triple valves in retarded release position (as would be the case where the brake pipe pressure is high), a small opening is had from the brake pipe to the auxiliary reservoirs; when the valves are in normal release position, a large opening is had from the brake pipe to the reservoirs. This difference in sizes of charging openings compensates for the difference in brake pipe pressure at the two ends of the train.

Q. Is any other benefit obtained by retarding the recharge of the head auxiliary reservoirs?

A. Yes. It permits a greater volume of air to flow to the rear, insuring a higher pressure and a more prompt release of the rear brakes.

Q. Does the retarded recharge feature interfere with the proper handling of trains on grades?

A. No. The retarded release feature combined with the quick service feature more than compensates for the retarding of recharge on the head end, and the uniform recharge more evenly distributes the brake work on the train.

Q. With all cars equipped with "K" triple valves, can the brakes on long trains be released at low speed without danger of a break in two.

A. Yes. The retarded release feature operating on about thirty of the head brakes will be sufficient to keep the slack from running out.

Q. If a number of "K" triple valves are located in the rear of a long train of old type of triple valves will the slack run out on the head end due to the retarded release feature of the "K" triple valves?

A. No. "K" triple valves on the rear of long trains do not go to retarded release position.

Q. With "K" valves scattered through a train equipped with old type of triple valves, would the higher cylinder pressure obtained with the "K" triple valves be sufficient to cause trouble?

A. No. The ordinary variation in piston travel found on different cars in the train results in a greater difference in cylinder pressure than would be had between the type "K" triple valves and old type triple valves.

Q. Will "K" triple valves work in perfect harmony with old style triple valves?

A. Yes. They not only work in harmony, but greatly improve the action of the older type.

Q. How should a brake be bled off by hand if there is air pressure in the brake pipe?

A. The release valve on the auxiliary reservoirs should be held open only until the discharge of air is heard at the retaining valve.

Q. What will be the effect if the release valve is held open after air commences to discharge from the retaining valve?

A. The triple valve will move to retarded release position and be much slower in releasing the brake.

Q. How should the brake be released by hand if there is no air in the brake pipe?

A. The release valve should be held open until all the air is exhausted from the brake cylinder.

Q. Is there any difference in the emergency parts of a "K" triple valve as compared to the old type quick action triple valves?

A. No. All parts are the same and interchangeable.

Q. How many sizes of "K" triple valves are there?

A. Two: The K-1 and K-2.

Q. What sizes of brake cylinders are these used with?

A. The K-1 for 8-inch cylinder, and the K-2 for 10-inch cylinders.

Q. Can the features of the type "K" valve be incorporated in the H-1 and H-2 valves?

A. Yes.

Q. How may the K-1 triple valve be distinguished from the K-2?

A. The K-1 has two holes in the reservoir flange, while the K-2 has three.

FULL RELEASE AND CHARGING POSITION.

Q. Explain the flow of air through the triple valve, in full release and charging position.

A. Air entering from the brake pipe flows through the cylinder cap and port to a chamber on the face of the triple piston; thence through the feed port to the slide valve chamber (which is always in free communication with the auxiliary reservoir). At the same time brake pipe air which has raised the check valve and filled that chamber, flows through the port in the body and valve seat and a port in the slide valve to the slide valve chamber until the auxiliary reservoir is charged equal to the brake pipe pressure. Brake cylinder air is now free to pass to the atmosphere.

Q. What is the object of having two passages through which the auxiliary reservoir is charged?

A. As the K-2 triple valve is used with an auxiliary reservoir of suitable size for a 10-inch cylinder, it is so large that to charge it in proper time through a single feed port "i" would require such port to be of considerable size, which would permit of an appreciable amount of auxiliary air feeding back into the brake pipe when a brake pipe reduction was made. For this reason the feed port "k" is made the same size in the K-1 and K-2 triple valves.

Q. With the feed port the same size in both the K-1 and K-2 valves, why will the reservoirs charge uniformly when the valves are in retarded release position?

A. When the valves are in retarded release position the auxiliary side of the piston comes in contact with the end of the slide valve bushing, making an airtight seal, except at one point where a small feed groove is cut in the piston to allow air to pass by the end of the slide valve bushing into the chamber and auxiliary reservoir. The size of this groove controls the charging of the auxiliary reservoirs when the valves are in retarded release position. The feed groove in the piston of the K-2 valve is larger than in the K-1; therefore both sizes of auxiliary reservoirs are charged in approximately the same time.

Q. Is there any other difference between the K-1 and K-2 valves?

A. No; in all other respects both valves are the same (except in size of parts and ports), therefore it will only be necessary in the following to consider the K-2 triple valve.

Q. With the triple valve in full release position, and the brake pipe and auxiliary reservoir pressure equal what must be done to cause the valve to move to application position and apply the brake?

A. The air pressure on the brake pipe side of the triple piston must be reduced below that on the auxiliary reservoir side.

Q. About how much lower must the brake pipe pressure be than the auxiliary reservoir pressure to cause the triple valve to move to application position?

A. About two pounds, or just enough to overcome the friction of the slide valve on its seat, and the piston packing ring in its cylinder.

QUICK SERVICE POSITION.

Q. Explain the action of the triple valve as it moves from release position to quick service position.

A. As the brake pipe pressure is reduced below auxiliary reservoir pressure the triple piston moves to the right until the spider on the end of the piston stem engages the slide valve, this movement permitting the piston to close the feed groove and move the graduating valve until it opens the service port in the top of the slide valve, and its cavity connects the two ports in the top of the slide valve; the piston continues its movement carrying the slide valve until it is arrested by the graduating stem, which is held in place by the compression of graduating spring. Two ports in the seat are in register with the ports in the slide valve. In this position of the valve auxiliary reservoir air flows through a port in the slide valve and the port in the seat to the brake cylinder.

Q. In quick service position service port "Z" in the slide valve is not in full register with brake cylinder port "r"; explain the reason for this.

A. The opening as shown is sufficient to permit the air in the auxiliary reservoir to reduce by flowing to the brake cylinder as fast as the pressure is reducing in the brake pipe when the train is of considerable length.

However, if the brake pipe is reduced more rapidly than that of the auxiliary reservoir, as may be the case on short trains or trains having heavy brake pipe leakage, the auxiliary reservoir pressure would become sufficiently above that in the brake pipe as to cause the triple piston to slightly compress the graduating spring and move the slide valve to full service position.

FULL SERVICE POSITION.

Q. Explain what takes place when the valve moves from quick service position to full service position.

A. As the triple piston moves to the right, slightly compressing the graduating spring, it moves the slide valve until the quick service ports in the slide valve and the ports in the seat are no longer in communication, and the auxiliary service port in the slide valve is brought in full register with the brake cylinder port in the seat, permitting the auxiliary reservoir air to flow to the brake cylinder at the same rate that the brake pipe pressure is being reduced.

Q. Does not air flow through the quick service ports when the valve is in full service position?

A. No. As it requires a prompt fall in brake pipe pressure to cause the valve to move to full service position, the local brake pipe reduction obtained by the quick service ports is unnecessary, therefore this feature is automatically cut out.

Q. Will the air that flows through the quick service ports to the chamber above the emergency piston develop sufficient pressure to force the piston down and cause the triple valve to operate in quick action?

A. No. The emergency piston is sufficiently loose in its cylinder to permit the air that flows through the small quick service ports to pass readily around the piston to the chamber and to the brake cylinder.

Q. With the triple valve in quick service or full service position, how much air will flow from the auxiliary reservoir to the brake cylinder?

A. That depends on the amount of reduction made in the brake pipe. When the discharge of air from the brake pipe ceases, the auxiliary reservoir pressure will continue to fall until the pressure on the auxiliary side of the triple valve piston is slightly below the pressure remaining on the brake pipe side, when the piston will move to the left, causing the graduating valve to close the auxiliary service port and quick service port in the slide valve.

Q. As the triple piston moves to the left causing the graduating valve to close the service ports, why does it not move the slide valve to release position?

A. The friction of the piston and graduating valve is much less than that of the slide valve, therefore the difference in pressure that will move the piston and graduating valve will not move the slide valve, and the movement of the piston is arrested when the collar on its stem comes in contact with the slide valve.

LAP POSITION.

Q. What is meant by lap position?

A. It is a position of the valve where all ports are lapped; that is, closed.

Q. Is there any difference between quick service lap and full service lap positions?

A. Yes. In quick service lap position the quick service ports in the slide valve are still in register with the quick service ports in the seat, whereas in full service lap these ports are not in register. As the slide valve does not move, when the triple goes to lap position, it will remain in full service position, but with the graduating valve moved back so as to blank the ports in slide valve.

Q. If a further brake pipe reduction is made, what action will be obtained from the triple valve?

A. It will move to the position it was in before it moved to "lap."

Q. What is the total number of pounds reduction in brake pipe pressure required to fully apply the brake?

A. Twenty pounds with proper brake cylinder piston travel (eight inches).

Q. Why will a reduction of twenty pounds in brake pipe pressure fully apply the brake?

A. Auxiliary reservoirs are so proportioned to the sizes of the brake cylinders that, with an initial pressure of seventy pounds in the brake pipe and auxiliary reservoirs, the pressure in the latter will equalize into brake cylinders at fifty pounds.

Q. What will be the effect if a reduction of more than twenty pounds is made in the brake pipe?

A. It will be a waste of brake pipe air. The triple piston will move the graduating stem, compress its spring and carry the slide valve to emergency position, but no greater brake cylinder pressure will be obtained as the auxiliary reservoir and brake cylinder pressures are already equalized.

Q. With the triple valve in application or lap position, what must be done to cause it to move to release position?

A. The brake pipe pressure must be raised sufficiently to overcome the friction of the piston slide valve.

Q. Explain the action of the triple valve when the brake pipe pressure acting on the piston is great enough to overcome the friction of piston and slide valve.

A. The piston will move to the left carrying with it the slide valve until the end of the piston and stem and slide valve comes in contact with the retarding stem which will arrest their movement and stop them in full release and charging position. The flow of air through the triple valve in this position has been explained heretofore.

RETARDED RELEASE POSITION.

Q. What must be done to cause the triple valve to move to retarded release position?

A. The air pressure on the brake pipe side of the piston must be raised above the pressure on the auxiliary reservoir side of the piston at least three pounds more than that required to overcome the friction of the piston and slide valve. This higher brake pipe pressure will then be sufficient to move the retarding stem and compress its spring until the piston comes in contact with the end of the slide valve bushing.

Q. Explain the flow of air through the triple valve in retarded release and charging position.

A. Brake pipe air, which is always present in the chamber on the right of the triple piston, flows through the feed groove in the bushing over the top of piston and through a small groove cut in the piston seal (at the point in contact with the slide valve bush), to slide valve chamber and the auxiliary reservoir. The exhaust cavity in the slide valve now being in register with the brake cylinder port, its tail port in register with the exhaust port; brake cylinder air will flow through port, cavity and restricted passage to the tail port, thence through the exhaust port to the atmosphere.

Q. Is the feed groove in the seal of the piston the same size as the feed groove in the bushing?

A. No. This groove is smaller in order that the charging of the auxiliary reservoir will be slower when the triple valve is in retarded release position, than when in full release position.

EMERGENCY POSITION.

Q. What must be done to cause the triple valve to operate in quick action?

A. When the brake pipe pressure on the right of the piston is reduced quickly, and considerably below the auxiliary reservoir pressure on the left, the piston moves quickly to the right, forcing back the graduating stem and compressing its spring, until the piston seats firmly against the cylinder cap gasket. As the slide valve moves with the piston, it opens the cylinder port in the slide valve seat and allows air from the auxiliary reservoir to flow to the top of the emergency piston, forcing it downward and opening the emergency valve. The pressure being thereby instantly reduced, allows brake pipe air to raise the check valve and flow rapidly through to the brake cylinder until brake cylinder and brake pipe pressures nearly equalize, when the check valve is forced to its seat by its spring, preventing the brake cylinder air from flowing back into the brake pipe. At the same time the emergency port in the slide valve, being in register with the brake cylinder port, permits auxiliary reservoir air to flow to the brake cylinder, but the size of these ports is such that comparatively little air gets through them before the brake pipe has stopped venting into the brake cylinder. The emergency valve being held open by the emergency piston, will return to its seat when the auxiliary and brake cylinder pressures have nearly equalized due to the pressure of the check valve spring under the emergency valve.

Q. What pressure will the auxiliary reservoir and brake cylinder equalize at with an emergency application?

A. With an initial pressure of seventy pounds in the brake pipe and auxiliary reservoir, the auxiliary reservoir and brake cylinder will equalize at approximately sixty pounds.

Q. If one triple valve operates in quick action, does the reduction it makes in brake pipe pressure apply other brakes in quick action?

A. Yes. Each valve causes the next to apply, thus giving a quick and full application of all the brakes throughout the train.

Q. How long a time does it require to apply the brakes in quick action throughout a fifty-car train?

A. About three seconds.

Q. Is the release after an emergency application accomplished the same as after a service application?

A. Yes. But it requires a longer time owing to the higher brake cylinder and auxiliary reservoir pressure and the lower brake pipe pressure.

Q. What is the object of having the triple valve piston make a joint on the cylinder cap gasket when in emergency position?

A. To prevent auxiliary reservoir air from leaking into the brake pipe past the piston.

Q. Is the graduating spring of the same strength as the retarding spring?

A. No. The retarding spring is heavier and stronger than the graduating spring.

MANIPULATION.

Q. Are any special instructions required by engineers regarding the handling of trains partially or wholly equipped with the K triple valve?

A. No; the automatic brake valve should be handled as good practice requires with the H triple valve.

Q. What important detail should be observed when making the terminal tests?

A. The results should be carefully checked by noting how the brakes hold in the first running application, and the engineer should be governed accordingly in subsequent applications.

Q. What rule should be observed relative to release?

A. Before attempting to release, have ample excess pressure for the length of the train, and in releasing leave the automatic brake valve handle in release position until the rear brakes have had time to release.

AUTOMATIC SLACK ADJUSTER.

Q. What is the function of the automatic slack adjuster?

A. It maintains a constant predetermined piston travel, and thus insures that each car performs its share of the work.

Q. Why is it necessary to take up the slack in the brake rigging?

A. On account of the wear of the brake shoes.

Q. Suppose two freight cars, with 8-inch brake cylinders and the same levers, be taken with 5 and 9 inches piston travel respectively. Charge them to 70 pounds pressure and then make a 7-pound train pipe reduction. How would the piston pressures of the two brake cylinders compare?

A. The piston with 5 inches travel would have about 1,150 pounds total pressure, nearly half of a full service application, while the piston with 9 inches travel would have a total pressure of only about 400 pounds—a little more than one-third of the other.

Q. With two cars braking with these different forces, due to unequal piston travel, what would be the piston pressures if a second or further 7-pound train pipe reduction were made?

A. The one with 5 inches travel would be fully applied, at about 2,600 pounds, and the one with 9 inches travel would be about three-fifths set, at about 1,500 pounds.

Q. Suppose a further reduction of 7 pounds, 21 in all, be made?

A. This last reduction would be wasted on the brake with 5 inches piston travel, as it was already fully applied, and the one with 9 inches piston travel would now be about as heavily applied as we could get it; but the total pressure in the cylinder of the latter would be only about 2,300 pounds, or approximately 90 per cent. of the other car.

Q. Then the car with 9 inches piston travel would have a much inferior brake, due to the simple fact that it has a too long piston travel?

A. Yes; it is only 90 per cent. as efficient on the third 7-pound train pipe reduction as the other one, only 60 per cent. on the second 7 pounds, and only 30 per cent. as efficient on the first 7-pound reduction.

Q. How does the automatic adjuster do its work?

A. It adjusts the piston at its proper running or working travel, regardless of the lost travel, or whether the car be high-leveraged or low-leveraged. Thus, if all cars in a train were equipped with automatic slack adjusters, the travel of all pistons would be uniform when brakes were set to slow down or stop the train. The same brake cylinder pressure would be had on all the cars at each reduction.

CONDUCTOR'S VALVE.

Q. What is the conductor's valve and what is it for?

A. It is simply an additional stop cock connected with the train pipe, and by opening it the conductor can apply the brakes in case of emergency.

Q. How is it connected?

A. A branch pipe connecting with the train pipe passes up through the body of the coach, usually in the toilet room, and on this branch pipe is placed the stop cock, or valve.

Q. How should the conductor's valve be handled?

A. If it is desired to make a gradual stop the valve should be opened gradually, but for a quick stop it must be opened quickly and left open until the train is stopped.

TYPE L TRIPLE VALVE.

Q. What is the Schedule LN Equipment?

A. It is an improved brake for high speed passenger service.

Q. In what respect does it differ from the old standard high speed brake equipment?

A. It has additional features necessary for the proper braking of modern trains.

Q. What features has the LN Equipment that were not obtained with the old standard high speed brake equipment?

A. Quick recharge of the auxiliary reservoir, quick service application, graduated release and high emergency brake cylinder pressure.

Q. In a general way how does this schedule differ from the old high speed brake schedule?

A. It has a new type of triple valve and an additional reservoir.

Q. What is the designation of the triple valve?

A. Type L.

Q. Is a high speed reducing valve used with the LN schedule?

A. No; a safety valve, which is a part of the L triple valve, takes the place of the high speed reducing valve.

Q. Does the type L, triple valve operate in harmony with the older standard types of passenger triple valve?

A. Yes; it has all the features of the old types of triple valves in addition to the new features.

Q. Are all of the improved features, such as quick recharge, quick service application, graduated release and high emergency brake cylinder pressure, obtained from the triple valve alone?

A. No; they are obtained through the combination of the improved triple valve and the additional reservoir.

Q. What is this reservoir called?

A. Supplementary reservoir.

Q. What is the size of the supplementary reservoir as compared with the auxiliary reservoir?

A. It is approximately two and one-half times the size of the auxiliary reservoir.

Q. Is the supplementary reservoir volume always confined to one reservoir?

A. No; where space under the car does not permit of using one large reservoir, two supplementary reservoirs having an equivalent capacity are sometimes used.

Q. In addition to the improved operating feature of the L triple valve, has any other improvement been made?

A. Yes; this valve is of the pipeless type, which permits it to be applied or removed from the brake cylinder head without disturbing any of the pipe joints.

Q. What improved features are derived by the use of the LN schedule?

A. (a) A moderate brake cylinder pressure obtained from light brake pipe reductions.

(b) Heavy service reductions can be made quickly without liability of obtaining quick action.

(c) The air pressure can be graduated into or out of the brake cylinder.

(d) The auxiliary reservoir re-charges quickly so as to permit of a prompt response to successive applications.

(e) A high brake cylinder pressure can be obtained quickly from an emergency application.

Q. Name the different parts of the complete LN brake schedule.

A. Type L triple valve with safety valve; type N brake cylinder with pressure head arranged for all pipe connections; auxiliary reservoir and its drain cock; supplementary reservoir and its drain cock; branch-pipe cut-out cock; conductor's valve; angle cocks; air hose and brake pipe fixtures ordinarily found on a car; also the automatic slack adjuster.

Q. What is the purpose of the cut-out cock?

A. It is furnished with this schedule in order that the supplementary reservoir can be cut out during the transition period.

Q. How many sizes of L triple valves are there?

A. Three; designated as follows: L-1, L-2, and L-3.

Q. What sizes of brake cylinders are these valves adapted for?

A. L-1 is for 8-in. and 10-in. brake cylinders; L-2 for 12-in. and 14-in.; and L-3 for 16-in. and 18-in. brake cylinders.

FULL RELEASE AND CHARGING POSITION.

Q. Explain the flow of air through the triple valve in full release and charging position.

A. Air from the brake pipe enters the triple valve and flows through into the chamber on the face of the triple valve piston; thence through feed groove to chamber R and the auxiliary reservoir. Brake pipe air also raises the check valve and flows through ports into the auxiliary reservoir. A port in the slide valve is now in register with the supplementary reservoir into which air also passes. In this way both auxiliary and supplementary reservoirs are charged at the same time with the same pressure. At the same time air from the brake cylinder entering the triple flows through a port in the body, and valve seat, to a port in the slide valve, thence through a cavity in the graduating valve to another port in the slide valve, and thence to the atmosphere.

QUICK SERVICE POSITION.

Q. Explain the operation and flow of air through the triple valve in qiuck service position.

A. With the air pressure equal in the brake pipe, auxiliary reservoir and supplementary reservoir, a service reduction in the brake pipe reduces the pressure on the face of triple valve piston below that in the auxiliary reservoir on the opposite side of the piston. The higher auxiliary reservoir pressure, therefore, forces the piston to the left, which carries with it the graduating valve. This movement of the piston closes the feed port in the bushing and permits the graduating valve to close the ports on the upper side of the slide valve, which closes the communication between the brake pipe and the auxiliary reservoir and supplementary reservoir; also closing the exhaust passage from the brake cylinder to the atmosphere. This same movement opens another port in slide valve and connects two ports through the small cavity in graduating valve. At this time the spider or lugs on the end of the piston stem engage the end of the slide valve, which is carried to the left with the graduating valve until the piston comes in contact with graduating sleeve, which causes it to stop in quick service position.

Q. What particular benefit is obtained by the flow of air from the brake pipe to the brake cylinder through the quick service ports just mentioned?

A. The brake pipe air assists in moving the brake cylinder piston beyond the leakage groove, and at the same time the local reduction made in brake pipe pressure by the triple valve results in the service reduction being quickly and uniformly transmitted from car to car throughout the train.

Q. Is the amount of air vented from the brake pipe to the brake cylinder through the quick service ports very great?

A. No.

Q. Why?

A. First—because the quick service ports and passages are small, and second—as the piston and slide valve move toward full service position, the quick service port is restricted and is completely closed just before the service port in the slide valve is fully opened.

Q. What governs the amount of opening, and time that the quick service port remains open?

A. The rate of reduction in brake pipe pressure as compared with that of the auxiliary reservoir.

Q. If the brake pipe pressure is reduced quickly, as would be the case with a short train, what will be the result?

A. The higher auxiliary reservoir pressure will move the piston and slide valve promptly to full service position, thereby automatically cutting out the quick service feature when it is not needed.

Q. What will result from a slow brake pipe reduction as with long trains?

A. A slow brake pipe reduction will cause a partial opening of the service port sufficient to reduce the auxiliary reservoir pressure as quickly as the brake pipe pressure is being reduced; therefore, with this port only partly open, a balance of pressure is maintained on the two sides of the triple valve piston.

Q. With the triple valve in quick service position and air flowing from the brake pipe and auxiliary reservoir to the brake cylinder, why does not the valve remain in this position until the brake is fully applied?

A. The triple valve will remain in quick service position as long as air is being discharged from the brake pipe at the brake valve; when the reduction is stopped, the triple valve will move to quick service lap position, due to the fact that the service port in the slide valve is larger than the quick service port.

Q. With the triple valve in quick service lap position, what action will take place if a further reduction is made in brake pipe pressure?

A. If the brake pipe pressure is reduced slowly, the triple valve piston will again move to the left, carrying with it the graduating valve and opening the service port, and the quick service ports as before mentioned.

Q. Will the air obtained from the brake pipe through the quick service ports cause a considerably higher brake cylinder pressure when the brake is fully applied?

A. No; the gain in cylinder pressure is approximately one pound above that which would be obtained without the use of the quick service feature.

FULL SERVICE POSITION.

Q. What causes the triple valve to move to full service position?

A. When the pressure in the brake pipe is being reduced rather promptly, as would be the case with a short train or a train having considerable brake pipe leakage, the triple valve piston will move to the left, coming in contact with the graduating sleeve, moving it slightly and compressing the graduating spring. By this movement the service port in the slide valve is brought in full register with the brake cylinder port in the seat, permitting auxiliary reservoir pressure to flow to the brake cylinder at the same rate at which the brake pipe pressure is being reduced.

Q. If the brake pipe reduction is less rapid than is required to fully open the port, what takes place?

A. This port is only partially opened, but sufficient to preserve a balance between the pressures on the two sides of the triple valve piston.

Q. How much air will leave the auxiliary reservoir and flow to the brake cylinder when the triple valve moves to full service position?

A. Approximately the same reduction in pressure as was made in the brake pipe.

Q. Is not the safety valve connected with the brake cylinder in all positions of the triple valve?

A. No; it is connected in all, except emergency position, as will be explained later.

Q. What pressure is the safety valve set for?

A. Sixty-two pounds.

Q. As this valve is connected to the brake cylinder during service operation of the triple valve, does it not answer the same purpose as the high speed reducing valve?

A. Yes; it limits the maximum pressure that can be obtained in the brake cylinder from service applications to an amount not liable to cause wheels to slide.

Q. When the triple valve is in quick service or full service positions, does not air from the supplementary reservoir flow to the brake cylinder in addition to the auxiliary reservoir air?

A. No.

Q. Why?

A. The supplementary reservoir is cut off when the triple valve is in quick service, full service or lap positions; therefore, this reservoir pressure will be retained.

LAP POSITION.

Q. What will cause the triple valve to move from service position to lap position?

A. After sufficient brake pipe reduction has been made to produce the desired application, and the brake valve handle is placed in lap position, a further escape of air from the brake pipe is prevented. When the flow of air from the auxiliary reservoir to the brake cylinder has reduced the pressure on the auxiliary side of the piston slightly below that remaining on the brake pipe side, the greater pressure on the brake pipe side, assisted by the graduating spring, will move the piston and graduating valve to service lap position.

Q. As the triple valve piston and graduating valve move from service position to service lap position, what prevents the piston from continuing its movement to release position?

A. As the triple valve piston and graduating valve move to service lap position, the shoulder on the stem of the piston comes in contact with the end of the slide valve. The slightly higher pressure acting on the brake pipe side of the piston, which was sufficient to move it and the graduating valve, is not sufficient to overcome the added resistance of the slide valve and the parts remain in the position shown.

Q. With the triple valve in service lap position, are there any ports or passages open?

A. No; except that the safety valve is still in register with the brake cylinder.

Q. Is there any difference between quick service lap and full service lap?

A. Yes. The position of the slide valve is not the same as in quick service position.

Q. After the triple valve has moved to lap position, following a service reduction, what parts move on a further brake pipe reduction?

A. The piston and graduating valve when the brake pipe pressure is reduced at approximately the same rate as the first reduction.

Q. With the triple valve in service lap position, what must be done to cause the valve to move to release position?

A. The pressure in the brake pipe must be raised higher than the pressure in the auxiliary reservoir.

Q. How can the brake pipe pressure be made greater than the auxiliary reservoir pressure?

A. By placing the engineer's brake valve in running or release position, and permitting air to flow from the main reservoir to the brake pipe, or by opening the drain cock on the auxiliary reservoir.

RELEASE POSITION.

Q. Explain the action of the triple valve and the flow of air through it when moved from service lap position to release position.

A. When the brake pipe pressure is raised above that in the auxiliary reservoir, the triple valve piston will move to the right, carrying with it the slide valve and graduating valve to full release and charging position. In this position the air in the brake cylinder is exhausted through the slide valve, graduating valve and passage to the atmosphere. At the same time the auxiliary reservoir is being re-charged from the brake pipe through the feed groove and ports, as previously described. The air in the supplementary reservoir which remained at its initial pressure when the triple valve moved to service position will now flow into the auxiliary reservoir and help re-charge it, resulting in a quick re-charge.

Q. What is the benefit of having the auxiliary reservoir quickly re-charged?

A. It insures an immediate response of the triple valve to a brake pipe reduction, should it be necessary to make a second brake application.

Q. What must be done to insure that the triple valve will move to full release position and remain there, exhausting all air from the brake cylinder?

A. The brake pipe pressure must be fully restored and the auxiliary reservoir, and supplementary reservoir will be fully re-charged.

Q. What will be the result if only sufficient air is admitted to the brake pipe, to move the triple valve to release position, and the brake valve handle is then moved to lap position?

A. The flow of air from the supplementary reservoir to the auxiliary reservoir continuing after the rise in brake pipe pressure has ceased, will raise the pressure on the auxiliary reservoir side of the triple valve piston slightly above that on the brake pipe side, which will cause the piston and graduating valve to move to graduated release lap position.

Q. What ports are closed when the piston and graduating valve move to graduated release lap position?

A. The graduating valve closes the exhaust port thus preventing further flow of air from the brake cylinder to the atmosphere.

Q. How much air will be retained in the brake cylinder when the triple valve moves to graduated release lap position?

A. This will depend upon the original amount of air pressure in the brake cylinder; also the amount that was permitted to escape when the triple valve was in release position.

Q. When the triple valve moves to graduated release lap, does the slide valve move?

A. No; only the triple valve piston and graduating valve.

Q. With the triple valve in graduated release lap, what must be done to cause it to move to release position?

A. The brake pipe pressure must again be raised above that in the auxiliary reservoir, as previously described.

Q. Can more than one graduation of the triple valve be had?

A. Yes; the brake cylinder pressure can be reduced by a series of steps or graduations until the brake pipe pressure has been fully restored and the exhaust of air from the brake cylinder completed.

Q. What governs the amount of reduction in brake cylinder pressure during graduations?

A. The amount of air pressure which has been restored in the brake pipe.

Q. Is the re-charge of the auxiliary reservoir influenced by the rise in brake pipe pressure?

A. Yes; the re-charge of the auxiliary reservoir is in proportion to the rise in brake pipe pressure.

EMERGENCY POSITION.

Q. With the triple valve in release position, and the auxiliary reservoir and supplementary reservoir charged, what must be done to cause the valve to move to emergency position?

A. The brake pipe pressure must be reduced quickly or more rapidly than the auxiliary reservoir pressure can flow through the service ports of the triple valve, which will result in the piston being forced quickly to the left, its full stroke, moving with it graduating sleeve, and compressing graduating spring.

Q. Explain the flow of air through the triple valve when in emergency position.

A. Air from the auxiliary reservoir enters the brake cylinder through a port in the slide valve and passage. Another port in the slide valve seat is uncovered by the end of the slide valve, admitting air from the auxiliary reservoir, through this port to the top of the emergency piston, forcing it down, which unseats the rubber-seated emergency valve. This permits brake pipe air to lift the check valve and flow through to the brake cylinder. At the same time a port in the slide valve registers with another port in the seat, thus allowing air from behind the by-pass piston to flow to the brake cylinder, in which there is no pressure at this instant. The by-pass piston and valve are forced to the left by auxiliary reservoir pressure acting on the right side of the piston. Air in the supplementary reservoir then flows past the by-pass valve into the passage leading to the auxiliary reservoir, thereby increasing the volume of air available three and one-half times the size of the volume used in service applications. Air from the supplementary reservoir continues to flow to the auxiliary reservoir until the pressure in the latter reservoir, and the pressure in the brake cylinder nearly equals the pressure remaining in the supplementary reservoir, when the by-pass valve returns to its seat, and closes communication between the two reservoirs.

Q. What pressure will thus be obtained in the brake cylinder?

A Pressure in the brake cylinder will rise to within a few pounds of the maximum brake pipe pressure.

Q. With the brake fully applied in emergency position will not the air in the brake cylinder reduce through the safety valve?

A. No; for the reason that there is no communication between the brake cylinder and the safety valve during an emergency application.

SAFETY VALVE FOR L TRIPLE.

Q. What is the function of the safety valve?

A. To prevent abnormal brake cylinder pressure during service applications of the brake.

Q. When is the safety valve in connection with the brake cylinder?

A. At all times, except when the triple valve is in emergency position.

Q. How many adjustments has the safety valve?

A. Two; maximum and minimum.

Q. Explain the action of the safety valve.

A. As air from the safety valve port in the triple valve enters the chamber below the safety valve, and its pressure becomes sufficient to overcome the tension of the valve spring the valve is moved upward closing the upper ends of the ports in the valve bushing, and opening the chamber to the atmosphere through ports in the body, thereby permitting the surplus air to escape. As the air pressure under the valve decreases, the tension of the spring forces the valve downward which action restricts the opening through the ports leading to the atmosphere, and also opens the ports through the bushing thus permitting air to enter the spring chamber above the valve, and this pressure added to the tension of the spring forces the valve to its seat quickly. As the chamber above the valve is open to the atmosphere at all times through small ports in the body, the air which has entered will escape after the valve is again seated. This action causes the valve to open, and close quickly with a pop action.

Q. What is the function of the exhaust regulating ring?

A. To regulate the size of opening through the ports in the valve body.

Q. Why is such regulation necessary?

A. To control the range between opening and closing of the safety valve.

Q. What is the purpose of the lock ring?

A. To hold the exhaust regulating ring securely in its proper position.

Q. How is the safety valve adjusted?

A. By means of the regulating nut on top of the spring.

Q. How is this nut secured in place?

A. By the cap nut.

Q. What pressure should this safety valve be adjusted to open at?

A. Sixty-two pounds.

Q. At what pressure should it close?

A. Fifty-eight pounds.

Q. How is the range between opening and closing regulated?

A. By screwing the regulating ring up or down until the exhaust ports have the proper area of opening to cause the valve to close at fifty-eight pounds.

TRIPLE VALVE DISORDERS AND REMEDIES THEREFOR.

Q. How often should a triple valve be cleaned?

A. Once in three months.

Q. What kind of lubricant should be used?

A. A special lubricant made for the purpose.

Q. What method should be pursued in the cleaning and repair of triple valves?

A. They should be removed from the cars, and the work done in the shop.

Q. Before applying a triple valve to a brake cylinder what should be done?

A. The piping should be thoroughly hammered and blown out in order to remove all scale and foreign matter.

Q. In applying a triple valve to a brake cylinder, should the gasket be placed on the brake cylinder head or on the face of the triple valve?

A. On the face of the triple valve in all cases.

Q. Should the safety valve be cleaned and tested when the triple valve is cleaned and tested?

A. Yes; and the safety valve strainer should also be cleaned.

Q. Should the operating parts of the safety valve be lubricated?

A. No.

Q. What is the most prolific cause of disorders in a triple valve?

A. Dirt or foreign matter getting into the triple valve or the valve becoming dry.

Q. What will cause a blow from the exhaust port of the triple valve?

A. A leaky slide valve, leaky graduating valve, leaky emergency valve, leaky check valve case gasket or a leaky triple valve body gasket.

Q. What air is escaping to the atmosphere when a blow exists at the triple valve exhaust port?

A. Brake pipe or auxiliary reservoir air, depending on what particular part of the valve is leaking.

Q. Name the different parts that would cause a leak from the auxiliary reservoir.

A. The slide valve, graduating valve, or body gasket.

Q. What parts, if defective, would cause a brake pipe leak?

A. The emergency valve rubber seat or the check valve case gasket.

Q. How can the source of leakage in triple valves be determined without removing the valve from the car?

A. By cutting out the brake. If the brake applies and the blow stops, it indicates a leak from the brake pipe. If the blow continues and the brake does not apply, it indicates a leak from the auxiliary reservoir.

Q. Will a leak from the brake pipe to the atmosphere through the triple valve when in release position cause a blow when the brake is applied?

A. No; with the brake applied, the exhaust port is closed.

Q. If a blow at the triple valve exhaust port is due to an auxiliary reservoir leak, will the blow continue after the brake is applied?

A. That depends on what part of the triple valve is defective. A leaky slide valve will usually cause a blow when the slide valve is in either release or application position. This might also be true of the graduating valve, while a leaky body gasket will only cause a blow when the triple valve is in release position.

Q. What is the effect of a leak by the emergency valve or check valve case gasket?

A. It is a waste of brake pipe air when the brake is not applied. When the brake is applied it causes the brake cylinder pressure to build up or equalize with the brake pipe pressure, which, with light application, may result in giving greater braking power than is desired.

Q. What is the effect of a leak from the auxiliary reservoir?

A. It is a waste of air and tends to release the brake after it has been applied.

Q. Why will not a leaky body gasket cause a blow from the exhaust port when the triple valve is in application position?

A. In this position the exhaust port is closed. Such air as may leak by the gasket will flow to the brake cylinder.

Q. What is wrong with a triple valve if a buzzing or humming sound is heard within the valve after the auxiliary reservoir is charged?

A. This is due either to a leaky emergency valve or leakage from the auxiliary or supplementary reservoirs.

Q. What is the usual effect if the triple valve becomes dry and gummy?

A. It tends to destroy the sensitiveness of the valve to graduated applications and release.

Q. What is the cause of a triple valve operating in quick action during service brake applications?

A. The triple valve may be dry or gummy, or the brake pipe pressure reduces through a leakage at too rapid a rate.

Q. Would a weak or broken graduating spring cause a triple valve to operate in undesired quick action?

A. It may and may not, depending entirely on the condition of the triple valve and the rate of brake pipe reduction.

Q. What is the effect if the triple valve piston packing ring is not a good fit in its cylinder?

A. It will allow air from the brake pipe to pass by the piston into the auxiliary reservoir and may cause the brake to fail to release.

Q. What is the effect if the triple valve piston does not make a good joint against the cylinder cap gasket when in emergency position?

A. In order for the piston to reach the gasket it is necessary to have the brake pipe pressure below that in the auxiliary reservoir; therefore, if a good joint is not made, auxiliary reservoir air can leak by the piston into the brake pipe.

Q. What will result from check valve leakage with the brake applied?

A. It will permit the brake cylinder and auxiliary reservoir air to leak back into the brake pipe whenever the brake pipe pressure is reduced below an equalized pressure in the brake cylinder and auxiliary reservoir, regardless of whether the brake has been applied in service or emergency.

Q. Is check valve leakage as detrimental with the L triple valves in emergency applications as with the older types of triple valves?

A. No; owing to the great volume of air in the combined reservoirs, it would take considerable time and leakage to make any material reduction in the reservoir pressure.

Q. What would be the effect of a leak by the by-pass valve?

A. It would permit supplementary reservoir air to flow to the auxiliary reservoir during service applications and might result in a heavier brake application than was desired during light applications.

Q. How can the by-pass valve be tested for leakage?

A. With the brake pipe, auxiliary reservoir and supplementary reservoir charged to 70 pounds, the brake pipe pressure should be reduced 20 pounds, which will cause equalization between the auxiliary reservoir and brake cylinder at about 50 pounds. Brake cylinder pressure should then be noted and, if it increases, the increase is due to leakage by the by-pass valve into the auxiliary reservoir and brake cylinder.

Q. When quick action triple valves have a continuous blow from the exhaust port, how can it sometimes be stopped?

A. By jarring the triple valve slightly near the emergency valve. Should this not stop the blow, apply the brake in quick action by parting the hose and opening the angle cock quickly, then release the brake and repeat the operation if necessary. This may dislodge the dirt and allow the emergency valve to seat properly.

Q. Should neither of these remedies prove effective, what should be done?

A. The brake should be cut out and the auxiliary reservoir and supplementary reservoir drain cocks opened and left in that position.

Q. If the triple valve fails to graduate the release of the brake, what is the cause?

A. A dry or gummy valve or leakage from the supplementary reservoir.

OPERATING THE LN EQUIPMENT.

Q. Are any special instructions required for handling a train in which are a few cars equipped with LN equipment and the remainder old style brake equipment?

A. No; the brakes should be handled in the ordinary way.

Q. During a service application, will the blow from the brake valve exhaust be as long if a number of LN equipments are in the train?

A. No; it will be shorter from the fact that a portion of the brake pipe air is flowing to the brake cylinders through the quick service ports of the L triple valves.

Q. What is the total number of pounds reduction in brake pipe pressure required to fully apply the brake when 70 pounds brake pipe, auxiliary and supplementary reservoir pressure is carried?

A. About 20 pounds with proper brake cylinder piston travel (8 inches).

Q. Why will a reduction of 20 pounds in brake pipe pressure fully apply the brakes?

A. Auxiliary reservoirs are so proportioned to the sizes of the brake cylinders that with an initial pressure of 70 pounds in the brake pipe, and reservoirs, the pressure in the auxiliary reservoir will equalize into the brake cylinder at about 50 pounds.

Q. What will be the effect if a reduction of more than 20 pounds is made in the brake pipe?

A. It will be a waste of air. The triple valve piston will move the graduating stem sleeve compressing the graduating spring and carry the slide valve to emergency position, but no greater brake cylinder pressure will be obtained, as the auxiliary reservoir and brake cylinder pressures are already equalized.

Q. When the triple valve moves to emergency position from an over brake pipe service reduction, does not the supplementary reservoir air flow to the auxiliary reservoir?

A. No; as the by-pass valve does not operate in this case.

Q. Is it more difficult to release a brake after the brake pipe pressure has been reduced below equalization than would be the case if the brake pipe and auxiliary reservoir pressures were equal?

A. Yes; as it will be necessary to raise the brake pipe pressure up to that in the auxiliary reservoir in addition to the added amount required to overcome the friction of the triple valve piston and slide valve.

Q. Is it more difficult to release the brake after an emergency application than after a service application?

A. Yes; with a full service application about 50 pounds would remain in the auxiliary reservoir, which would have to be overcome when moving the triple valve to release position; whereas, after an emergency application, the auxiliary reservoir pressure, being considerably higher, would necessarily require a much higher brake pipe pressure to move the triple valve to release position.

Q. Can the release of air from the brake cylinder be graduated after an emergency application?

A. No.

Q. Why?

A. Because the auxiliary reservoir and supplementary reservoir pressures are equal.

Q. If one triple valve operates in quick action, does the reduction it makes in brake pipe pressure apply other brakes in quick action?

A. Yes; each valve causes the next to apply, thus giving a quick and full application of all the brakes throughout the train.

Q. If either 90 or 110 pounds brake pipe and auxiliary reservoir pressure is carried, how much of a reduction in brake pipe pressure is required to raise the brake cylinder pressure up to the adjustment of the safety valve?

A. About 25 pounds.

Q. Will any greater brake cylinder pressure be obtained with a 20-pound brake pipe reduction from 110 pounds initial pressure than would be the case with 70 pounds brake pipe pressure?

A. No; approximately the same brake cylinder pressure would be had.

Q. What is the proper method of stopping a train fully equipped with LN brake equipment?

A. When the speed of the train is high, a 20 to 25 pound brake pipe reduction should be made, which will develop maximum service brake cylinder pressure and, as the speed of the train reduces, the brake cylinder pressure should be graduated off by movements of the brake valve handle from lap to running position and back to lap; thereby reducing the brake cylinder pressure as the speed of the train is being reduced, the effort being to have nearly all brake cylinder pressure discharged at the moment the train comes to rest.

Q. Can the brake be re-applied promptly after a release?

A. Yes; owing to the quick re-charge feature, a prompt response will be had to any brake pipe reduction.

Q. If the brake pipe, auxiliary reservoir and supplementary reservoirs are over-charged, how can the pressure be reduced to normal?

A. By making three or four full service applications and releases of the brake, or by bleeding with the auxiliary and supplementary reservoir drain cocks.

Q. If the brake is applied with a service application, can it be bled off by reducing the air pressure in the supplementary reservoir?

A. Yes; by reducing the supplementary reservoir pressure sufficiently below that in the auxiliary reservoir to permit the by-pass valve to unseat. The auxiliary reservoir air will then flow into the supplementary reservoir and reduce to an amount sufficient to cause the brake pipe pressure to move the triple valve to release position.

Q. Should the supplementary reservoir drain cock be used in bleeding off brakes?

A. This may be done, but it is more desirable to do so with the drain cock in the auxiliary reservoir.

Q. In bleeding off a brake with the drain cock in the auxiliary reservoir, if the same is closed at the instant the triple valve moves to release position, what might be expected?

A. The triple valve may graduate and only exhaust a portion of the air from the brake cylinder, due to the air from the supplementary reservoir flowing into the auxiliary reservoir when the triple valve is in release position, causing it to move to graduated release lap position.

Q. What must be done to insure that the triple valve will remain in release position when bleeding off the brake?

A. The auxiliary reservoir pressure should be reduced a considerable amount, and it should be observed that the piston returns into the brake cylinder.

Q. Can a brake be bled off by opening the drain cocks in the auxiliary or supplementary reservoirs when the brake pipe is empty?

A. As a general rule it cannot, the triple valve being in emergency position. When the auxiliary reservoir pressure is reduced sufficiently to permit the graduating spring to move the triple valve piston and slide valve to emergency lap position, communication is closed between the brake cylinder and the auxiliary reservoir, and such air as is then in the brake cylinder would remain, unless the graduating valve lifted from its seat, which is rarely the case.

Q. When cars are to be set out in a yard, what is the proper manner for releasing the brake?

A. The drain cock in the auxiliary reservoir should be opened while there is air remaining in the brake pipe.

Q. If, when releasing the brake, air exhausts from the triple valve until the brake cylinder is empty, but the brake piston fails to return to release position, what does it indicate??

A. That the triple valve moved to release position properly, but the brake piston or the rods and levers are bound in some manner.

Q. Is a retaining valve necessary on a car equipped with the LN equipment?

A. Not when all cars in the train are equipped with LN equipment, but during the transition period when both LN and old-style equipment are in the train the graduated release feature is not used and retaining valves are required.

THE WESTINGHOUSE E. T. LOCOMOTIVE BRAKE EQUIPMENT—FOR INDEPENDENT CONTROL OF ENGINE AND TRAIN BRAKES.

The great disadvantage of the old style combined automatic and straight air brake valve is that it cannot be used to independently release an automatic application of the engine brakes, because the double check valve prevents it, nor can it be used to retain an automatic application at anything less than what the straight air reducing valve is set, and another serious objection to it is the fact that in automatic applications engine and tender brakes are not operated as a unit, which they should be. To meet and overcome these objections it was necessary to produce a new type of engine equipment, and the Westinghouse E. T. is one of several new types of engine equipments designed for this purposee.

The object of the E. T. equipment is to provide a means whereby an engineer can operate the locomotive and train brakes independently or together, as conditions may require.

The letters E. T. signify Engine and Tender, and while this equipment was first introduced in 1905, it has, however, just recently been brought to its present state of development. During the experimental period of this equipment there have been six styles of it produced, but the No. 5 and No. 6 are the only styles that need to be explained, as the others are now obsolete and are not being made.

Aside from the pump, main reservoir and brake cylinders, the essential parts of the E. T. equipment consist of two brake valves and a distributing valve, two reducing valves and a duplex pump governor. One brake valve is known as the "Automatic" and the other as the "Independent." The automatic is used in applying and releasing the train and engine brakes together, and also to hold the engine while releasing the train brakes, and the independent valve is used to operate the engine brakes seperately from the train brakes, but in all cases the action of the engine brakes is dependent upon the operation of the distributing valve, the parts of which are practically the same as two triple valves. For instance, if it is desired to make an independent application of the engine brakes, it is necessary to pass the air from the main reservoir by way of the independent brake valve to a chamber in the distributing valve known as the application cylinder in order to cause the mechanism in the distributing valve to admit main reservoir pressure into the brake cylinders on the engine and tender; consequently if the distributing valve is inoperative, an independent or automatic application of the engine brakes cannot be made. Under certain conditions the automatic side of the distributing valve can be cut out, and still allow the independent portion to be operative, but if the distributing valve itself has to be cut out, there can be no action whatever of the engine brakes. In operation the important advantages of the E. T. equipment are that the locomotive brakes may be used with, or independent of the train brakes, and this without regard to the position of the locomotive in the train. The brake cylinder pressure on the engine can be automatically maintained by the distributing valve regardless of ordinary brake cylinder leakage and of variation in piston travel, if the pipe connections between the brake valves and the distributing valve are perfectly tight.

The engine brakes can be graduated off with either brake valve, and independently graduated on with the independent brake valve; hence, in all kinds of service the train may be handled without shock or danger of parting, and in passenger service smooth, accurate stops can be made with much greater ease than was heretofore possible with the old style Westinghouse equipment.

MANIPULATION.

The following instructions are general, and must necessarily be supplemented to a limited extent to fully meet the varying local conditions on different railways.

The instructions for manipulating the ET equipment are practically the same as those given for the combined automatic and straight air brake; therefore, no radical departure from present methods of brake manipulation is required to get the desired results.

The necessary instructions are briefly as follows:

When not in use, carry the handles of both brake valves in running position.

To apply the brakes in service, move the handle of the automatic brake valve to the service position, making the required brake pipe reduction, then back to lap position which is the one for holding all the brakes applied.

To make a smooth and accurate two-application passenger stop, make the first application sufficiently heavy to bring the speed of train down to about 15 miles per hour at a convenient distance from the stopping point, then release as explained in the following paragraph and re-apply as required to make the desired stop, the final release being made as explained below.

Releasing Brakes.—With the changes in operating conditions, and in train and locomotive equipments during the past few years it has become possible to obtain still better results in general train handling if the method of operating the brakes is also slightly changed to conform with the progress which has been made in other directions. This is especially true with regard to releasing brakes, and the general instructions which follow are intended to apply particularly to trains having modern equipment, that is, large compressor capacity, large main reservoir volume, high excess pressure and operating under present day average conditions. They are not intended to apply rigidly to all individual cases or conditions, specific instructions usually being issued by each road to cover its own recommended practice.

Passenger Service. In making the first release of a two-application stop the brake valve handle should be moved to release position and then quickly back to running position, where it should be allowed to remain for an instant (1st, to permit the pressure in the equalizing reservoir and brake pipe to equalize and 2nd, to release part of the driver brake cylinder pressure), then moved to lap position and from there to service position as required. In passenger service the time the handle is in release position should be only momentary but the time in running position should be governed by the conditions existing for each particular case, such as the length of train, kind of reduction made, time available, and so on.

In making the final release of a two-application stop, with short trains, release shortly before coming to a standstill by moving the handle to release position and immediately back to running position, and leave it there. With long trains, the brakes should, as a rule, be held applied until the train stops.

The release after a one-application stop should be made in the same manner as the final release of a two-application stop.

FREIGHT SERVICE. Under present conditions it is, as a rule, safest to come to a stop before releasing the brakes on a freight train, especially a long one, rather than attempt to release at low speed. However, if conditions (for example, a short train, or a train equipped with Type K triple valves), permit of the release while in motion, the brake valve handle should be moved to release position and held there long enough to move as many of the triple valves to release position as possible without unduly overcharging the head end of the train (the time in release position should be governed by the length of train, amount of reduction made, etc.) then returned to running position to release the locomotive brakes and complete the re-charging of the auxiliary reservoirs. A few seconds after such a release, particularly on long trains, it is necessary to again move the handle to release position and quickly back to running position to "kick off" any brakes at the head end of the train that may have re-applied due to their auxiliary reservoirs having been slightly overcharged.

HOLDING LOCOMOTIVE BRAKES APPLIED. If, when releasing as explained above, it is desired to hold the locomotive brakes applied after the other brakes release, move the handle from release back to holding instead of running position, then releasing the locomotive brakes fully by moving the handle to running position and leaving it there, or graduating them off, as circumstances require, by short, successive movements between holding and running positions. A little experience with the ET equipment will enable the engineer to make smooth and accurate stops with much greater ease than was heretofore possible.

To apply the brakes in emergency, move the handle of the automatic brake valve quickly to emergency position and leave it there until the train stops and the danger is past.

When using the independent brake only, the handle of the automatic brake valve should be carried in running position. The independent application may be released by moving the independent brake valve handle to running position. Release position is for use only when the automatic brake valve handle is not in running position.

While handling long trains of cars, in road or switching service, the independent brake should be operated with care, to prevent damage to cars and lading, caused by running the slack in or out too hard. In cases of emergency arising while the independent brake is applied, apply the automatic brake instantly. The safety valve will restrict the brake cylinder pressure to the proper maximum.

The brakes on the locomotive and on the train may be alternated in heavy grade service where conditions (such as short, steep grades or where grade is heavy and straight for short distance) require, to prevent overheating of driving wheel tires and to assist the pressure retaining valves in holding the train while the auxiliary reservoirs are being recharged. This is done by keeping the locomotive brakes released by use of the independent brake valve when the train brakes are applied, and applying the locomotive brakes just before the train brakes are released, and then releasing the locomotive brakes after the train brakes are re-applied.

Care and judgment should always be exercised in the use of driver brakes on grades to prevent overheating of tires.

When all brakes are applied automatically, to graduate off or entirely release the locomotive brakes only, use release position of the independent brake valve.

The red hand of gauge No. 2 (Fig. 79) will show at all times the pressure in the locomotive brake cylinders, and this hand should be watched in brake manipulation.

Release position of the independent brake valve will release the locomotive brakes under any and all conditions.

The train brakes should invariably be released before detaching the locomotive, holding with hand brakes where necessary. This is especially important on a grade, as there is otherwise no assurance that the car, cars or train so detached will not start when the air brakes leak off, as they may in a short time where there is considerable leakage.

The automatic brakes should never be used to hold a locomotive or a train while standing even where the locomotive is not detached, for longer than ten minutes, and not for such a time if the grade is very steep or the condition of the brakes is not good. The safest method is to hold with hand brakes only and keep the auxiliary reservoirs fully charged, so as to guard against a start from brakes leaking off, and to be ready to obtain any part of full braking power immediately on starting.

The independent brake is a very important safety feature in this connection, as it will hold a locomotive with a leaky throttle, or quite a heavy train on a fairly steep grade if, as the automatic brakes are released, the slack is prevented from running in or out (depending on the tendency of the grade), and giving the locomotive a start. To illustrate:—the best method to make a stop on a descending grade is to apply the independent brake heavily as the stop is being completed, thus bunching the train solidly; then, when stopped, place and leave the handle of the independent brake valve in application position; then release the automatic brakes and keep them charged. Should the independent brakes be unable to prevent the train from starting, the automatic brakes will become sufficiently recharged to make an immediate stop; in such an event enough hand brakes should at once be applied as are necessary to assist the independent brake to hold the train. Many runaways and some serious wrecks have resulted through failure to comply with the foregoing instructions.

When leaving the engine, while doing work about it, or when it is standing at a coal chute or water plug, always leave the independent brake valve handle in application position.

In case the automatic brakes are applied by a bursted hose, a break-in-two or the use of a conductor's valve, place the handle of the automatic brake valve in emergency position.

Where there are two or more locomotives in a train, the instructions already given remain unchanged so far as the leading locomotive, or the locomotive from which the brakes are being operated, is concerned. On all other locomotives in the train, however, the double-heading cock under the automatic brake valve must be closed and the automatic and independent brake valve handles carried in running position.

Before leaving the round house, the engineer should try the brakes with both brake valves and see that no serious leaks exist. The pipes between the distributing valve and the brake valves should be absolutely tight.

PARTS OF THE EQUIPMENT.

1. The Air Compressor to compress the air.

2. The Main Reservoirs, in which to store and cool the air and collect water and dirt.

3. A Duplex Pump Governor to control the pump when the pressures for which it is regulated are obtained.

4. A Distributing Valve, and small double chamber reservoir to which it is attached, placed on the locomotive to perform the functions of triple valves, auxiliary reservoirs, double check valves, high-speed reducing valves, etc.

5. Two Brake Valves, the Automatic to operate the locomotive and train brakes, and the Independent to operate the locomotive brakes only.

6. A Feed Valve to regulate the brake pipe pressure.

7. A Reducing Valve to reduce the pressure for the independent brake valve and for the air-signal system when used.

8. Two Duplex Air Gauges; one, to indicate equalizing reservoir and main reservoir pressures; the other, to indicate brake pipe and locomotive brake cylinder pressures.

9. Driver, Tender, and Truck Brake Cylinders, Cut-Out Cocks, Air Strainers, Hose Couplings, Fittings, etc., incidental to the piping, for purposes readily understood.

NAMES OF PIPING.

Discharge Pipe: Connects the Air Compressor to the first Main Reservoir.

Connecting Pipe: Connects the two Main Reservoirs.

Main Reservoir Pipe: Connects the second main reservoir to the Automatic Brake Valve, Distributing Valve, Feed Valve, Reducing Valve, and Pump Governor.

Feed Valve Pipe: Connects the Feed Valve to the Automatic Brake Valve.

Excess Pressure Pipe: Connects the Feed Valve Pipe to the upper connection of the Excess Pressure Head of the Pump Governor.

Excess Pressure Operating Pipe: Connects the Automatic Brake Valve to the lower connection of the Excess Pressure Head of the Pump Governor.

Reducing Valve Pipe: Connects the Reducing Valve to the Independent Brake Valve, and to the Signal System, when used.

Brake Pipe: Connects the Automatic Brake Valve with the Distributing Valve and all Triple Valves on the cars in the train.

Brake Cylinder Pipe: Connects the Distributing Valve with the Driver, Tender and Truck Brake Cylinders.

Application Cylinder Pipe: Connects the Application Cylinder of the Distributing Valve to the Independent and Automatic Brake Valves.

DISTRIBUTING VALVE RELEASE PIPE: Connects the Application Cylinder exhaust port of the Distributing Valve to the Automatic Brake Valve through the Independent Brake Valve.

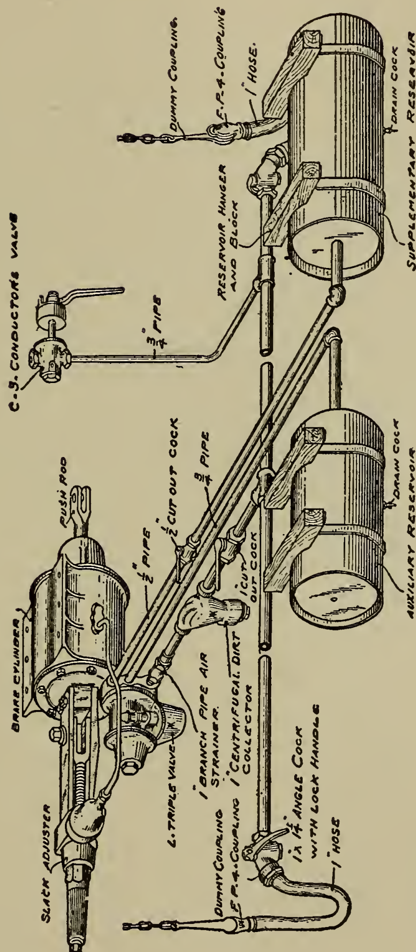


Fig. 57—Plan View of the "L N" Equipment as Applied to a Coach.

ARRANGEMENT OF APPARATUS.

Fig. 58 is a diagram giving the designations of apparatus and piping.

Referring to Fig. 58, air compressed by the pump passes as usual to the main reservoirs and the main-reservoir pipe. The main-reservoir cut-out cock is to cut off and vent the air from the main-reservoir pipe, when removing any of the apparatus except the governor. The end toward the main reservoir is tapped for a connection to the Pump Governor. Before this cock is closed the double-heading cock should be closed, and the brake-valve handle placed in release position. This is to prevent the slide valve of the feed valve, and the rotary valve of the brake valve, being lifted from their seats.

Beyond the main-reservoir cut-out cock, the reservoir pipe has four branches, one of which runs to the automatic brake valve, one to the feed valve, one to the reducing valve, and one to the distributing valve. As a result, the automatic brake valve receives air from the main reservoir in two ways, one direct and the other through the Feed Valve.

The Feed-Valve Pipe from the feed valve to the automatic brake valve has a branch to the top or spring-box of the low-pressure head of the duplex governor.

The third branch of the main reservoir pipe connects with the reducing valve. Air at the pressure for which this valve is set (45 pounds) is supplied to the independent brake valve through the reducing-valve pipe. When the air signal system is installed, it is connected to the reducing valve pipe, in which case the reducing valve takes the place of the signal-reducing valve formerly employed. In the branch pipe supplying the air signal

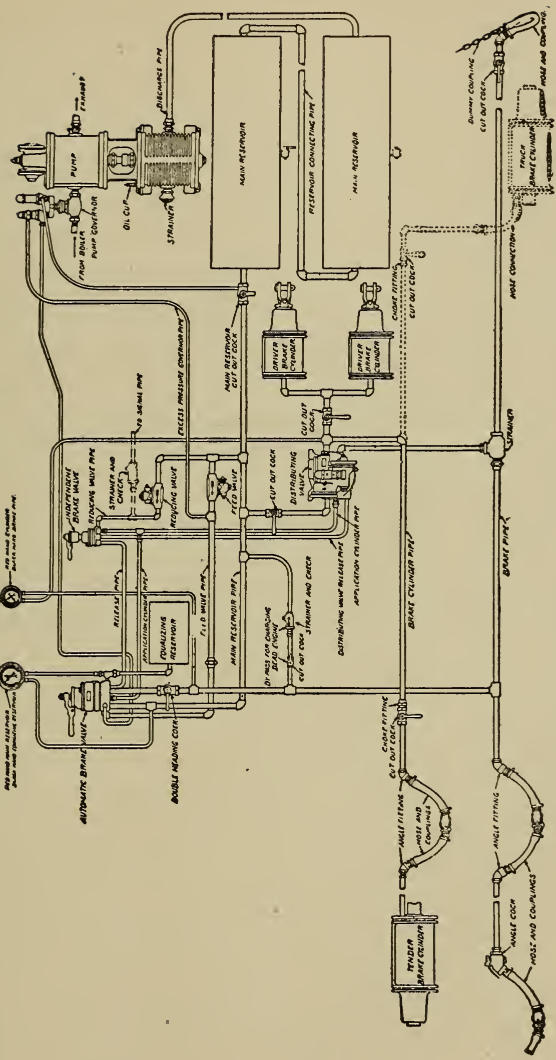


Fig. 58—Instruction Diagram of the No. 6 E.-T. Equipment.

system are placed a combined strainer and check-valve, and a choke fitting. The strainer prevents any dirt from reaching the check valve and choke fitting. The check valve prevents air from flowing back from the signal pipe when the independent brake is applied. The choke fitting prevents the reducing valve from raising the signal-pipe pressure so quickly as to destroy the operation of the signal.

The distributing valve has five pipe connections, made through the end of the double-chamber reservoir, three on the left and two on the right. Of the three on the left, the upper is the supply from the main reservoir, the intermediate is the application cylinder pipe, leading to the independent, and automatic brake valves, and the lower is the distributing valve release pipe leading through the independent brake valve, (when the handle is in running position) to the automatic brake valve.

Of the two on the right, the lower is the brake pipe branch connection and the upper is the brake cylinder pipe, branching to all brake cylinders on the engine and tender. In this pipe are placed cocks for cutting out the brake cylinders when necessary, and in the engine truck, and tender brake cylinder cut-out cocks, are placed choke fittings to prevent serious loss of main reservoir air, and the release of the other locomotive brakes during a stop, in case of a burst brake cylinder hose.

The two duplex air gauges are connected as follows, Gauge No. 1, red hand, to main reservoir pipe under the automatic brake valve, black hand to gauge pipe tee of the automatic brake valve.

Gauge No. 2, red hand to the brake cylinder pipe, black hand to the brake pipe below the double-heading cock. The amount of reduction made during an automatic application is indicated by the black hand of gauge No. 1.

The black hand of gauge No. 2 is to show the brake pipe pressure when the engine is second in double-header, or a helper.

The automatic brake-valve connections other than those already mentioned are, the brake pipe, the main reservoir, the equalizing reservoir and the lower connection to the low-pressure head of the pump governor.

PRINCIPLES OF OPERATION.

Before taking up the description of each part of this equipment, the fact should be emphasized that the principles governing the operation of it are just the same as those of previous equipments. The difference consists in the means for supplying the air pressure to the brake cylinders. Instead of a triple valve and auxiliary reservoir for each of the engine and tender equipments, the distributing valve is made to supply all brake cylinders. The distributing valve consists of two portions called the "equalizing portion" and "application portion." It is connected to a "double-chamber reservoir," the two chambers of which are called respectively the "pressure chamber" and the "application chamber." The latter is ordinarily connected to the application portion of the distributing valve in such a way as to enlarge the volume of that part of it called the "application cylinder" Fig. 59. The connections between these parts as well as their operation, may be compared with that of a miniature brake set—the equalizing portion representing the triple valve; the pressure chamber, the auxiliary reservoir; and the application portion always having

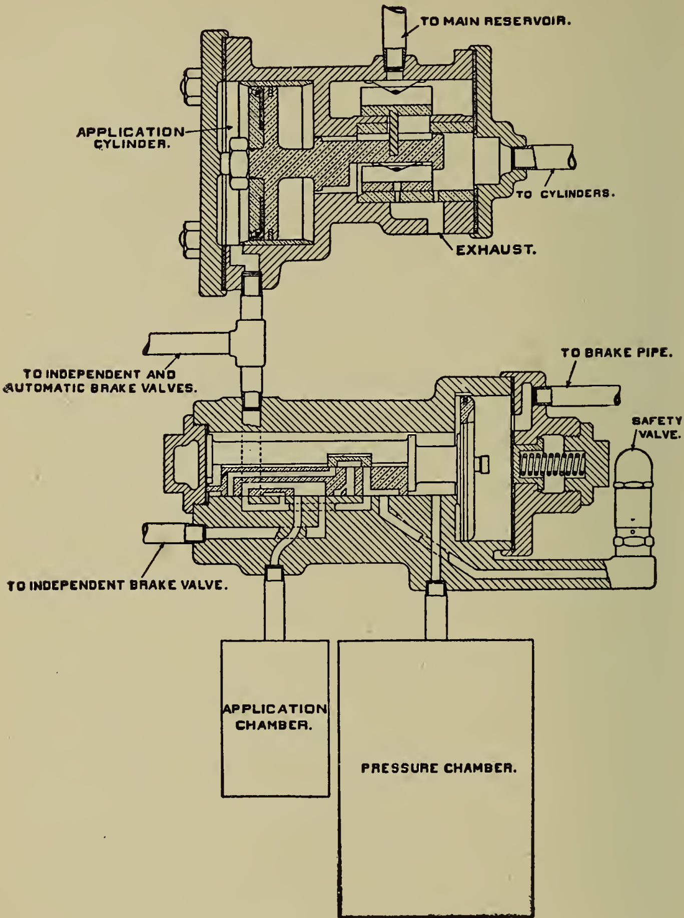


Fig. 59—Diagrammatic View of the Essential Parts of the Distributing Valve, and Double-Chamber Reservoir.

practically the same pressure in its cylinder as that in the brake cylinders. This is shown by the diagrammatic illustration in Fig. 59. For convenience, compactness and security they are combined in one device as shown in Figs. 60, 61 and 62. The equalizing portion and pressure chamber are used in automatic applications only; reductions of brake-pipe pressure cause the equalizing valve to connect the pressure chamber to the application cylinder, allowing air to flow from the former to the latter. The upper slide valve connected to the piston rod of the application portion, admits air to the brake cylinders and is called the "application valve," while the lower one releases the air from the brake cylinders and is called the "exhaust valve." As the air admitted to the brake cylinders comes directly from the main reservoirs, the supply is practically unlimited. Any pressure in the application cylinder will force the application piston to close the exhaust valve, open the application valve and admit air from the main-reservoirs to the locomotive brake cylinders until their pressure equals that in the application cylinder; also any variation of application-cylinder pressure will be exactly duplicated in the locomotive brake cylinders, and the resulting pressure maintained regardless of any brake-cylinder leakage. The whole operation of this locomotive brake, therefore, consists in admitting and releasing air pressure into or out of the application cylinder; in independent applications, directly through the independent brake valve; in automatic applications, by means of the equalizing portion and the air pressure stored in the pressure chamber.

The well-known principle embodied in the quick-action triple valve, by which it gives a high braking power in emergency applications, and a sufficiently lower one in

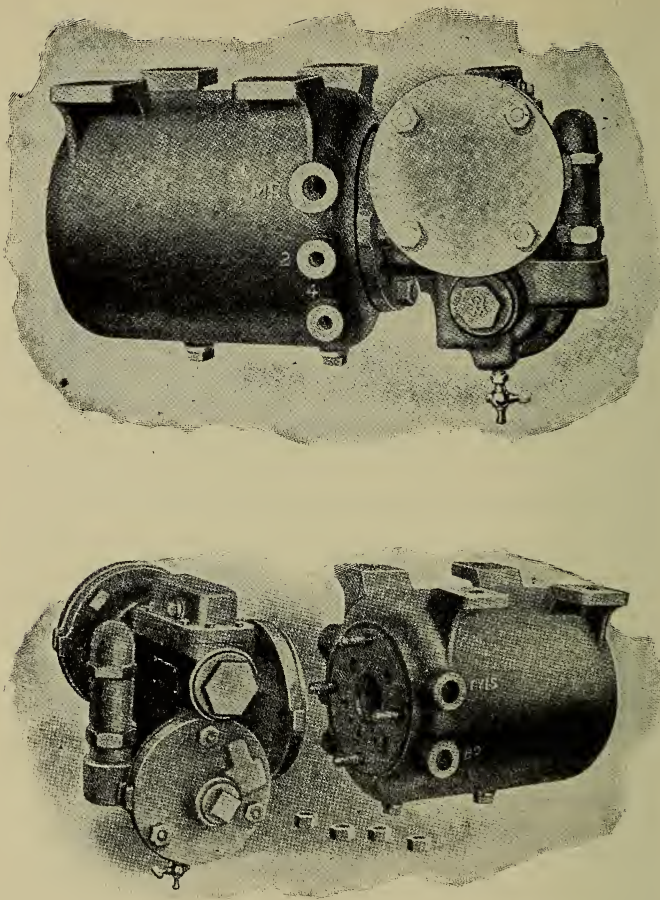


Fig. 60—No. 6 Distributing Valve and Double Chamber Reservoir.

CONNECTIONS:

MR—Main-Reservoir Pipe; 4—Distributing-Valve Release Pipe; 2—Application-Cylinder Pipe; CYLS—Brake-Cylinder Pipe; BP—Brake Pipe.

full service applications, to provide a desired protection against wheel sliding, is embodied in the No. 6 distributing valve. This is accomplished by cutting off the application chamber from the application cylinder in all emergency applications. In such applications, the pressure chamber as to fill the small volume of the application cylinder only, thus giving a high equalization, and a correspondingly high brake-cylinder pressure. In service applications, it must fill the same volume combined with that of the application chamber, thus giving a lower equalization and correspondingly lower brake-cylinder pressure.

The following description gives the operation in detail:

THE NO. 6 DISTRIBUTING VALVE.

This valve is the important feature of the E.-T. equipment. Fig. 60 shows photographic views of the valve and its double-chamber reservoir. The pipe connections, as previously referred to, are plainly shown. Fig. 61 shows the two chambers of the reservoir. The safety valve, 34, is an essential part of the distributing valve, and is described later on.

Referring to Figs. 61 and 62, the names of parts of this apparatus are as follows: 2, Body; 3, Application-Valve Cover; 4, Cover Screw; 5, Application Valve; 6, Application-Valve Spring; 7, Application-Cylinder Cover; 8, Cylinder-Cover Bolt and Nut; 9, Cylinder-Cover Gasket; 10, Application Piston; 11, Piston Follower; 12, Packing-Leather Expander; 13, Packing Leather; 14, Application-Piston Nut; 15, Application-Piston Packing Ring; 16, Exhaust Valve; 17, Exhaust-Valve Spring; 18, Application-Valve Pin; 19, Applica-

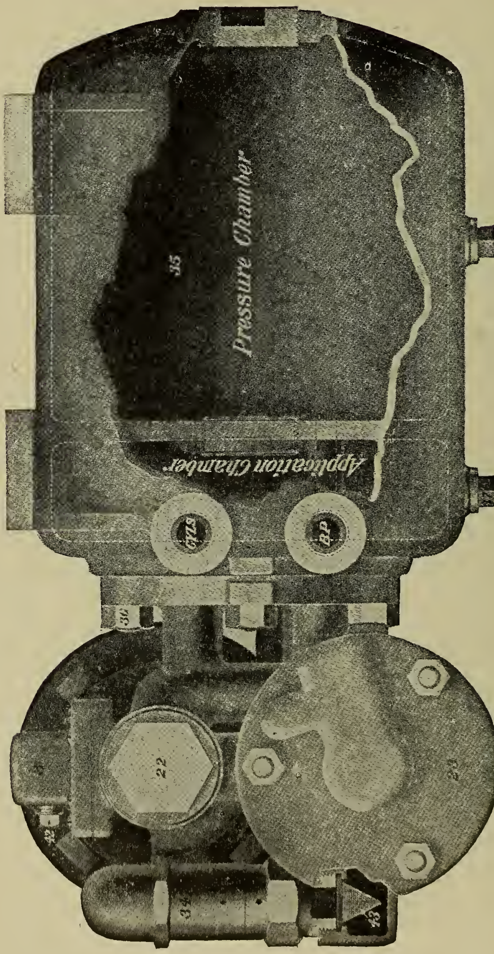


Fig. 61—No. 6 Distributing Valve and Double-Chamber Reservoir. Pipe Connections:
CYLS—Brake-Cylinder Pipe; BP—Brake Pipe.

tion-Piston Graduating Stem; 20, Application-Piston Graduating Spring; 21, Graduating-Stem Nut; 22, Upper Cap Nut; 23, Equalizing-Cylinder Cap; 24, Cylinder-Cap Bolt and Nut; 25, Cylinder-Cap Gasket; 26, Equalizing Piston; 27, Equalizing-Piston Packing Ring; 28. Graduating Valve; 29, Graduating-Valve Spring; 31,

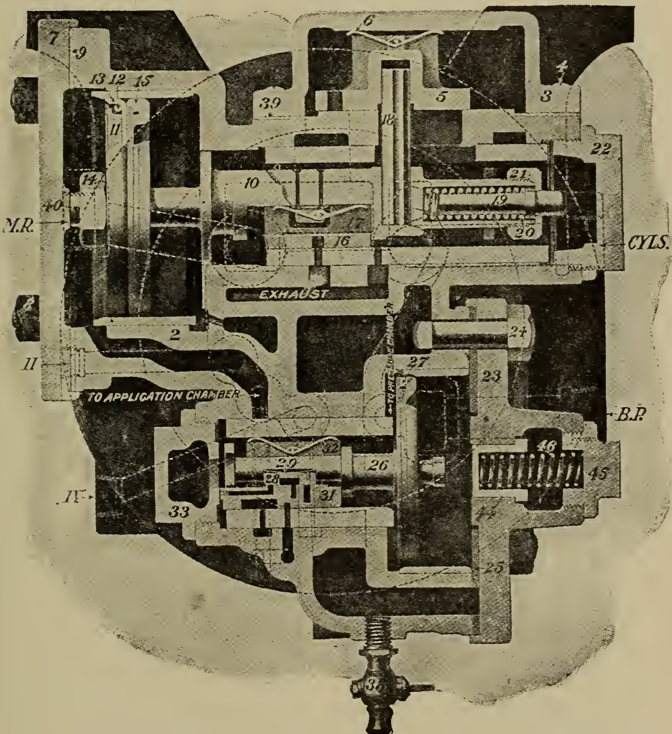


Fig. 62—No. 6 Distributing Valve. Cross-Sectional View.

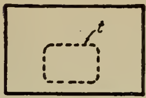
CONNECTIONS:

MR—Main-Reservoir Pipe; IV—Distributing-Valve-Release Pipe; II—Application-Cylinder Pipe; CYLS—Brake-Cylinder Pipe; BP—Brake Pipe.

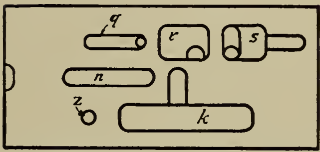
Equalizing Valve; 32, Equalizing-Valve Spring; 33, Lower Cap Nut; 34, Safety Valve; 35, Double-Chamber Reservoir; 36, Reservoir Stud and Nut; 37, Reservoir Drain Plug; 38, Distributing-Valve Drain Cock; 39, Application-Valve-Cover Gasket; 40, Application-Piston Cotter; 41, Distributing-Valve Gasket (not shown); 42, Oil Plug; 43, Safety-Valve Air Strainer; 44, Equalizing-Piston Graduating Sleeve; 45, Equalizing-Piston Graduating-Spring Nut; 46, Equalizing-Piston Graduating Spring.

To simplify the tracing of the ports and connections, the various positions of this valve are illustrated in nine diagrammatic views; that is, the valve is distorted to show the parts differently than actually constructed with the object of explaining the operation clearly instead of showing exactly how they are designed. The chambers of the reservoir are for convenience indicated at the bottom as a portion of the valve itself. In Fig. 62 equalizing piston 26, graduating valve 28, and equalizing slide valve 31, are shown as actually constructed. But as there are ports in the valves which cannot thus be clearly indicated, the diagrammatic illustrations show each slide valve considerably elongated so as to make all the ports appear in one plane, with similar treatment of the equalizing valve seat. Fig. 63 shows the correct location of these ports.

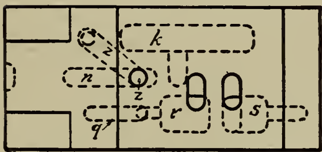
Referring to Fig. 64 it will be seen that main-reservoir pressure is always present in the chamber surrounding application valve 5 by its connection through passage *a*, *a*, to the main-reservoir pipe. Chamber *b* to the right of application piston 10 is always in free communication with the brake cylinders, through passage *c* and the brake-cylinder pipe. Application cylinder *g* at the left



PLAN OF GRADUATING VALVE.

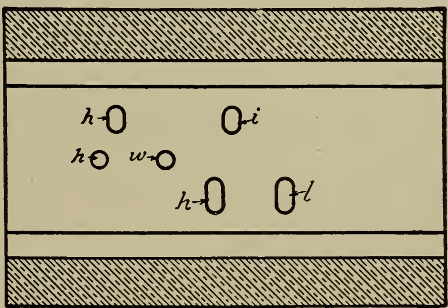


FACE OF SLIDE VALVE.



PLAN OF SLIDE VALVE.

(Looking through the top, the dotted lines indicate the cavities in the bottom face of slide valve.)



PLAN OF SLIDE VALVE SEAT.

Fig. 63—Graduating Valve, Equalizing Valve, and Equalizing-Valve Seat of No. 6 Distributing Valve.

of application piston 10 is connected by passage *h* with the equalizing-valve seat, and to the brake valve through the application-cylinder pipe.

AUTOMATIC OPERATION OF THE DISTRIBUTING VALVE.

CHARGING. Referring to Fig. 64, which shows the movable parts of the valve in the release position, it will be seen that as chamber *p* is connected to the brake pipe, brake-pipe air flows through the feed groove *v* around the top of piston 26 into the chamber above equalizing valve 31, and through port *o* to the pressure chamber, until the pressures on both sides of the piston are equal.

SERVICE. When a service application is made with the automatic brake valve, the brake-pipe pressure in chamber *p* is reduced, causing a difference in pressure on the two sides of this piston, which results in the piston moving toward the right. The first movement of the piston closes the feed groove, and at the same time moves the graduating valve until it uncovers the upper end of port *z* in the equalizing valve 31. As the piston continues its movement, the shoulder on the end of its stem engages the equalizing valve which is then also moved to the right until the piston strikes equalizing-piston graduating sleeve 44, graduating spring 46 preventing further movement; port *z* in the equalizing valve then registers with port *h* in the seat, and cavity *n* in the equalizing valve connects ports *h* and *w* in the seat. As the equalizing-valve chamber is always in communication with the pressure chamber, air can now flow from the latter to both the application cylinder and application chamber. This pressure forces application piston 10 to the right,

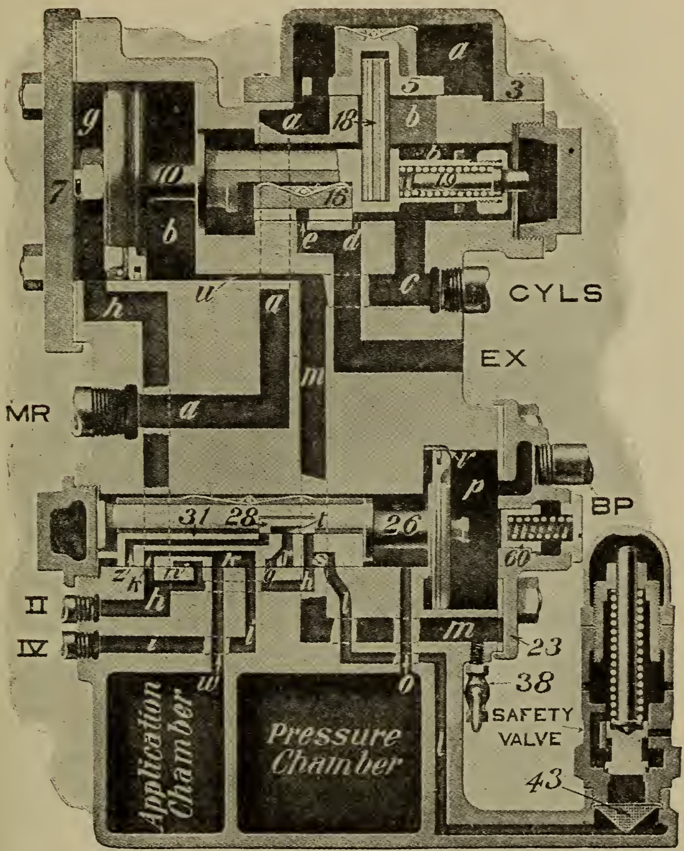


Fig. 64—No. 6 Distributing Valve Release Position, Automatic or Independent.

CONNECTIONS:

MR—Main-Reservoir Pipe; IV—Distributing-Valve Release Pipe; II—Application-Cylinder Pipe; CYLS—Brake-Cylinder Pipe; BP—Brake-Pipe.

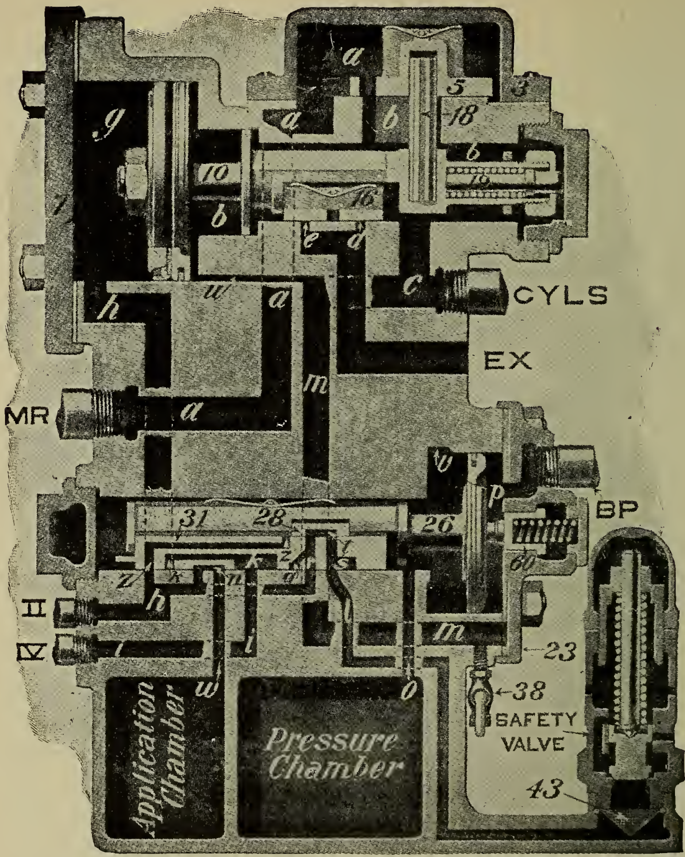


Fig. 65—No. 6 Distributing Valve Automatic Service Position.

as shown in Fig. 65, causing exhaust valve 16 to close exhaust ports *e* and *d*, and to compress application-piston graduating spring 20; also causing appliaction valve 5, by its connection with the piston stem through pin 18, to open its port and allow air from the main-reservoirs to flow into chambers *b, b,* and through passage *c* to the brake cylinders.

During the movement just described, cavity *t* in the graduating valve connects ports *r* and *s* in the equalizing valve, and by the same movement ports *r* and *s* are brought into register with ports *h* and *l* in the seat, thus establishing a communication from the application cylinder to the safety-valve, which being set at 68 pounds, three pounds above the maximum obtained in an emergency application from 70-pounds brake-pipe pressure, limits the brake-cylinder pressure to this amount.

The amount of pressure resulting in the application cylinder for a certain brake-pipe service reduction, depends on the comparative volumes of the pressure chamber, application cylinder and its chamber. These volumes are such that with 70 pounds in the pressure chamber and nothing in the application cylinder and chamber, if they are allowed to remain connected by the ports in the equalizing valve, they will equalize at about 50 pounds.

Service Lap. When the brake-pipe reduction is not sufficient to cause a full service application, the conditions described above continue until the pressure in the pressure chamber is reduced enough below that in the brake pipe to cause piston 26 to force graduating valve 28 to the left until stopped by the shoulder on the piston stem striking the right-hand end of equalizing valve 31, the position indicated in Fig. 66 and known as Service Lap. In this position, graduating valve 28 has closed port *z* so that no more air can flow from the pressure chamber to the application cylinder and chamber. It also has closed port *s*, cutting off communication to the safety valve, so that any possible leak in the latter can-

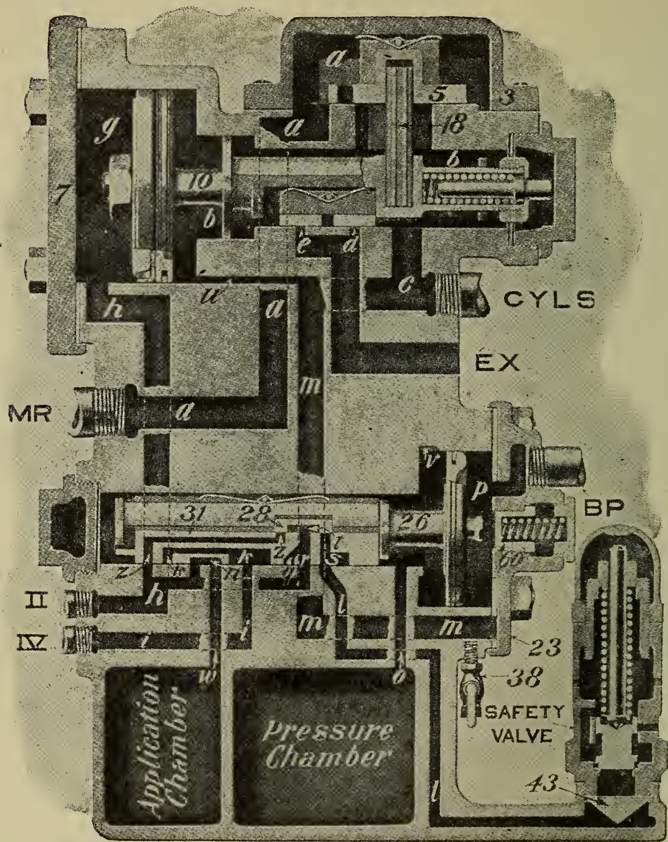


Fig. 66—No. 6 Distributing Valve Service Lap Position.

not reduce the application-cylinder pressure, and thus similarly affect the pressure in the brake cylinders. The flow of air past application valve 5 to the brake cylinders continues until their pressure slightly exceeds that in the application cylinder when the higher pressure and application-piston graduating spring together force piston 10 to the left to the position shown in Fig. 66, thereby closing port *b*. Further movement is prevented by the resistance of exhaust valve 16, and the application-piston graduating spring having expanded to its normal position. The brake-cylinder pressure is then practically the same as that in the application cylinder and chamber.

Application piston 10 has application-cylinder pressure on one side and brake-cylinder pressure on the other. When either pressure varies, the piston will move toward the lower. If that in chamber *b* is reduced, by brake-cylinder leakage, the pressure maintained in the application cylinder will force piston 10 to the right, opening application valve 5 and again admitting air from the main reservoirs to the brake cylinders until the pressure in chamber *b* is again slightly above that in the application cylinder when the piston again moves back to lap position. In this way the brake-cylinder pressure is maintained equal with that in the application cylinder. This is the *pressure-maintaining feature,* and consequently the pressure maintaining feature depends entirely upon keeping all connections to the application chamber absolutely air tight.

AUTOMATIC RELEASE. When the automatic brake valve is placed in release position, and the brake-pipe pressure in chamber *p* is thereby increased above that in the pressure chamber, equalizing piston 26 moves to the left, carrying with it equalizing valve 31 and graduating valve 28. The feed groove *v* now being open permits the pressure in the pressure chamber to feed up until it is equal with that in the brake-pipe. This action does not release the locomotive brakes because it does not discharge application-cylinder pressure. The release pipe is closed by the rotary valve of the automatic brake valve, and the application-cylinder pipe is closed by the rotary valves of both brake valves. To release the locomotive brakes, the automatic brake valve must be moved to running position. The release pipe is then connected by the rotary valve to the atmosphere, and as exhaust cavity *k* in the equalizing valve 31 connects ports *i, w* and *h* in the valve seat, application-cylinder and chamber pressure will escape. As this pressure reduces, the brake-cylinder pressure will force application piston 10 to the left until exhaust valve 16 uncovers exhaust ports *d* and *e,* allowing brake-cylinder pressure to escape (Fig. 64), or in case of graduated release, to reduce in like amount to the reduction in the application-cylinder pressure.

EMERGENCY. When a sudden and heavy brake-pipe reduction is made, as in an emergency application, the air in the piston chamber forces equalizing piston 26 to the right with sufficient force to compress equalizing-piston graduating spring 46, so that the piston moves until it strikes against the leather gasket beneath cap 23 as shown in Fig. 67. This movement causes equalizing valve 31 to uncover port *h* in the bush without opening port *w,* making a direct opening from the pressure chamber to the *application cylinder only,* so that they quickly become equalized. This cylinder volume, being small, and connected with that of the pressure chamber at 70-pounds pressure, equalizes at about 65 pounds. Also in this position of the automatic brake valve, a small port in the rotary valve allows air from the main-reservoirs to feed into the application-cylinder pipe, and thus to the application cylinder. The application cylinder is now connected to the safety valve through port *h* in the seat,

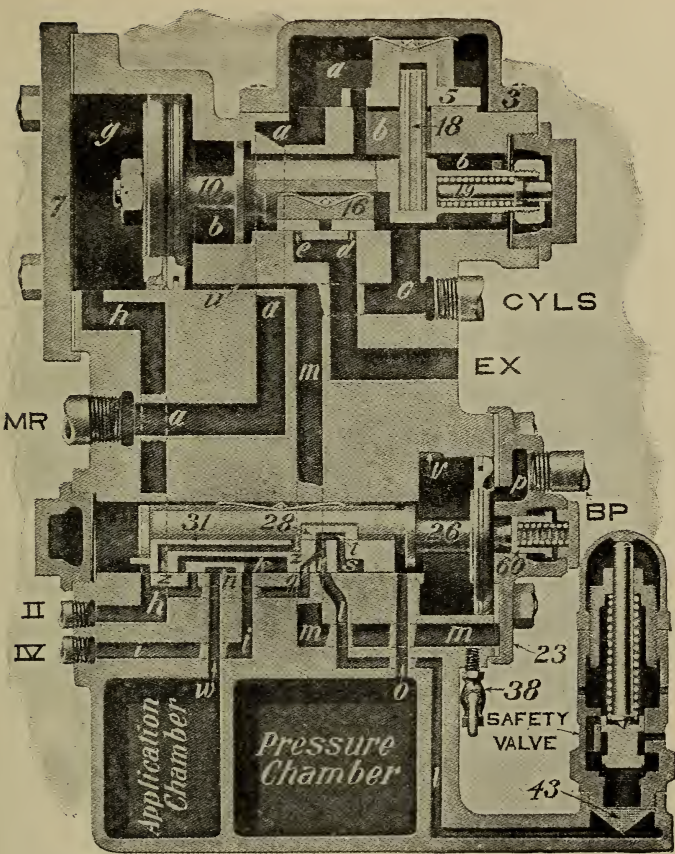


Fig. 67—No. 6 Distributing Valve Emergency Position.

cavity *q* and port *r* in the equalizing valve, and port *z* in the seat. Cavity *q* and port *r* in the equalizing valve are connected by the small port, the size of which permits the air in the application cylinder to escape through the safety valve at the same rate that the air from the main-reservoir, feeding through the rotary valve of the automatic brake valve, can supply it, preventing the pressure from rising above the adjustment of the safety valve.

In High-Speed Brake Service, the feed valve is regulated for 110-pounds brake-pipe pressure instead of 70, and main-reservoir pressure is 130 or 140 pounds. Under these conditions an emergency application raises the application-cylinder pressure to about 93 pounds, but the passage between cavity *q* and port *r* is so small that the flow of application-cylinder pressure to the safety valve is just enough greater than the supply through the brake valve, to decrease that pressure in practically the same time and manner as is done by the high-speed reducing valve, until it is approximately 75 pounds. The reason why the pressure in the application cylinder, pressure chamber and brake cylinders does not fall to 68 pounds, to which pressure the safety-valve is adjusted, is because the inflow of air through the brake valve with the high main-reservoir pressure used in high-speed service is equal, at 75 pounds, to the outflow through the small opening in the safety valve. This is done to get a shorter stop in emergency. The application portion of the distributing valve operates similarly, but more quickly than in service application.

Emergency Lap. The movable parts of the valve remain in the position shown in Fig. 67 until the brake-cylinder pressure slightly exceeds the application-cylinder pressure, when the application piston and application valve move back to the position known as *Emergency Lap* as shown in Fig. 68.

The release after an emergency is brought about by the same manipulation of the automatic brake valve as that following service application, but the effect on the

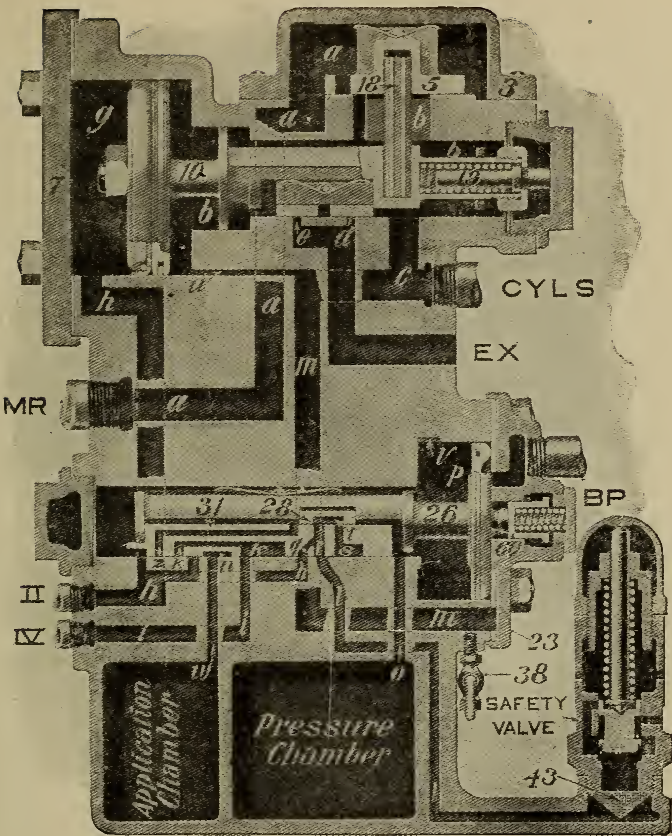


Fig. 68—No. 6 Distributing Valve Emergency Lap Position.

distributing valve is somewhat different. When the equalizing piston, valve, and graduating valve are forced to the release position by the increased brake-pipe pressure in chamber *p*, the application chamber, with no pressure in, is connected to the application cylinder, with the emergency pressure in, through port *w*, cavity *k*, and port *h*. The pressure in the application cylinder at once expands into the application chamber until these pressures are equal, which results in the release of brake-cylinder pressure until it is slightly less than that in application cylinder and chamber. Consequently, in releasing after an emergency, the brake-cylinder pressure will *automatically* reduce to about 15 pounds, which will remain until the automatic-brake-valve handle is moved to running position.

If the brakes are applied by a conductor's valve, a burst hose, or parting of train, the movement of equalizing valve 31 breaks the connection between ports *h* and *i* through cavity *k*, so that the brakes will apply and remain applied until the brake-pipe pressure is restored. The handle of the automatic brake valve should be moved to lap position to prevent a loss of main-reservoir pressure. With the No. 5 equipment it is necessary to lap one of the brake valves in order to allow the engine brakes to apply when a conductor's valve is opened.

Independent Application. When the handle of the Independent Brake Valve is moved to either application position, air from the main reservoir, limited by the reducing valve to a maximum of 45 pounds, is allowed to flow to the application cylinder, forcing application piston 10 to the right as shown in Fig. 69. This movement causes application valve 5 to open its port and allow air from the main-reservoirs to flow into chambers *b*, *b* and through passage *c* to the brake cylinders, as in an automatic application, until the pressure slightly exceeds that in the application-cylinder. The application-piston graduating spring and higher pressure then force application piston 10 to the left until application valve 5 closes its

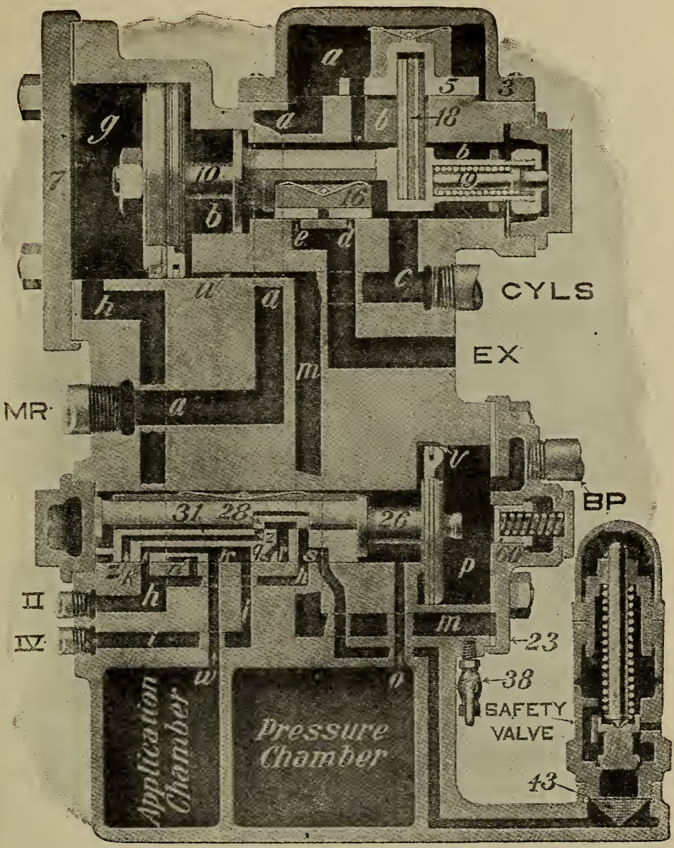


Fig. 69—No. 6 Distributing Valve Independent Application Position.

port. Further movement is prevented by the resistance of exhaust valve 16, and the application-piston graduating spring having expanded to its normal position. This position, shown in Fig. 70 is known as Independent Lap.

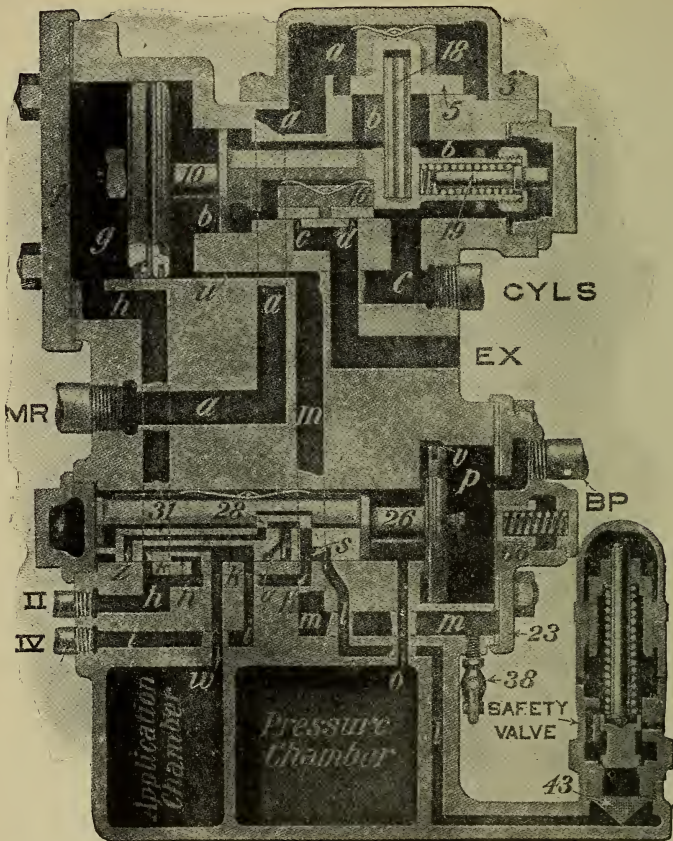


Fig. 70—No. 6 Distributing Valve Independent Lap Position.

It will be seen that whatever pressure exists in the application cylinder will be maintained in the brake cylinders by the "pressure maintaining" feature already described.

INDEPENDENT RELEASE. When the handle of the independent brake valve is moved to release position, a direct opening is made from the application cylinder to the atmosphere. As the application-cylinder pressure escapes, brake-cylinder pressure in chamber *b* moves application piston 10 to the left, causing exhaust valve 16 to open exhaust ports *e* and *d* as shown in Fig. 64 thereby allowing brake-cylinder pressure to discharge to the atmosphere.

If the independent brake valve is returned to lap before all of the application-cylinder pressure has escaped, the application piston 10 will return to *independent lap* position as soon as the brake-cylinder pressure is reduced a little below that remaining in the application cylinder, thus closing exhaust ports *e* and *d*, and holding the remaining pressure in the brake cylinders. In this wav the independent release may be graduated as desired.

This equipment has all the flexibility and ease of manipulation possessed by the combined automatic and straight air equipment, with much less apparatus and complication, besides the other important features of pressure maintaining, equal pressures in all brake cylinders, and the fact that it is *always* possible to release the locomotive brakes with the independent-brake valve, even when automatically applied. In connection with this last mentioned feature, Fig. 71 shows the position the distributing-valve parts will assume, if the locomotive brakes are released by the independent brake valve after an automatic application has been made. This results in the application portion going to release position without changing the conditions in either the pressure-chamber or brake pipe; consequently, the equalizing portion does not move until release is made by the automatic brake valve.

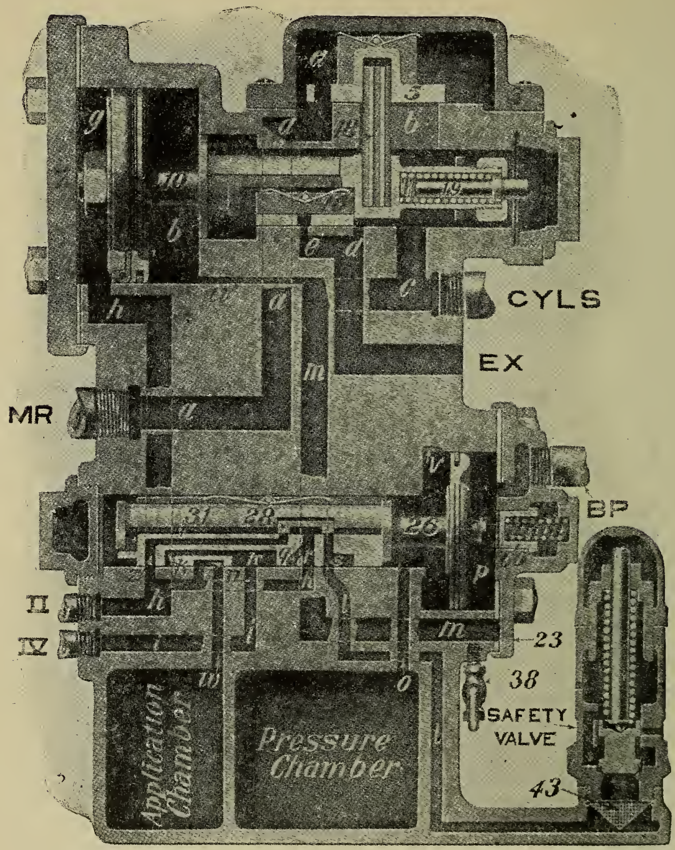


Fig. 71—No. 6 Distributing Valve Release Position.

When Locomotive Brake is released by Independent Brake Valve after an Automatic Application.

An independent release of locomotive brakes may also be made in the same manner, after an emergency application made by the automatic brake valve. However, owing to the fact that, in this position, the automatic brake valve will be supplying the application cylinder through the maintaining port in the rotary valve (see Fig. 67), the handle of the independent brake valve must be *held* in release position to prevent the locomotive brakes from reapplying, so long as the handle of the automatic brake valve remains in emergency position. The equalizing portion of the distributing valve will remain in the position shown in Figs. 67 and 68, while the application portion will assume the position shown in Fig. 71.

Double Heading. When there are two or more locomotives in a train, the handles of both brake valves on each locomotive should be carried in *running* position. The release pipe from the distributing valve on the helper engines is then open to the atmosphere at the automatic brake valve, and the operation of the distributing valve is the same as that described during automatic-brake applications. In double heading, therefore, the application and the release of the distributing valve on each helper locomotive is similar to that of the triple valves on the train. But in case an engineer on a helper finds it necessary to apply or to release his brakes independently of the train, he can do so by using the independent brake valve, without moving the handle of the automatic valve.

Port *u* drains the application cylinder of any moisture precipitated from the air in chambers *b*; such moisture passes to the lower part of the distributing valve through port m, where it may be drawn off by drain cock 38.

To remove piston 10 and slide valve 16, it is absolutely necessary to *first* remove cover 3, application valve 5 and valve pin 18.

THE QUICK-ACTION CYLINDER CAP.

The equalizing portion of the distributing valve, as already described, corresponds to the plain triple valve of the old standard locomotive brake equipments. There are, however, conditions under which it is advisable to

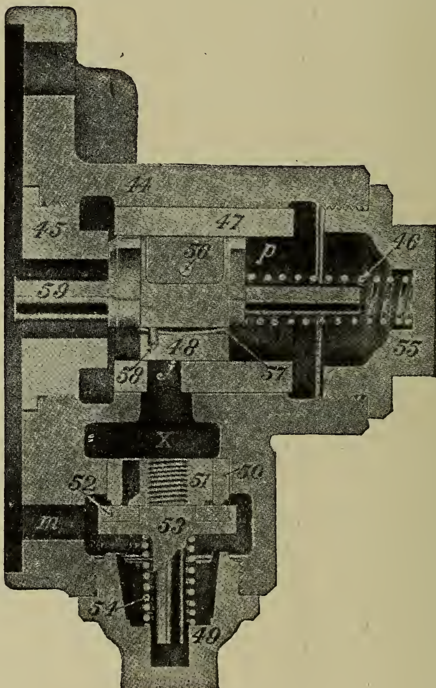


Fig. 72—The Quick-Action Cylinder Cap for No. 6 Distributing Valve.

have it correspond to a quick-action triple; that is,—vent brake-pipe air into the brake cylinder in an emergency application. To obtain this, the cylinder cap 23, Fig. 62, is replaced by the "Quick-Action Cylinder Cap," illustrated in Fig. 72.

In an emergency application, as equalizing piston 26 moves to the right and seals against the gasket (Fig. 73), the knob on the piston strikes the graduating stem

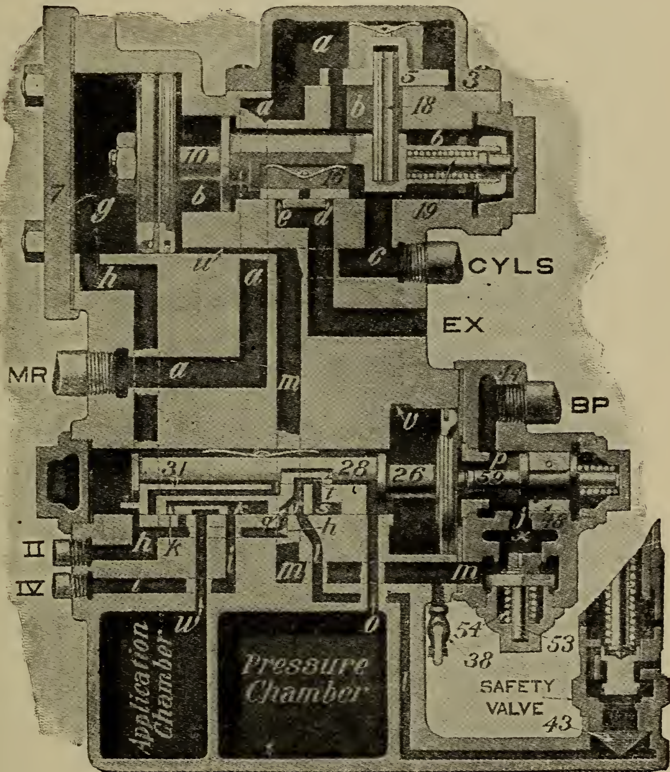


Fig. 73—Emergency Position of No. 6 Distributing Valve with Quick-Action Cap.

59, causing it to compress equalizing-piston graduating spring 46, and move slide valve 48 to the right, opening port *j*. Brake-pipe pressure in chamber *p*, flows to chamber X, pushes down check valve 53, and passes to the brake cylinder through port *m* in the cap and distributing-valve body. When the brake cylinders and brake pipe equalize, check valve 53 is forced to its seat by spring 54, thus preventing air in the brake-cylinders from flowing back into the brake pipe. When a release of the brakes occurs and piston 26 is moved back to its normal position (Fig. 64), spring 46 forces graduating stem 59 and slide-valve 48 back to the position shown in Fig. 72.

In all other respects, the operation of a distributing valve having this cap is exactly as described before.

E-6 SAFETY VALVE.

Fig. 74 is a sectional view of the safety valve which is an essential part of the distributing valve. It is unlike the ordinary safety valve, as its construction is such as to cause it to close quickly with a "pop" action, insuring its seating firmly. It is sensitive in operation and responds to slight differences of pressure.

The names of the parts are 2, Body; 3, Cap Nut; 4, Valve; 5, Valve Stem; 6, Adjusting Spring; 7, Adjusting Nut.

Valve 4 is held to its seat by the compression of spring 6 between the stem and adjusting nut 7. When the pressure below valve 4 is greater than the force exerted by the spring, it rises, and as a larger area is then exposed, its movement upward is very quick, being guided by the brass bush in the body 2. Two ports are drilled in this bush upward to the spring chamber; and two outward through the body to the atmosphere, although only one of each of these is shown in the cut. As the valve

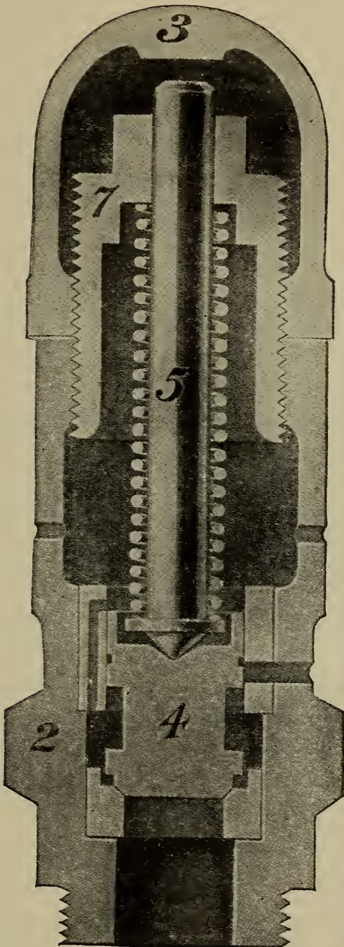


Fig. 74—E-6 Safety Valve

moves upward, its lift is determined by the stem 5 striking cap nut 3. It closes the two vertical ports in the bush connecting the valve and spring chambers, and opens the lower ports to the atmosphere. As the air pressure below valve 4 decreases, and the compression of the spring forces the stem and valve downward, the valve restricts the lower ports to the atmosphere and opens those between the valve and spring chambers. The discharge air pressure then has access to the spring chamber. This chamber is always connected to the atmosphere by two small holes through the body, 2; the air from the valve chamber enters more rapidly than it can escape through these holes, causing pressure to accumulate above the valve and assist the spring to close it with the "pop" action before mentioned.

The safety valve is adjusted by removing cap nut 3, and screwing up or down on adjusting nut 7. After the proper adjustment is made, cap nut 3 must be replaced and securely tightened, and the valve operated a few times. Particular attention must be given to see that the holes in the valve body are always open, and that they are not changed in size, especially the two upper holes.

This safety valve should be adjusted for 68 pounds. The safety valve, as are all adjustable devices, is more easily and accurately adjusted when done on a shop testing rack.

THE H.-6 AUTOMATIC BRAKE VALVE.

This Brake Valve, although modelled to a considerable extent upon the principles of previous valves, is necessarily different in detail, since it not only performs all the functions of such types but also those absolutely necessary to obtain all the desirable operating features of the No. 6 Distributing Valve.

Figure 75 is taken from a photograph of this brake valve, while Figs. 76 and 77 show two views, the first one being a plan view with section through the rotary-valve chamber, the rotary valve being removed; the other one a vertical section. In these views the pipe connections are indicated.

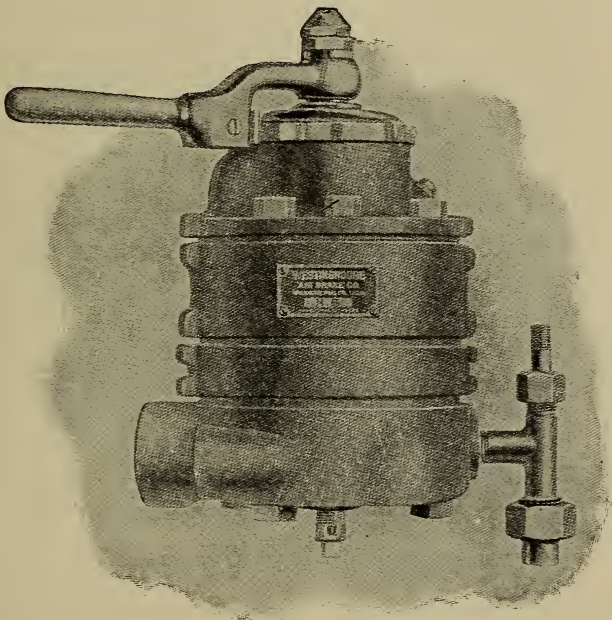


Fig. 75—H-6 Automatic Brake Valve.

Figure 78 shows two views of this valve similar to those of Figs. 76 and 77, with the addition of a plan or top view of the rotary valve. The six positions of the brake-valve handle are, beginning at the extreme left, Release, Running, Holding, Lap, Service, and Emergency.

The names of the parts are as follows: 2, Bottom Case; 3, Rotary-Valve Seat; 4, Top Case; 5, Pipe Bracket; 6, Rotary Valve; 7, Rotary-Valve Key; 8, Key Washer; 9, Handle; 10, Handle-Latch Spring; 11, Handle Latch; 12, Handle-Latch Screw; 13, Handle Nut; 14, Handle Lock Nut; 15, Equalizing Piston; 16, Equalizing-Piston

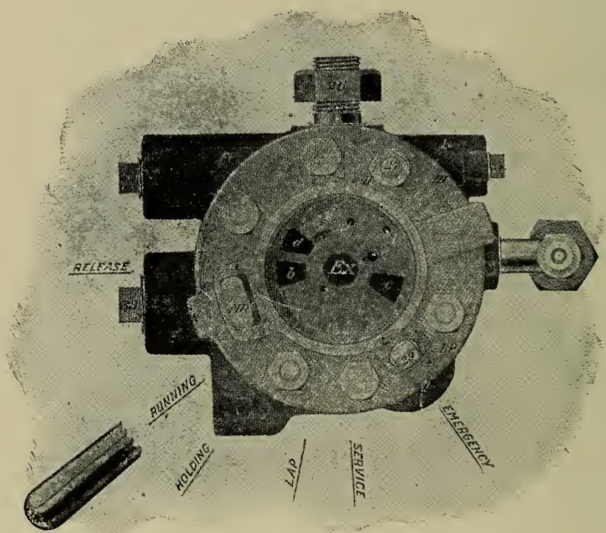


Fig. 76—H-6 Brake Valve Rotary Valve Seat.

Packing Ring; 17, Valve-Seat Upper Gasket; 18, Valve-Seat Lower Gasket; 19, Pipe Bracket Gasket; 20, Small Union Nut; 21, Brake-Valve Tee; 22, Small Union Swivel; 23, Large Union Nut; 24, Large Union Swivel; 25, Bracket Stud; 26, Bracket-Stud Nut; 27, Bolt and Nut; 28, Cap Screw; 29, Oil Plug; 30, Rotary Valve Spring; 31, Service Exhaust Fitting.

Referring to the rotary valve, *a, j* and *s* are ports extending directly through it, the latter connecting with a groove in the face; *f* and *k* are cavities in the valve face; *o* is the exhaust cavity; *x* is a port in the face of the valve connecting by a cored passage with *o; h* is a

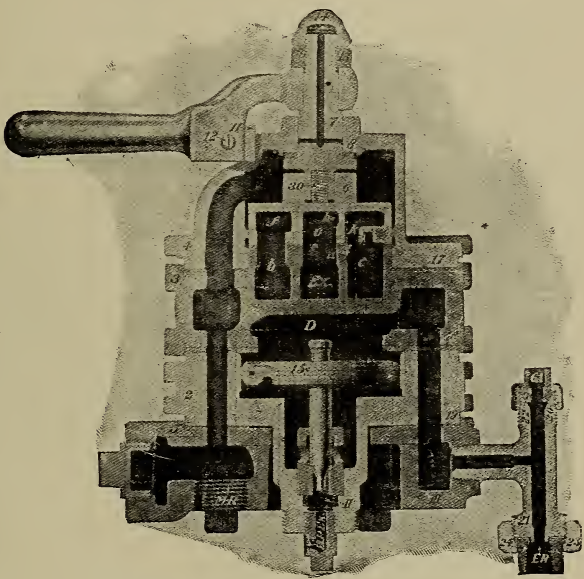


Fig. 77—H-6 Automatic Brake Valve.
CONNECTIONS:

FV—Feed-Valve Pipe; MR—Main Reservoir Pipe; GO—To Governor; III—Distributing-Valve-Release Pipe; EX—Emergency Exhaust; II—Application of Cylinder Pipe; BP—Brake Pipe; GA—No. 1 Duplex Air Gauge; ER—Equalizing Reservoir; BP Ex.—Service Exhaust.

port extending from the face over cavity *k* and connecting with exhaust cavity *o; n* is a groove in the face having a small port which connects through a cavity in the valve with cavity *k*. Referring to the ports in the rotary-

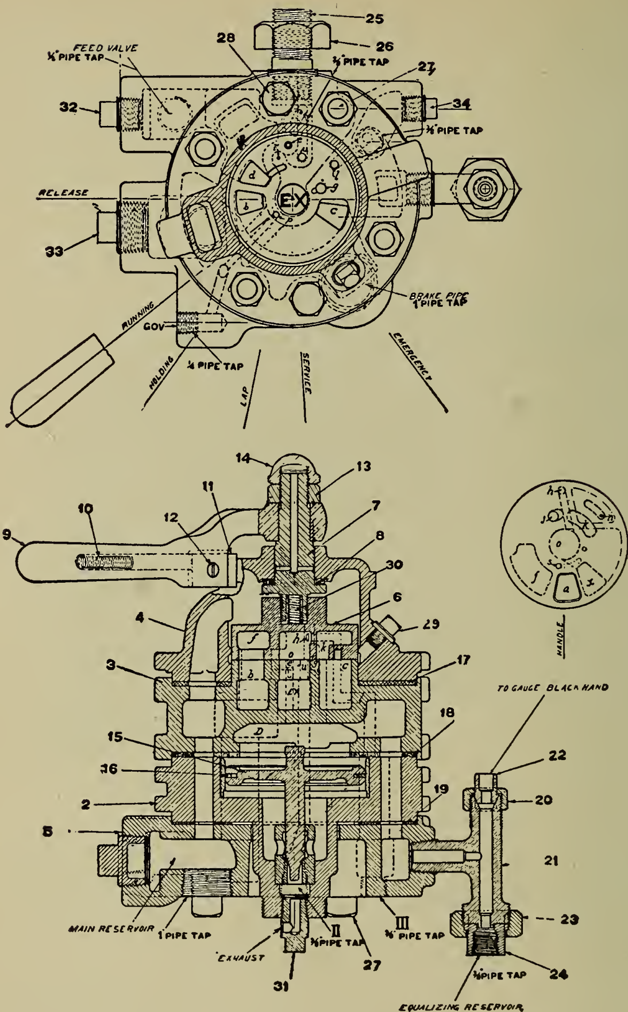


Fig. 78—The H-6 Automatic Brake Valve. Cross Section.

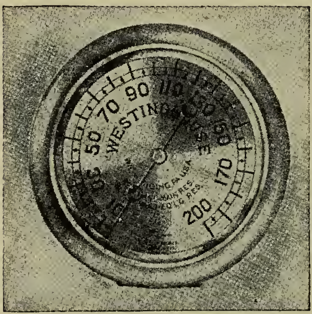
valve seat, *d* leads to the feed-valve pipe; *b* and *c* lead to the brake pipe; *g* leads to chamber D, EX is the exhaust opening leading out at the back of the valve; *e* is the preliminary exhaust port leading to chamber D; *r* is the warning port leading to the exhaust; *p* is the port leading to the pump governor; *l* leads to the distributing-valve release pipe; *u* leads to the application-cylinder pipe.

In describing the operation of the brake valve, it will be more readily understood if the positions are taken up in the order in which they are most generally used, rather than their regular order as mentioned previously.

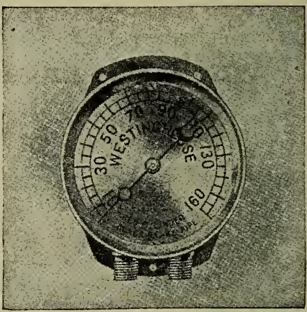
CHARGING AND RELEASE POSITION. The purpose of this position is to provide a large and direct passage from the main reservoir to the brake pipe, to permit a rapid flow of air into the latter to (a) charge the train brake system; (b) quickly release and recharge the brakes; but (c) *not* release locomotive brakes, if they are applied.

Air at main-reservoir pressure flows through port *a* in the rotary valve and port *b* in the valve seat to the brake pipe. At the same time, port *j* in the rotary valve registers with equalizing port *g* in the valve seat, permitting main-reservoir pressure to enter chamber D above the equalizing piston.

If the handle were allowed to remain in this position, the brake system would be charged to main-reservoir pressure. To avoid this, the handle must be moved to Running or Holding position. To prevent the engineer from forgetting this, a small port discharges feed-valve pipe air to the atmosphere in release position. Cavity *f* in the rotary valve connects port *d* with warning port *r* in the seat and allows a small quantity of air to escape into the exhaust cavity EX, which makes sufficient noise to attract the engineer's attention to the position in which the valve handle is standing. The small groove in the face of the rotary valve which connects with port *s*, extends to port *p* in the valve seat, allowing main-reservoir pressure to flow to the excess-pressure head of the pump governor.



Large Duplex Air Gauge. (No. 1)



Small Duplex Air Gauge. (No. 2)

Fig. 79.

Running Position. This is the proper position of the handle (a) when the brakes are charged and ready for use; (b) when the brakes are not being operated; and (c) to release the locomotive brakes. In this position, cavity *f*, in the rotary valve connects ports *b* and *d* in the valve seat, affording a large direct passage from the feed-valve pipe to the brake pipe, so that the latter will charge up as rapidly as the feed valve can supply the air, but cannot attain a pressure above that for which the feed valve is adjusted. Cavity *k* in the rotary valve connects ports *c* and *g* in the valve seat, so that chamber D and the equalizing reservoir charge uniformly with the brake pipe, keeping the pressure on the two sides of the equalizing piston equal. Port *s* in the rotary valve registers with port *p* in the valve seat, permitting the main-reservoir pressure, which is present at all times above the rotary valve, to pass to the excess-pressure head of the pump governor. Port *h* in the rotary valve registers with port *l* in the seat, connecting the distributing-valve-release pipe through the exhaust cavity EX with the atmosphere.

If the brake valve is in running position when uncharged cars are cut in, or if, after a heavy brake application and release, the handle of the automatic brake valve is returned to running position too soon, the governor will stop the pump until the difference between the hands on gauge No. 1 is less than 20 pounds. The pump stopping from this cause, calls the engineer's attention to the seriously wrong operation on his part, as running position results in delay in charging, and is liable to cause some brakes to stick. Release position should be used until all brakes are released and nearly charged.

SERVICE POSITION. This position gives a gradual reduction of brake-pipe pressure to cause a service application. Port *h* in the rotary valve registers with port *e* in the valve seat, allowing air from chamber D and the equalizing reservoir to escape to the atmosphere through cavities *o* in the rotary valve and EX in the valve seat. Port *e* is restricted so as to make the pressure in the equalizing reservoir and chamber D fall gradually.

As all other ports are closed, the fall of pressure in chamber D allows the brake-pipe pressure under the equalizing piston to raise it, and unseat its valve, allowing brake-pipe air to flow to the atmosphere gradually through the opening marked BP Ex. When the pressure in chamber D is reduced the desired amount, the handle is moved to *lap position,* thus stopping any further reduction in that chamber. Air will continue to discharge from the brake-pipe until its pressure has fallen to an amount a trifle less than that retained in chamber D, permitting the pressure in this chamber to force the piston downward gradually and stop the discharge of brake-pipe air. It will be seen, therefore, that the amount of reduction in the equalizing reservoir determines that in the brake pipe, regardless of the length of the train.

The gradual reduction of brake-pipe pressure is to prevent quick action, and the gradual stopping of this discharge is to prevent the premature release of head brakes.

LAP POSITION. This position is used (a), while holding the brakes applied after a service application until it is desired either to make a further brake-pipe reduction, or to release them; and (b) to prevent loss of main-reservoir pressure in the event of a burst hose, a break-in-two, or the opening of the conductor's valve. All ports are closed.

RELEASE POSITION. This position, which is used for releasing the train brakes after an application, without relasing the locomotive brakes, has already been described under CHARGING AND RELEASE. The air flowing from the main-reservoir-pipe connection through port *a* in the rotary valve and port *b* in the valve seat to the brake pipe, raises the pressure in the latter, thereby causing the triple valves and equalizing portion of the distributing valve to go to release position, which releases the train brakes and recharges the auxiliary reservoirs and the pressure chamber in the distributing valve. When the brake-pipe pressure has been increased sufficiently to cause this, the handle of the brake valve should be moved to either *Running* or *Holding* position; the former when it is desired to release locomotive brakes, and the latter when they are to be still held applied.

HOLDING POSITION. This position is so named because the locomotive brakes are held applied while the train brakes recharge to feed-valve pressure. All ports register as in running position, except port *l*, which is closed.

Therefore, the only difference between *Running* and *Holding* Positions is that in the former the locomotive brakes are released, while in the latter they are held applied.

EMERGENCY POSITION. This position is used when the most prompt and heavy application of the brakes is required. Port *x* in the rotary valve registers with port *c* in the valve seat, making a large and direct communication between the brake pipe and atmosphere through cavity *o* in the rotary valve and EX in the valve seat. This direct passage makes a sudden and heavy discharge of brake-pipe pressure, causing the triple valves and distributing valve to go to the emergency position and give maximum braking power in the shortest possible time.

In this position, main-reservoir air flows to the application cylinder through port *j*, which registers with a groove in the seat connecting with cavity *k*; thence through ports *n* in the valve and *u* in the seat to the application-cylinder pipe, thereby maintaining application-cylinder pressure as already described.

The oil plug 29 is placed in the top case 4, at a point to fix the level of an oil bath in which the rotary valve operates. The position of this oil hole is such that it is impossible to pour oil into the valves in excess of the amount required. This arrangement furnishes thorough lubrication. Valve oil should be used. Leather washer 8 prevents air in the rotary-valve chamber from leaking

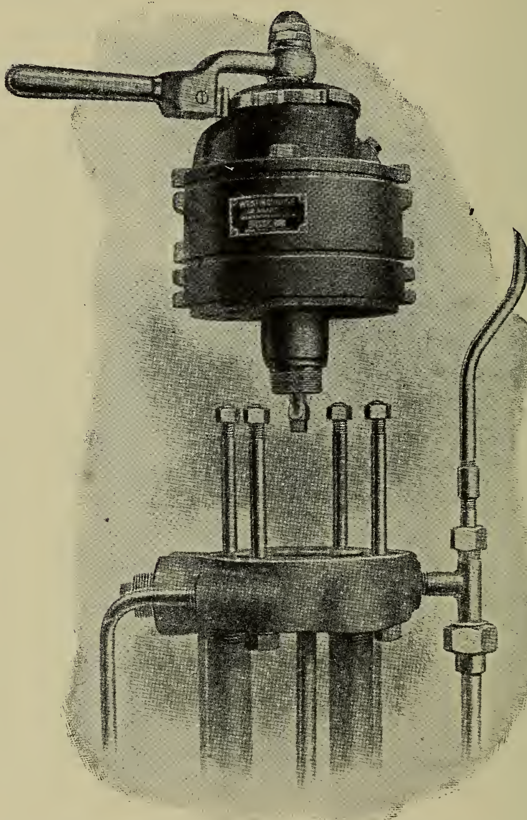


Fig. 80—H-6 Automatic Brake Valve Removed from its Pipe Bracket.

past the rotary-valve key to the atmosphere. Spring 30 keeps the rotary valve key firmly pressed against washer 8 when no main-reservoir pressure is present. The handle 9 contains latch 11, which fits into notches in the quadrant of the top case, so located as to indicate the different positions of the brake-valve handle. Handle-latch spring 10 forces the latch against the quadrant with sufficient pressure to indicate each position.

To remove the brake valve, close the cocks and take off nuts 27. (See Fig. 80.) To take the valve proper apart, remove cap screws 28.

The brake valve should be located so that the engineer can operate it conveniently from his usual position, while looking forward or back out of the side cab window.

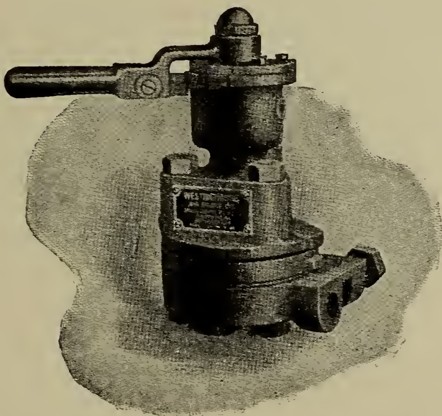


Fig. 81—S-6 Independent Brake Valve Complete.

THE S-6 INDEPENDENT BRAKE VALVE.

Figures 81 and 82 illustrate this valve, which is of the rotary type. Fig. 83 shows a vertical section through the center of the valve, and a horizontal section through the valve body, with the rotary valve removed, showing the rotary valve seat. Fig. 84 shows this valve similarly to Fig. 83, with the addition of a top view of the rotary valve. In these views, the pipe connections and positions of the handle are indicated. Referring to Fig. 84, the names of parts are as follows:

2, Pipe Bracket; 3, Rotary-Valve Seat; 4, Valve Body; 5, Return-Spring Casing; 6, Return Spring; 7, Cover; 8, Casing Screw; 9, Rotary Valve; 10, Rotary-Valve Key; 11, Rotary-Valve Spring; 12, Key Washer; 13,

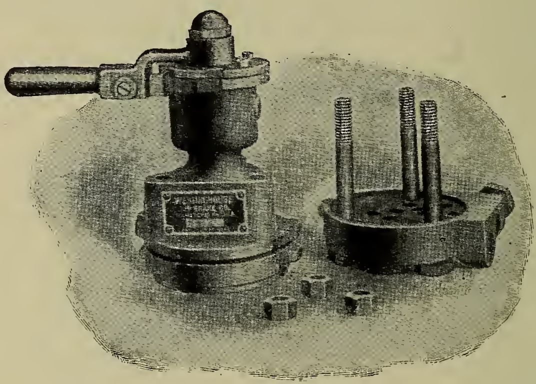


Fig. 82—S-6 Independent Brake Valve Removed from Pipe Bracket.

Upper Clutch; 14, Handle Nut; 15, Handle; 16, Latch Spring; 17, Latch Screw; 18, Latch; 19, Cover Screw; 20, Oil Plug; 21, Bolt and Nut; 22, Bracket Stud; 23, Bracket-Stud Nut; 24, Upper Gasket; 25, Lower Gasket; 26, Lower Clutch; 27, Return-Spring Stop; 28, Cap Screw.

Port *b* in the seat leads to the Reducing Valve pipe. Port *a* leads to that portion of the Distributing-Valve

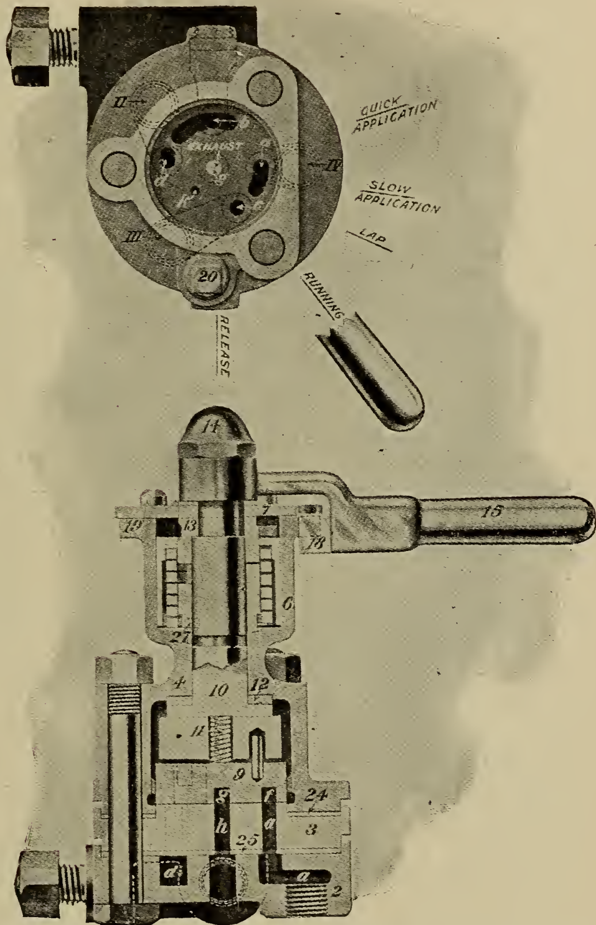


Fig. 83—The S-6 Independent Brake Valve.

CONNECTIONS:

RV—Reducing-Valve Pipe; EX—Exhaust; IV—Distributing-Valve Release Pipe to the Distributing Valve; III—Distributing-Valve Release Pipe to the Automatic Brake Valve; II—Application-Cylinder Pipe.

Release Pipe which connects to the distributing valve at IV (Fig. 64). Port *c* leads to the other portion of the release pipe which connects to the automatic-brake valve at III (Fig. 78). Port *d* leads to the application-cylinder pipe which connects to the distributing valve at II (Fig. 64). Port *h* in the center, is the exhaust port leading directly down to the atmosphere. Port *k* is the warning port, connecting with the atmosphere. Exhaust cavity *g* in the rotary valve is always in communication at one end with exhaust port *h*. Groove *e* in the face of the valve communicates at one end with a port through the valve. This groove is always in communication with a groove in the seat connecting with supply port *b*, and through the opening just mentioned air is admitted to the chamber above the rotary valve, thus keeping it to its seat. Port *m* connects by a small hole with groove *e*; *f* is a groove in the face of the rotary valve; *l* consists of ports in top and face of valve connected by a passage.

Running Position. This is the position that the independent brake valve should be carried in at all times when the independent brake is not in use. Groove *f* in the rotary valve connects ports *a* and *c* in the valve seat, thus establishing communication between the application cylinder of the distributing valve and port *l* of the automatic brake valve (Fig. 76), so that the distributing valve can be released by the latter. It will also be noted that if the automatic brake valve is in running position, and the independent brakes are being operated, they can be released by simply returning the independent valve to running position, as the application-cylinder pressure can then escape through the release pipe and automatic brake valve.

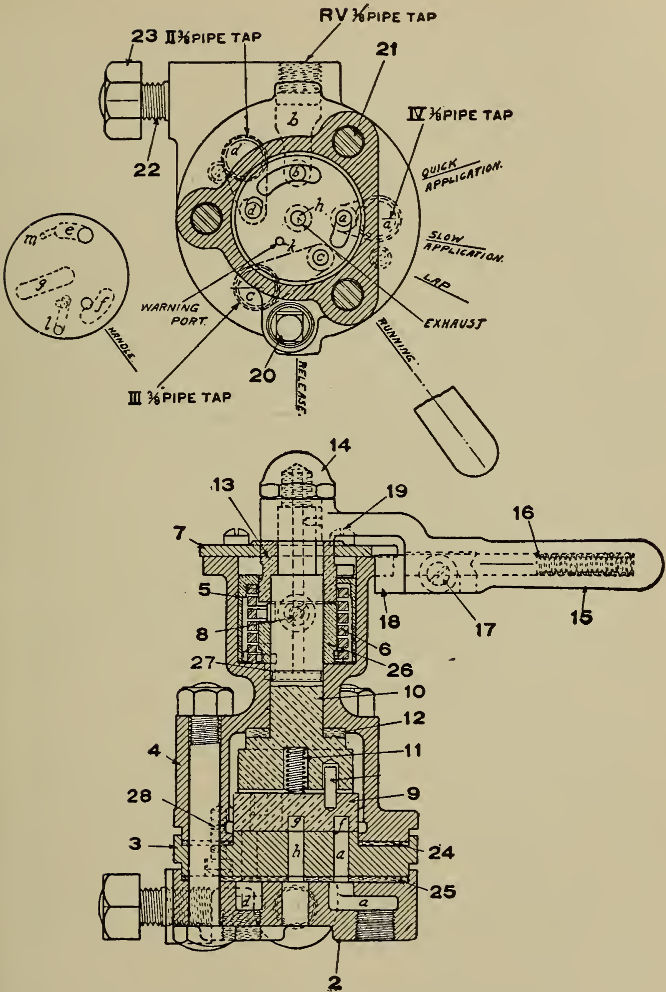


Fig. 84—The S-6 Independent Brake Valve. Cross Section.

Slow-Application Position. To apply the independent brake lightly or gradually, move the brake-valve handle to the slow-application position; port *m* registers with port *d*, allowing air to flow from the reducing-valve pipe through port and groove *b* in the seat, groove *e* in the rotary valve, and the comparatively small port *m* to port *d;* thence through the application-cylinder pipe to the application cylinder of the distributing valve.

Quick-Application Position. To obtain a quick application of the independent brake, move the brake-valve handle to quick-application position; groove *e* then connects ports *b* and *d* directly, making a larger opening between them than in the slow-application position, allowing supply air to flow rapidly from the reducing-valve pipe to the application cylinder of the distributing valve.

Since the supply pressure to this valve is fixed by the regulation of the reducing valve to 45 pounds, this is the maximum cylinder pressure that can be obtained.

Lap Position. This position is used to hold the independent brake applied after the desired cylinder pressure is obtained, at which time all communication between operating ports is closed.

Release Position. This position is used to release the pressure from the application cylinder when the automatic brake valve is not in running position. At such time, the offset in cavity *g* registers with port *d*, allowing pressure in the application cylinder to flow through the application-cylinder pipe, ports *d*, *g* and *h* to the atmosphere.

The purpose of return spring 9 is to automatically move the handle 15 from the release to the running position, or from the quick-application to the slow-application

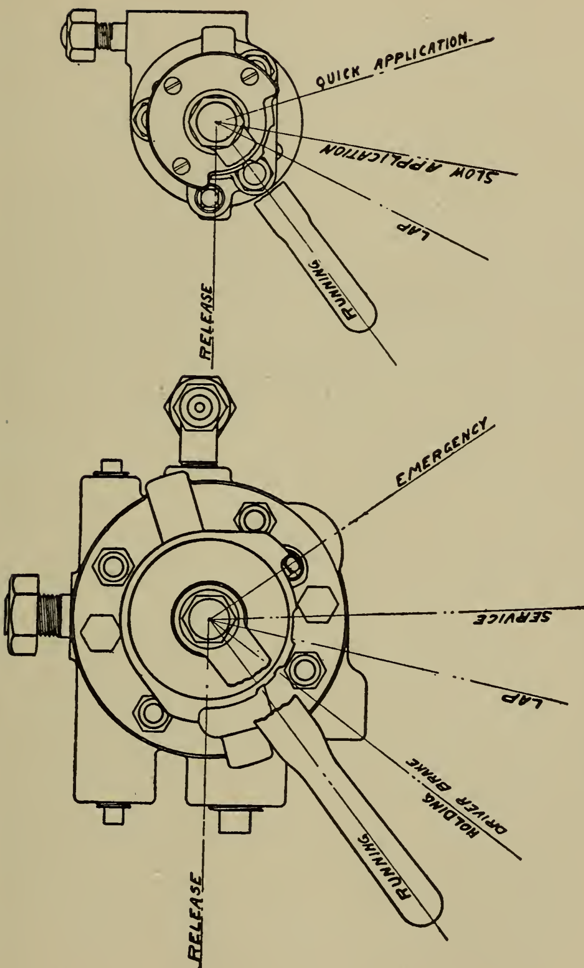


Fig 85—Positions of H-6 and S-6 Brake-Valve Handles.

position, as soon as the engineer lets go of it. The automatic return from release to running position is to prevent leaving the handle in the former, and thereby make it impossible to operate the locomotive brake with the automatic brake valve. The action of the spring between quick-application and slow-application positions serves to accentuate the latter, so that in rapid operation of the valve, the engineer is less likely to unintentionally pass over it to the quick-application position, thereby obtaining a heavy application of the locomotive brake when only a light one was desired. As a warning to the engineer in case of a broken return spring, port *l* in the face of the rotary registers in release position with port *k* in the seat, allowing air to escape to the atmosphere.

The purpose of the oil plug 20 is the same as that described in the automatic brake valve.

The location of this valve should be governed by the same considerations as those mentioned concerning the automatic brake valve.

Fig. 85 gives a top view of both brake valves, showing the position of their handles.

THE B-6 FEED VALVE.

The B-6 feed valve (Figs. 86 and 87), furnished with the No. 6 equipment, is an improved form of the slide-valve type It differs from previous ones in charging to the regulated pressure somewhat quicker, and in maintaining the pressure more accurately under the variable conditions of short and long trains, and of good and poor maintenance. Also, it gives high and low brake-pipe pressure control. It is supplied with air di-

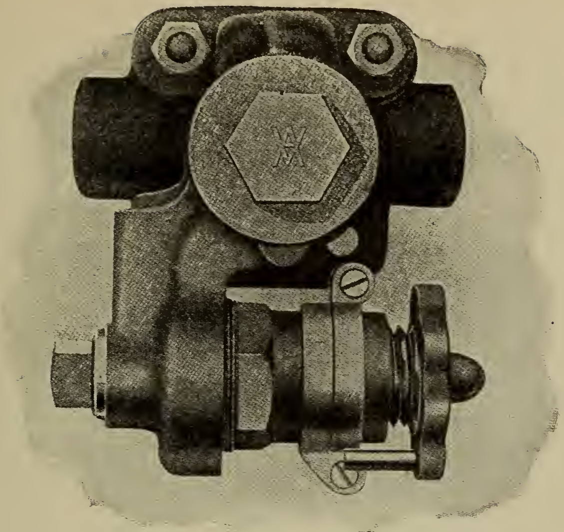


Fig. 86—The B-6 Feed Valve—Valve and Pipe Bracket Complete.

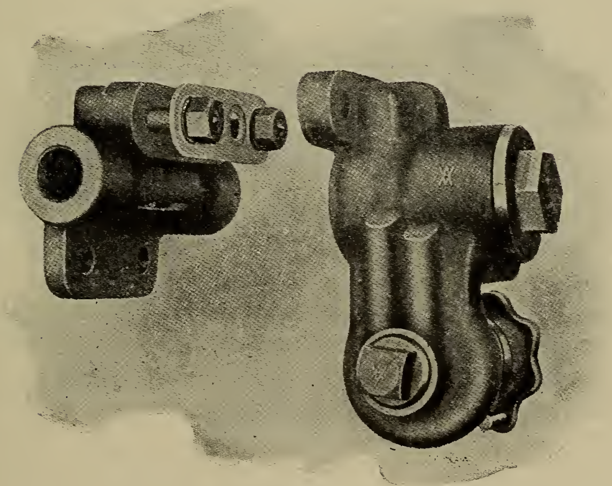


Fig. 87—The B-6 Feed Valve—Valve Removed from Pipe Bracket.

rectly from the main reservoir. It regulates the pressure in the feed-valve pipe, and also the brake pipe in running and holding positions of the automatic brake valve as the latter then connects these two pipes. It is connected to a pipe bracket located in the piping between the main reservoir and the automatic brake valve, and is interchangeable with previous types.

Figures 88 and 89 are diagrammatic views of the valve and pipe brackets having the ports and operating parts in one plane to facilitate description. The names of the parts shown in the diagram are as follows: 2, Valve Body; 3, Pipe Bracket; 5, Cap Nut; 6, Piston Spring; 7, Piston Spring Tip; 8, Supply-Valve Piston; 9, Supply Valve; 10, Supply-Valve Spring; 11, Regulating-Valve Cap; 12, Regulating Valve; 13, Regulating-Valve Spring; 14, Diaphragm; 15, Diaphragm Ring; 16, Diaphragm Spindle; 17, Regulating Spring; 18, Spring Box; 19, Upper Stop; 20, Lower Stop; 21, Stop Screw; 22, Adjusting Handle.

This feed valve consists of two sets of parts, the supply and regulating. The supply parts, which control the flow of air through the valve, consist of the supply valve 9 and its spring 10; the supply-valve piston 8 and its spring 6. The regulating parts consist of the regulating valve 12, regulating-valve spring 13, diaphragm 14, diaphragm spindle 16, regulating spring 17, and regulating handle 22.

Main-reservoir air enters through port *a*, *a* to the supply-valve chamber B, forces supply-valve piston 8 to the left, compresses piston spring 6 and causes the port in supply valve 9 to register with port *c* (See Fig. 89). This permits air to pass through ports *c* and *d* to the feed-valve pipe at FVP, and through port *e* to the diaphragm chamber L.

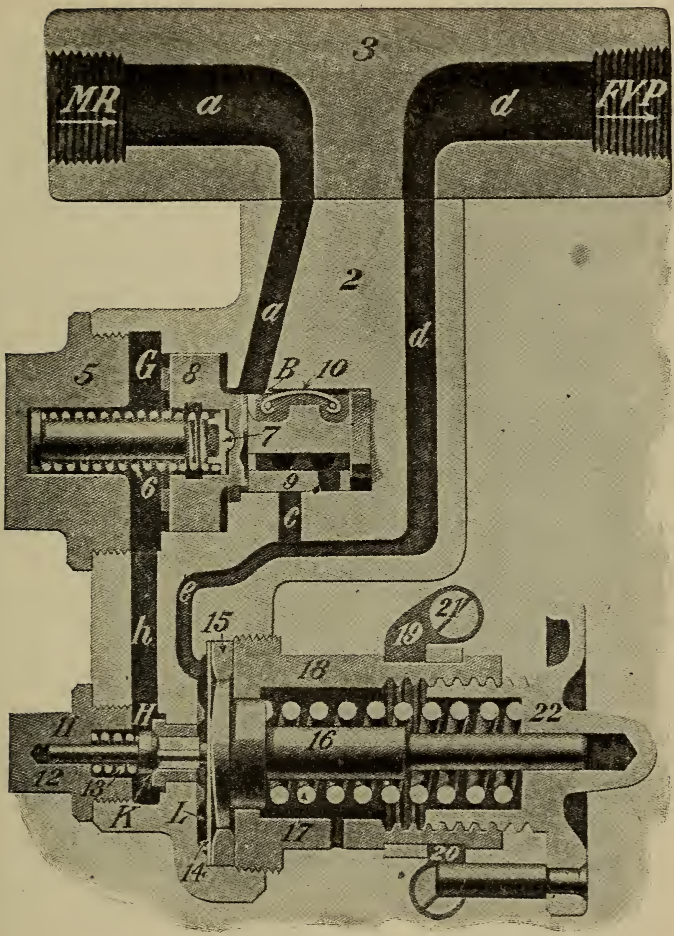


Fig. 88—Diagram of B-6 Feed Valve Closed.

CONNECTIONS:

MR—Main-Reservoir Pipe; FVP—Feed-Valve Pipe.

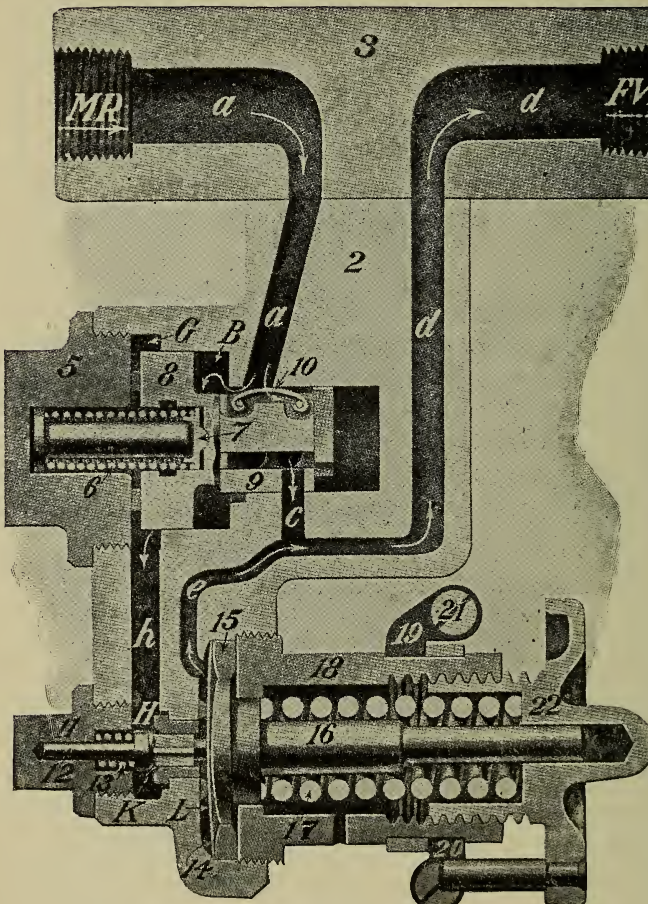


Fig. 89—Diagram of B-6 Feed Valve Open.
(For connections see Fig. 88.)

Regulating valve 12 is then open and connects chamber G, on the left of piston 8, to the feed-valve pipe through passage *h,* port *k,* chamber L, and passage *e, d, d.* Air feeding by the piston cannot accumulate above feed-valve pipe pressure. When regulating valve 12 is closed, the pressure on the left of piston 8 quickly rises, to the main-reservoir pressure on the right, and piston spring 6 forces piston 8 and supply valve 9 to the right, closes port *c,* and stops the flow to the feed-valve pipe.

The regulating valve is operated by diaphragm 14. When the pressure of regulating spring 17 on its right is greater than the feed-valve pipe pressure in chamber L on its left, it opens regulating valve 12. This causes the supply valve to admit air to the feed-valve pipe. When the feed-valve pipe pressure in chamber L is greater than that of the regulating spring 17, the diaphragm allows regulating valve 12 to close. This causes the supply valve to stop admitting air to the feed-valve pipe.

As already explained under subject H-6 Automatic Brake Valve, in release position of the latter, the warning port is supplied from the feed-valve pipe. This insures that the low-pressure governor head will keep the brake-pipe pressure equal to the low pressure governor head in release position even though the feed valve is leaking slightly.

The distinguishing feature of this type of feed valve is the duplex adjusting arrangement by which it eliminates the necessity of the two feed valves in high and low pressure service. The spring box, 18, has two rings encircling it, which are split through the lugs marked 19 and 20 in the diagram, and which may be secured in any position by the screw 21. The pin forming part of adjusting handle 22, limits the movement of the handle to the distance between stops 19 and 20. When testing the valve, stop 19 is located so that the compression of spring 17 will give the desired high brake-pipe pressure, and stop 20 so that the spring compression is enough less to give the low brake-pipe pressure. Thereafter, by simply turning handle 22 until its pin strikes either one of these stops, the regulation of the feed valve is changed from one brake-pipe pressure to the other.

To adjust this valve, slacken screws 21, which allows stops 19 and 20 to turn around spring box 18. Adjusting handle 22 should be turned until the valve closes at the lower brake-pipe pressure desired, when stop 20 should be brought in contact with the handle pin, at which point it should be securely fastened by tightening screw 21. Adjusting handle 22 should then be turned until the higher adjustment is obtained, when stop 19 is brought in contact with the handle pin and securely fastened. The stops should be placed to give 110 pounds high, and 70 pounds low, brake-pipe pressure.

When replacing this feed valve on its pipe bracket after removal, the gasket, shown in Fig. 87, must always be in place between the valve and bracket, to insure a tight joint.

THE C-6 REDUCING VALVE.

This valve, illustrated in Fig. 90, is the well known feed valve that has been used for many years in connection with the G-6 brake valve, but in this equipment is attached to a pipe bracket. The only difference between it and the B-6 feed valve just described is in the adjustment, it being designed to reduce main-reservoir pressure to a single fixed pressure, which in this equipment, is, as already stated, 45 pounds. To adjust this valve, remove the cap nut on the end of the spring box; this will expose the adjusting nut, by which the adjustment is

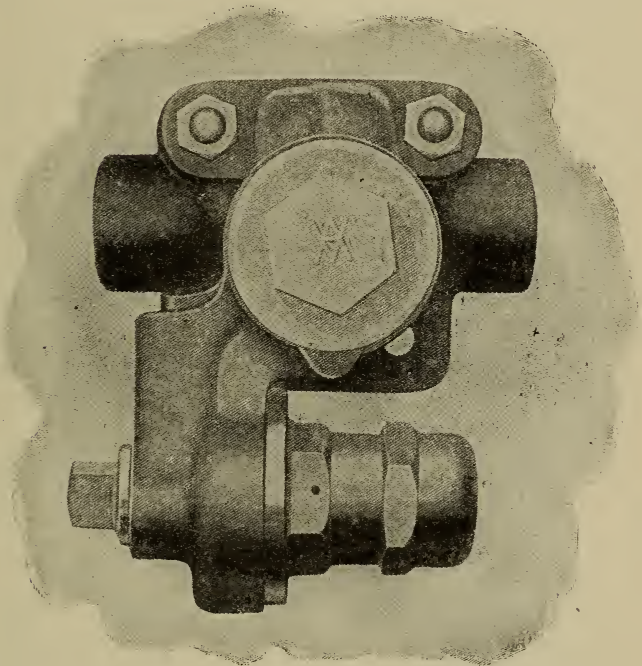


Fig. 90—The C-6 Reducing Valve.

made. It is called a "Reducing Valve" when used with the independent brake and air-signal systems, simply to distinguish it from the feed valve supplying the automatic brake valve.

THE SF TYPE OF PUMP GOVERNOR.

The duty of the SF Pump Governor is to sufficiently restrict the speed of the pump, when the desired main-reservoir pressure is obtained, as will prevent this pressure from rising any higher. During most of the time on a trip, the automatic brake valve is in running position, keeping the brakes charged. But little excess pressure is then needed, and the governor regulates the main-reservoir pressure to about 20 pounds only above the brake-pipe pressure, thus making the work of the pump easier. On the other hand, when the brakes are applied (lap position of the automatic brake valve, following the use of its service position) a high main-reservoir pressure is needed to insure their prompt release and recharge. Therefore, as soon as the use of lap, service or emergency positions is commenced, the governor allows the pump to work freely until the maximum main-reservoir pressure is obtained. Again, when the brake-pipe pressure is changed from one amount to another by the feed valve, as where a locomotive is used alternately in high-speed-brake and ordinary service, the governor automatically changes the main-reservoir pressure to suit, and at the same time maintains the other features just described.

Another important feature is that, before commencing and during the descent of steep grades, this governor enables the engineer to raise and maintain the brake-pipe pressure about 20 pounds above the feed-valve regulation merely by the use of release position of the automatic brake valve, the position which should be used during such braking.

The following will explain the construction and operating of the SF Governor.

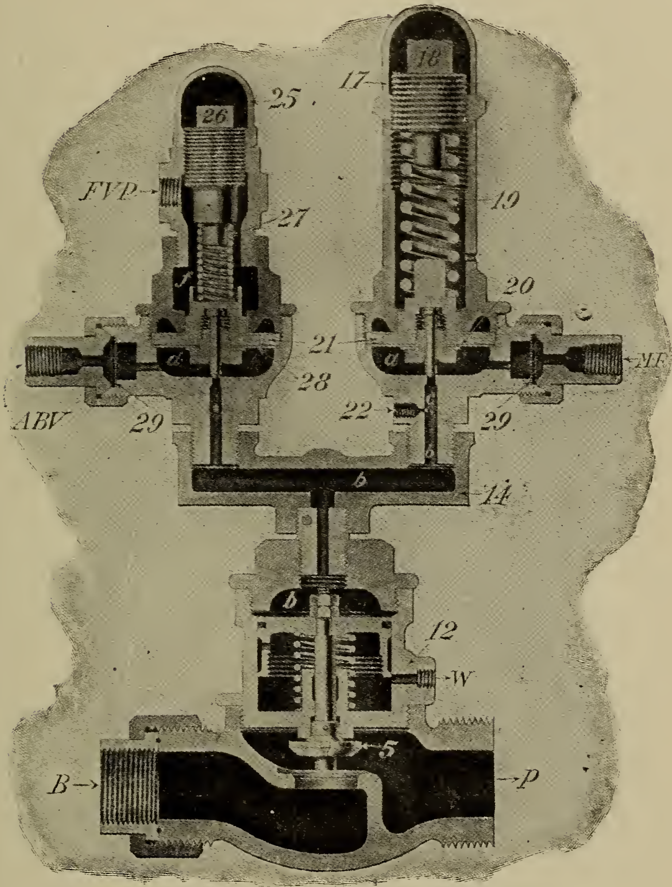


Fig. 91—The SF-4 Pump Governor.

Figure 91 shows a sectional view of this governor with steam valve 5 open. By reference to the piping diagram in Fig. 58, connection B leads to the boiler; P to the air pump; MR to the main reservoir; ABV to the automatic brake valve; FVP to the feed-valve pipe; W is the waste-pipe connection. Steam enters at B and passes by steam valve 5 to the connection P and to the pump. The governor regulating head on the left is called the "low-pressure head," and the one on the right the "maximum-pressure head." Air from the main reservoirs flows through the automatic brake valve (when the latter is in release, running or holding position) to the connection marked ABV into chamber *d* below diaphragm 28. Air from the feed-valve pipe enters at the connection FVP to chamber *f* above diaphragm 28, adding to the pressure of regulating spring 27 in holding it down. As this spring is adjusted to about 20 pounds, this diaphragm will be held down until the main-reservoir pressure in chamber *d* slightly exceeds the combined air and spring pressure in chamber *f*. At such time, diaphragm 28 will rise, unseat its pin valve, and allow air to flow to chamber *b* above the governor piston, forcing the latter downward, compressing its spring and restricting the flow of steam past steam valve 5 to the point where the pump will just supply the leakage in the brake system.

When the main-reservoir pressure in chamber *d* becomes reduced, the combined spring and air pressure above the diaphragm forces it down, seating its pin valve. As chamber *b* is always open to the atmosphere through the small vent port *c*, the pressure in chamber *b* above the governor piston will then escape to the atmosphere and allow the piston spring, and steam pressure below valve 5, to raise it and the governor piston to the position shown. Since the connection from the main reservoir to chamber *d* is open only when the handle of the automatic brake valve is in release, running or holding positions, in the other positions this governor head is cut out. The connection marked MR in the maximum-pressure head should be connected to the main reservoir cut-out cock, or to the pipe connecting the two main reservoirs, so as to be *always* in communication with the main reservoir, so that when the low-pressure head is cut out by the brake valve, or by the main-reservoir cut-out cock, this head will control the pump. When main-reservoir pressure in chamber *a* exceeds the adjustment of spring 19 in the maximum-pressure head, diaphragm 20 will raise its pin valve and allow air to flow in to chamber *b* above the governor piston, controlling the pump as above described. The adjustment of spring 19 thus forms the maximum limit of main-reservoir pressure, as, for example, when the train brakes are applied. As each governor head has a vent port *c*, from which a small amount of air escapes whenever pressure is present in port *b*, to avoid an unnecessary waste of air, one of these should be plugged.

To adjust the low-pressure head of this governor, remove cap nut 25 and turn adjusting nut 26 until the compression of spring 27 gives the desired difference between main reservoir and brake-pipe pressures, the handle of the automatic brake valve being in running position. To adjust the maximum-pressure head, remove cap nut 17 and turn adjusting nut 18 until the compression of spring 19 causes the pump to stop at the maximum main-reservoir pressure required, the handle of the automatic brake valve now being on lap. Spring 27 should be adjusted for 20 pounds excess pressure, and spring 19 for a pressure ranging from 120 to 140 pounds, depending on the service.

THE "DEAD ENGINE" FEATURE.

The "Dead Engine" feature shown in Fig. 58 is for the operation of the locomotive brakes when the pump on a locomotive in a train is inoperative through being broken down, or by reason of no steam. Fig. 92 shows the combined strainer, check valve, and choke fitting. As these parts are not required at other times, a cut-out cock is provided. This cock should be kept closed except under the conditions just mentioned. The air for operating the brakes on such a locomotive must then be supplied through the brake pipe from the locomotive operating the train brakes.

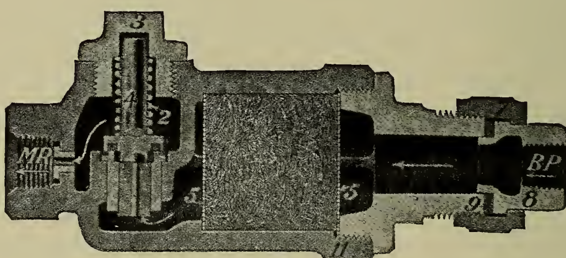


Fig. 92—Combined Air Strainer and Check Valve.

With the cut-out cock open, air from the brake pipe enters at BP, Fig. 92, passes through the curled hair strainer, lifts check valve 4, held to its seat by a strong spring, passes through the choke bushing, and out at MR to the main-reservoir, thus providing pressure for operating the brakes on this locomotive. The double-heading cock should be closed, and the handle of each brake valve should be in running position. Where absence of water in the boiler, or other reason, justifies keeping the maximum braking power of such a locomotive lower than the standard, this can be accomplished by reducing the adjustment of the safety valve on the distributing valve. It can also be reduced at will by the independent brake valve.

The strainer protects the check valve and choke from dirt. Spring 2 over the check valve insures this valve seating and, while assuring an ample pressure to operate the locomotive brakes, keeps the main-reservoir pressure somewhat lower than the brake-pipe pressure, thereby reducing any leakage from the former. The choke prevents a sudden drop in brake-pipe pressure and the application of the train brakes, as would otherwise occur with an uncharged main reservoir cut in to a charged brake pipe. In this, it operates similarly to the feed groove in a triple valve.

THE HIGH-SPEED BRAKE.

Briefly stated, the high speed brake is an apparatus which enables the engineer to apply a very high pressure to the brake cylinders while running at a high speed, which automatically reduces as the train slows down.

When a train is equipped with the high-speed brake a pressure of 110 pounds is carried in the trainpipe and auxiliaries and 120 in the main reservoir.

The equipment for the high-speed brake is the same as the ordinary quick-action brake, except that there is a duplex pump governor, an additional slide valve feed-valve, a quick action instead of a plain triple on the tender, a specially designed plain triple for the driver and truck

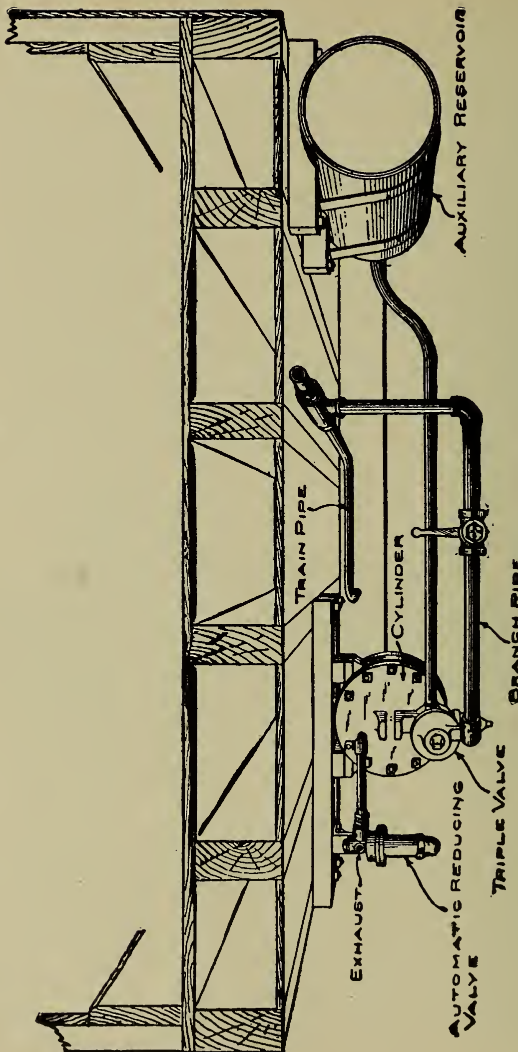


Fig. 93—High-Speed Brake: Car Pipe Arrangement.

brakes, and an automatic reducing valve attached to the cylinder 8 under the locomotive when the ET equipment is not used, and each car, as shown in Fig. 93.

As the high pressures are only to be used on trains which run at a very high speed, there are cut-out cocks on the pump governor and feed valves with old style equipment, so that the regular seventy and ninety pounds can be carried when required, but with the new style ET equipment the duplex governor system is used.

When it is desired to change the locomotive equipment from the quick-action to the high-speed brake with old style equipment, it is only necessary to turn two handles, that of the reversing cock of the feed valve and that of the quarter-inch cut-out cock on the pipe leading to the governor. These handles must be turned at right angles to the position occupied when the quick-action brake is being used.

The duplex pump governor consists merely of two diaphragm portions of the ordinary pump governor (only one of which is in use at a time) connected with one steam valve portion, see Fig. 91.

DESCRIPTION OF FIG. 93—HIGH-SPEED BRAKE AS ATTACHED TO CAR.

This illustration shows how the reducing valve is attached to a car and piped to the pressure head of brake cylinder.

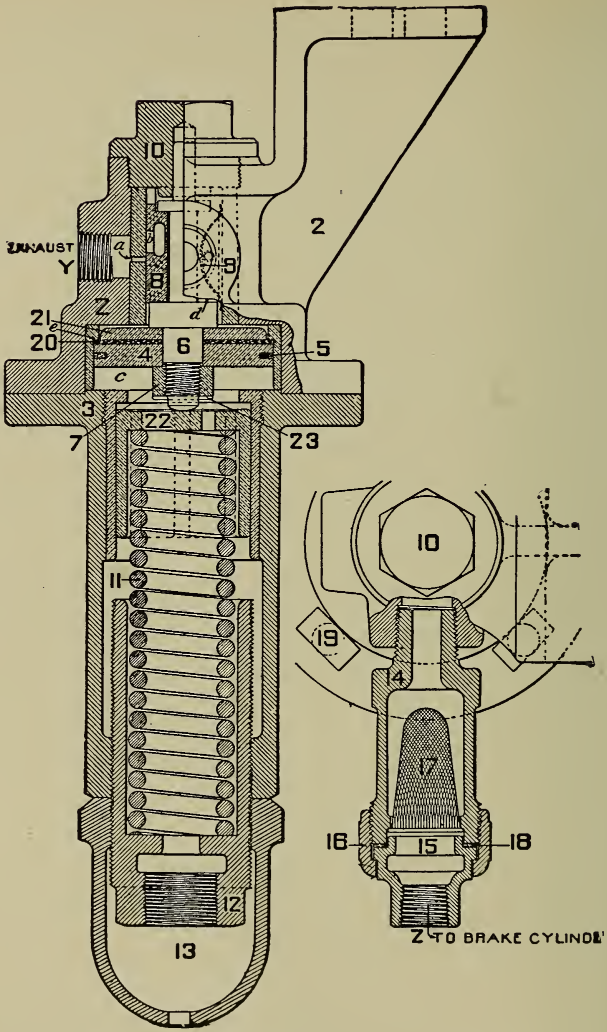


Fig. 94—The High-Speed Automatic Reducing Valve.

DESCRIPTION OF FIG. 94—AUTOMATIC REDUCING VALVE

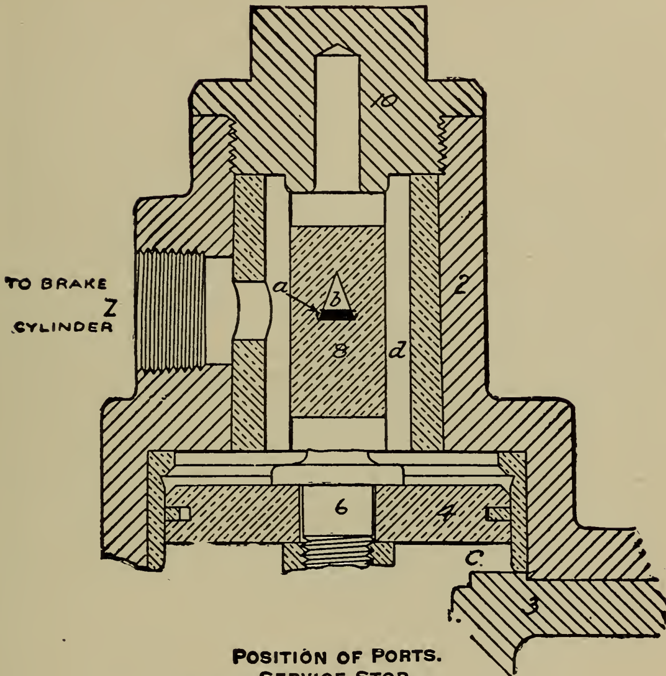
10. Cap nut.
9. U spring of slide valve.
8. Slide valve.
6. Slide-valve piston.
11. Regulating spring.
12. Regulating nut.

The principle of the high-speed brake is as follows: As the friction between the shoe and the wheel is lessened as the rapidity of rotation of the wheel increases, and as the adhesion between the wheel and rail remains practically the same regardless of speed, a greater cylinder pressure can be used while the train is moving at a high speed without danger of sliding wheels, but as the train slows down the cylinder pressure must be correspondingly reduced. This is done by what is called the automatic reducing valve.

Attached to the brake cylinder on each car there is an automatic reducing valve. Fig. 94 shows how the air passes in at Z, through a strainer (17), and, if the pressure is above sixty pounds, it overcomes the tension of regulating spring 11, and piston 4 is forced down, which carries the slide valve (8) with it, so that port *b* in the valve registers with port *a* in the seat, and allows the surplus pressure to escape to the atmosphere until the cylinder pressure is down to sixty pounds, when the regulating spring forces the slide valve up and thereby closes the exhaust port *a*, and holds the sixty pounds in the cylinder until the engineer releases the brake in the usual way.

Figures 95, 96 and 97 illustrate the positions of the ports in the valve seat and slide valve of the reducing valve when making a service stop, an emergency stop, or when there is sixty pounds or less in the cylinder.

The opening *d* in the side of the slide valve always admits cylinder pressure to port *b*, and, as port *b* is triangular in form, when a service stop is made the largest end of port *b* is in register with port *a*, to allow the air to reduce as rapidly as possible from the cylinder, but when an emergency application is made the slide



POSITION OF PORTS.
SERVICE STOP.
PRESSURE EXCEEDING 60 POUNDS
IN BRAKE CYLINDER.

Fig. 95—Service Stop.

DESCRIPTION OF FIG. 95—SERVICE STOP.

8. Face of slide valve, showing large end of port *b* to be in register with exhaust port *a*.

valve is forced down so that the small end of port *b* is in register with port *a,* and as the surplus cylinder pressure is gradually exhausted the regulating spring gradually raises the slide valve until, when there is a fraction less than sixty pounds left in the cylinder, port *b* is beyond port *a,* and the exhaust is closed.

The air remaining in the cylinder is released in the usual manner, by way of the triple exhaust.

The reducing valve should be examined occasionally in order to detect and overcome any possible leak through the discharge port.

Cars that are not equipped with automatic reducing valve should never be attached to trains employing the high-speed brake, unless the brake cylinders are equipped with the safety valve provided for temporary use in such cases. The safety valve has been specially designed to prevent a higher than standard pressure in the brake cylinders of cars not equipped with the automatic reducing valve. It may be quickly screwed into the oiling hole of the brake-cylinder head and removed when the car is again placed in ordinary service.

HIGH-PRESSURE CONTROL OR SCHEDULE U.

The purpose of the high-pressure control equipment is to enable enginemen to safely handle freight trains which are hauled out empty and brought back loaded.

For example, all freight-brake rigging is supposed to be adjusted so that the brake power exerted will be equal to only seventy per cent of the light weight of the car with a seventy-pound auxiliary pressure, but when the car is loaded its weight is changed. Consequently if the brake power on an empty car should be only sev-

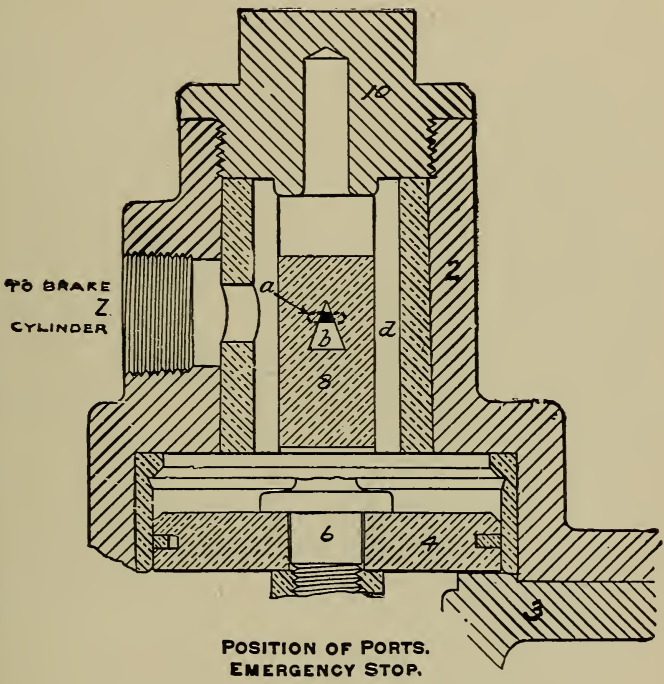


Fig. 96—Emergency Stop.

DESCRIPTION OF FIG. 96—EMERGENCY STOP.

8. Face of slide valve, showing small end of port *b* to be in register with exhaust port *a*.

enty per cent, that percentage would be very materially lowered when you increase the weight by loading the car. Even a very light load will materially change the percentage of brake power. As it would be very difficult to change the percentage of brake power by altering the brake rigging every time the weight of a train was changed (although this has been tried by using a lever shifting attachment) it is at once seen that the easiest and most practical way out of the difficulty is to change the standard of pressure carried in the auxiliary reservoir, and it is with this object in view that freight locomotives are equipped with the high-pressure control, for with this equipment an engineer can change his air pressure from 70 and 90 pounds to 90 and 110 pounds by simply turning a cut-out cock, and thereby increasing the percentage of brake power on his train.

This is explained as follows: If the brake piston travel on a car is 8 inches, and the engineer should make a service reduction of 30 pounds from a 70 pound auxiliary, and train pipe pressure, he would simply get 50 pounds pressure in the brake cylinder, and would be wasting 10 pounds train pipe pressure, because the auxiliary and brake cylinder pressures would have equalized at 50 pounds with a 20 pound reduction. On the other hand if there is 90 pounds pressure in the auxiliary, a 26 pound reduction would cause the auxiliary and brake cylinder pressures to equalize at about 67 pounds, thus giving a much greater brake power with a full service application than would ordinarily be obtained from a 70 pound train pipe pressure with an emergency application.

The reason for this is, that the auxiliary and brake cylinder pressures will equalize at a point (2-7) two-

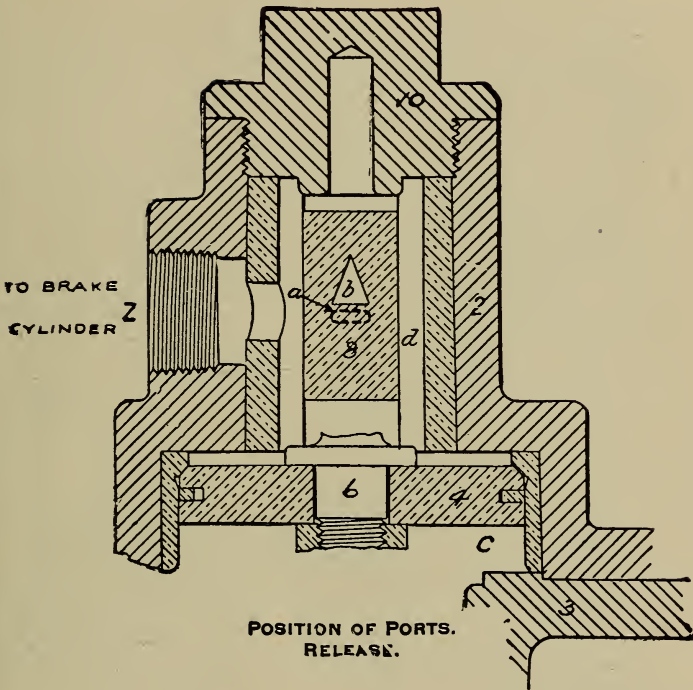


Fig. 97—Release Position.

DESCRIPTION OF FIG. 97—RELEASE POSITION.

8. Face of slide valve, showing port *b* closed to exhaust port *a*.

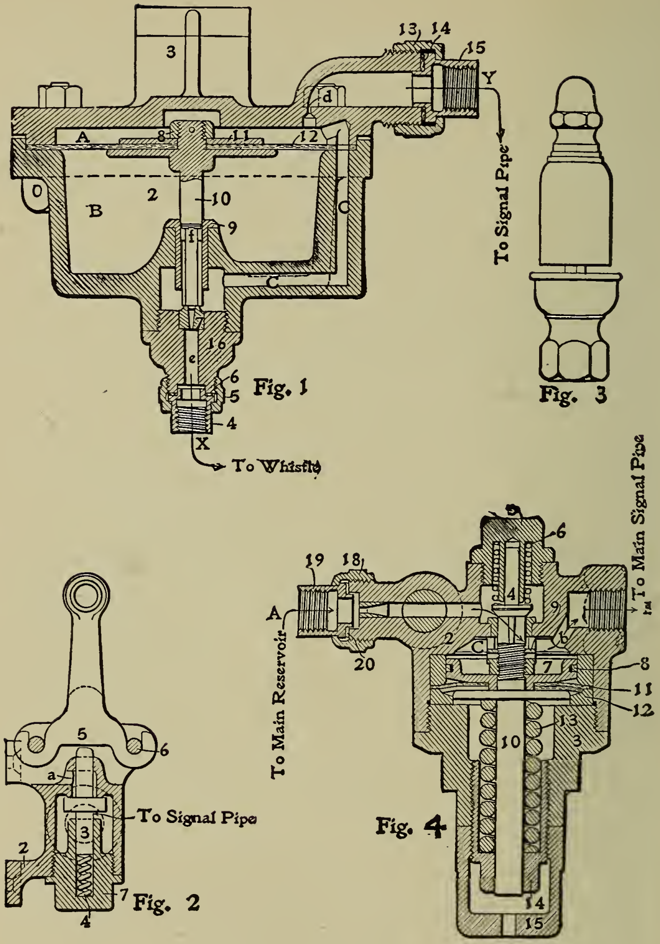


Fig. 98—Whistle Signal System.

sevenths below the original auxiliary pressure. For example, a 20-pound reduction from a 70-pound auxiliary pressure will equalize at 50, and 20 is two-sevenths of 70.

By this arrangement an engineer can greatly increase the brake power on his train so that he has it under better control in descending grades, and with little or no

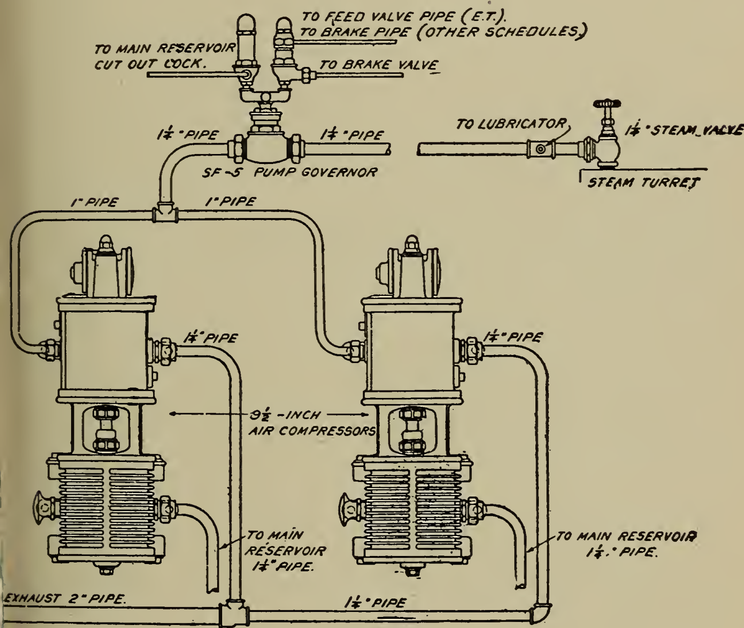


Fig. 99—Diagrammatic Illustration of Connections Between 1¼-inch Steam Valve, 1¼-inch Governor and Two Air Compressors on the Same Side of the Boiler. This Represents Sequence of Parts Only and Not Exact Location on Engine.

chance of sliding wheels, for the reason that the increased load not only makes the increased cylinder pressure safe, but absolutely essential.

As a precaution against sliding wheels on the engine and tender, there are attached to them safety valves which automatically let out all but 50 pounds of brake cylinder pressure when an application is made.

The difference between the high pressure control and the high-speed brake is as follows: the cars require no additional parts when using the high-pressure control; safety valves are used on the engine and tender instead of automatic reducing valves, and plain triple valves are used on both the engine and tender brakes, whereas a quick-action triple is used on the tender with the high-speed brake. The duplex pump governor is piped to both the main reservoir and slide valve feed valve with the high pressure control, whereas with the high-speed brake the governor is piped direct to the main reservoir.

Owing to the fact that the 90 pound pump governor is piped to the feed valve and because the feed valve is automatically cut out by the action of the rotary whenever the handle of the brake-valve is in any other position but running or release, it will be seen that when the handle of the brake valve is in any other position the 110-pound governor controls the pump, thereby causing it to quickly pump up the excess pressure.

With the high speed brake the governor is piped direct to the main reservoir, the same as with the quick-action equipment, consequently the cutting in, or out of the 90-pound governor by the quarter-inch cut-out cock on the governor pipe will give the low or high pressure as desired. The reason for having but one cut-out cock for the two governors with the high-speed brake is because if the 90-pound governor is cut in, the steam valve will be closed at 90 pounds, and if the 90-pound governor is cut out, it will require 120 pounds to unseat the diaphragm valve in order to let the air shut off the steam valve. The tension of the steam valve spring is, of course, always the same, no matter which governor is in use, but the tension of the diaphragm spring 41 is regulated by nut 40, so that one diaphragm valve will be lifted by 90 and the other by 120 pounds, or, if using the high pressure control, at 90 and 110 pounds.

WESTINGHOUSE DUPLEX MAIN RESERVOIR CONTROL.

Figure 110 illustrates the duplex main reservoir control. The function of this arrangement is to permit the accumulation of a high main reservoir pressure with which to release the brakes and recharge the auxiliary reservoirs, and at the same time requiring the pump to operate against this high pressure only for the short time that the brakes are held applied. The governor heads are usually adjusted for 85 pounds for the low pressure head, and 110 pounds for the high pressure head, and pump control is transferred from one head to the other by the movement of the brake valve handle.

By referring to Fig. 110, which is a semi-sectional view of the arrangement of piping, it will be seen that the high pressure head is coupled to the usual main reservoir connection of the brake valve, while the low pressure head is connected to port A in the brake valve, which leads to the running position port.

The explanation of the transfer of pump control from one head to the other is as follows: As the low pressure head is coupled to the running position port f of the brake valve, it is, therefore, subject to main reservoir pressure when the brake valve is in running or release position, which allows the air pressure to pass to the low pressure head, causing the pump to stop when the main reservoir pressure is equal to the adjustment of this head. However, in placing the brake valve in lap,

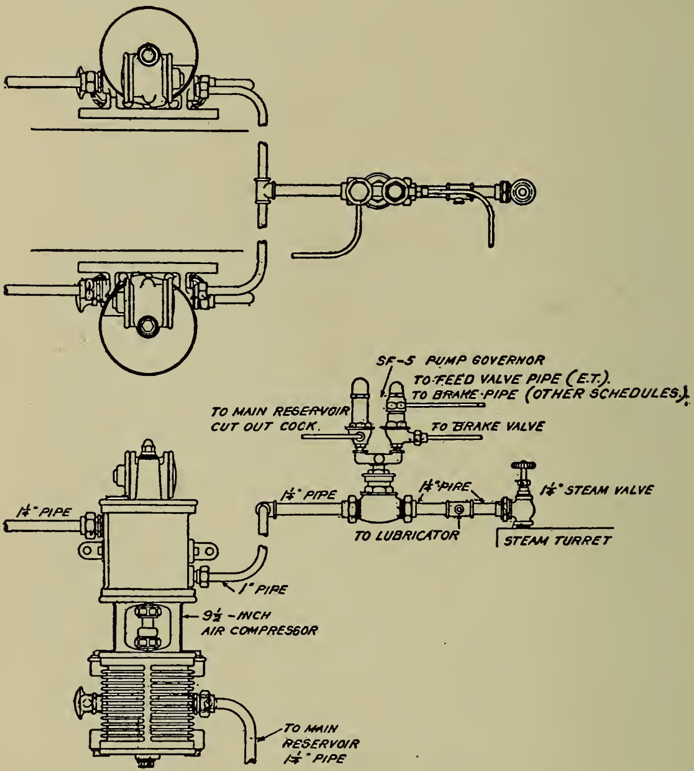


Fig. 100—Diagrammatic Illustration of Connections Between 1¼-inch Steam Valve, 1¼-inch Governor and Two Air Compressors, One on Each Side of the Boiler. This Represents Sequence of Parts Only and Not Exact Location on Engine.

service, or emergency positions, the main reservoir pressure, being cut off from the feed valve, is also cut off from the low pressure governor head, which permits the pump to run until the pressure in the main reservoir is

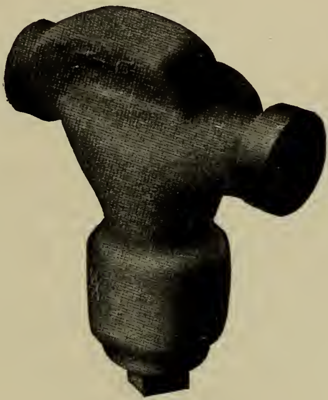


Fig. 101.

equal to the adjustment of the high pressure head, which will then stop the pump.

THE WESTINGHOUSE COMBINED AUTOMATIC AND STRAIGHT AIR BRAKE.

By means of this device, either the automatic brake, or the straight air brake may be operated on the engine and tender at the discretion of the engineer, without in any way interfering with each other, and the arrangement of the parts is such that the engineer can go from one brake to the other without any preparatory movement, each brake being entirely independent of the other in its action, although both are combined and attached to the same common system.

Besides the regular apparatus used with the automatic brake, the Westinghouse and New York Straight Air equipment consists of the following parts: a double seat check valve for the purpose of automatically shifting the connection from the cylinder to either the triple valve or the straight air-brake valve, as the case may require; a straight air-brake valve, having three positions, release, lap and application; a slide valve feed valve, set at 45 pounds, and attached to the straight air-brake valve, to reduce the main reservoir pressure when using straight air. The double seat check valve is used on both the engine and tender brakes.

THE DOUBLE SEAT CHECK VALVE.

The double seat check valve consists of a casing (2-3) with two end and two side openings, and has inside a loose, spool-shaped piece with a leather seat on each end (6) for the purpose of making a joint with the valve seat (a-b) at either of the end openings, against which it is driven by the air pressure entering at the other.

The pipe leading from the straight air-brake valve is connected to one end opening of the double seat check valve and the pipe from the triple is connected to the other end opening, and the connection with the brake cylinder is made by a pipe leading from either of the side openings, and to the other side opening is attached a safety valve set at about 50 pounds.

Figure 102 shows the double check valve when straight air is being used, for as the air from the brake valve strikes the check valve it is forced against seat b, which shuts off the triple and opens port c, which allows the air to rush into the cylinder.

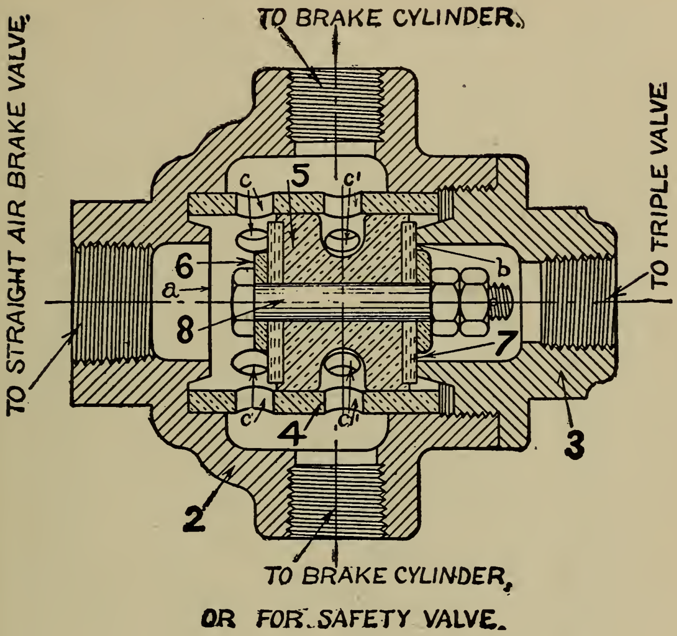


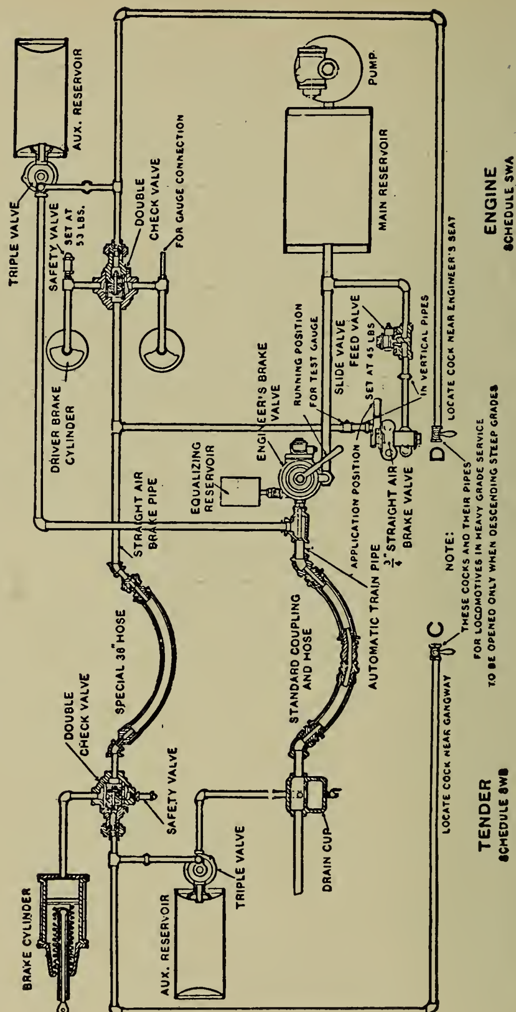
Fig. 102—Double Seat Check Valve.

DESCRIPTION OF DOUBLE SEAT CHECK VALVE.

4. Bushing.
5. Check valve.
a and *b*. Valve seat.
c, *c*. Ports for "straight air."
*c*1, *c*1. Ports for "automatic."
7. Leather gasket.

Fig. 103.

METHOD OF PIPING THE WESTINGHOUSE COMBINED AUTOMATIC AND STRAIGHT AIR BRAKE.



(For description see following page.)

DESCRIPTION OF FIG. 103.

[Figure 103 is a diagrammatic illustration showing the method of piping the Westinghouse Combined Automatic Straight Air Valve. The main features to be remembered are that the hose between the engine and tender, marked special 36 inch hose, should be one continuous piece in order to avoid possible leakage; that with this arrangement two double check valves are needed and two exhaust valves marked D and C, are used for the purpose of enabling the engineer to reduce the pressure on the locomotive when descending heavy grades, or when the wheels are sliding; as shown in the chart, there must also be a safety valve attached to the brake cylinders on both the engine and tender, and there should also be a pressure gauge for indicating what the brake cylinder pressure is at all times, and this is very important, for the reason that should the reducing valve become defective it is liable to allow a much too heavy pressure to get into the cylinder. The exhaust valves C and D, as shown in the diagram, are located on the tender and engine respectively, and should be within easy reach of the engineer, for when they are needed they are needed in a hurry.]

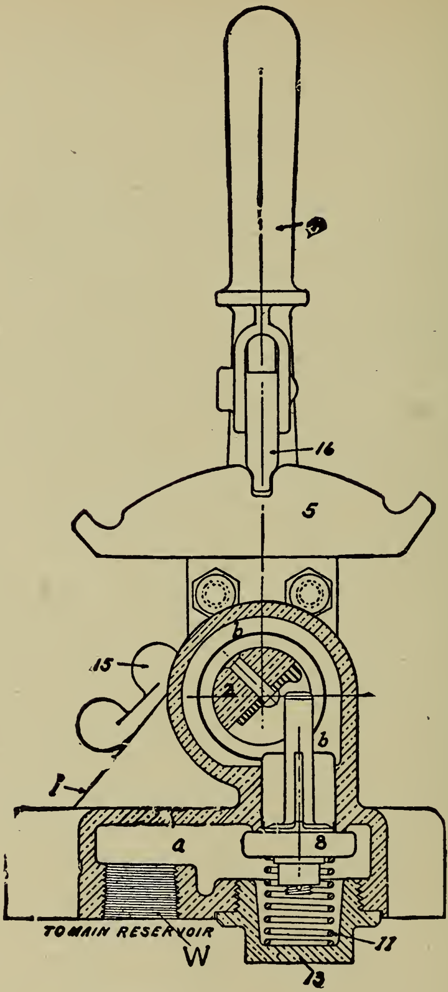


Fig. 104—Westinghouse Straight Air Brake Valve (Old Style), Showing Valve 8.

(For description see following page.)

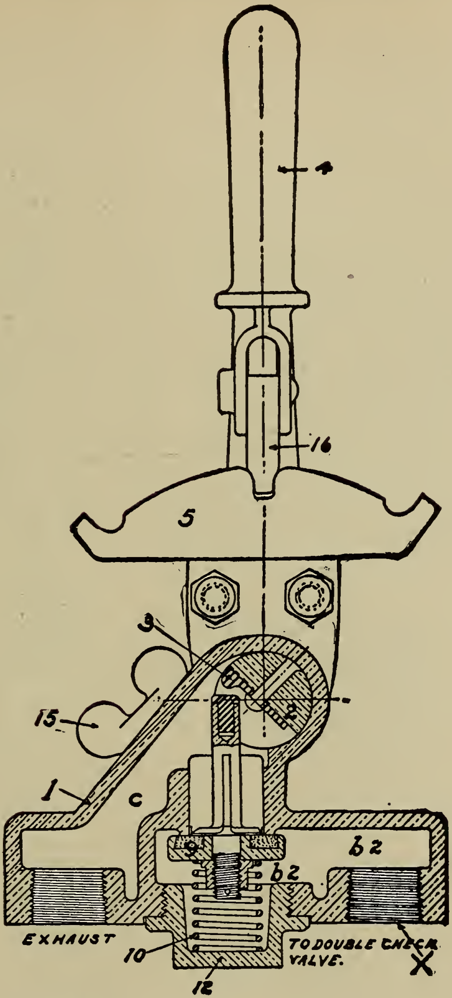


Fig. 105—Westinghouse Straight Air Brake Valve Showing Valve 9.

Description of Figures 104 and 105—2. Shaft attached to handle (4) for operating valve 8 and release valve 9. The handle is on lap position.

DESCRIPTION OF FIG. 106.

Section F.F. shows how the air passes from the main reservoir by way of valve 8 to the double check valve, and how in returning from the double check it passes under valve 9 to the exhaust.

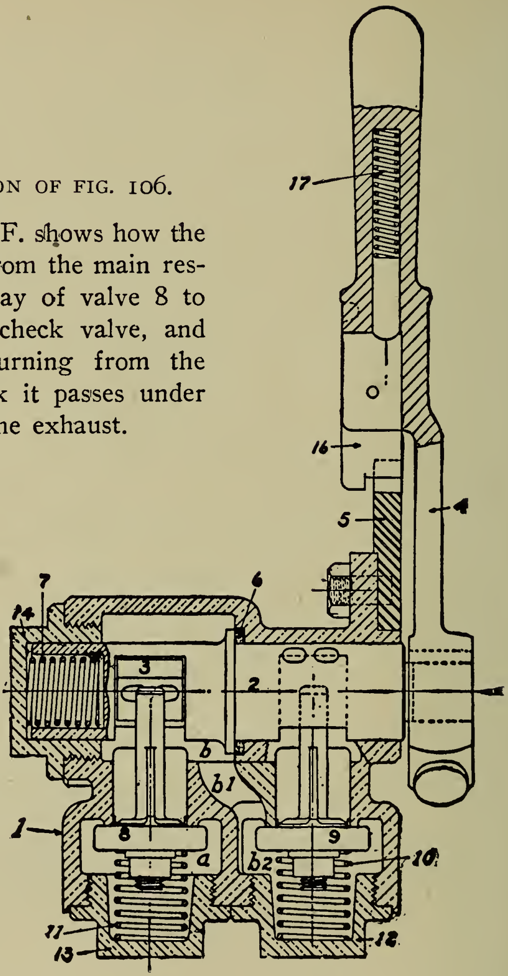


Fig. 106—Brake Valve for Combined Straight Air and Automatic Engine Brake.

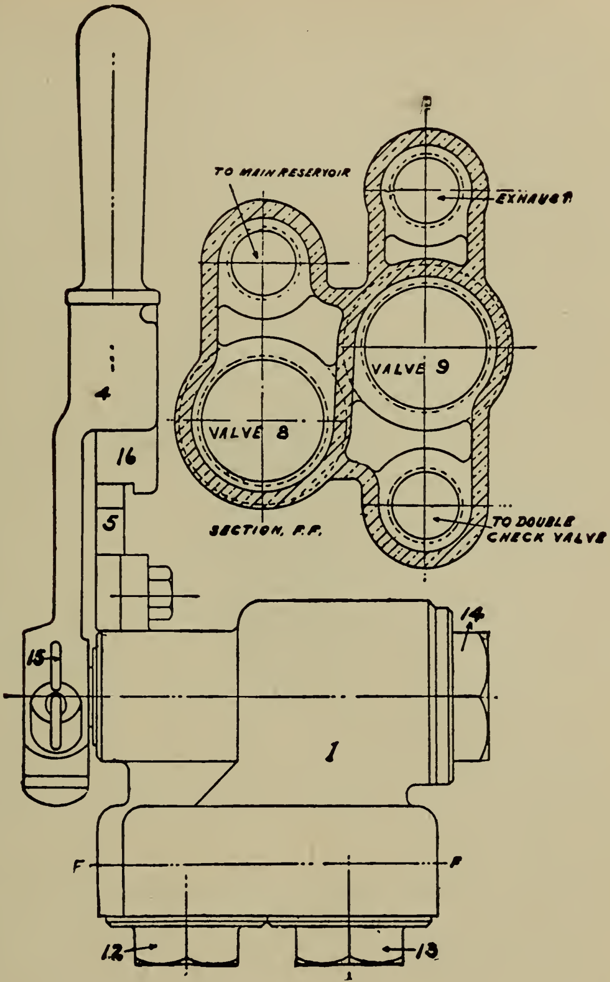


Fig. 107—Brake Valve for Combined Straight Air and Automatic Engine Brake, Old Style.

(*For description see following page.*)

To release the brake the engineer simply places the handle of the brake valve on release position and the air in the cylinder returns through the same ports in the check valve and escapes to the atmosphere by way of the release port in the brake valve.

To apply the brakes with the automatic, the old style straight air brake valve *must* be in release position, and when using the straight air the automatic brake valve must be left in running position. The engine brakes cannot be released with the Westinghouse or New York Straight Air Brake Valve if the triple is in application position.

When a reduction is made on the trainpipe pressure in the usual way, with the automatic brake valve, the air from the auxiliary forces the check valve against seat *a*, and thereby opens ports *c* 1, which allows the auxiliary air to rush into the cylinder. The brake is released in the usual way, for when the automatic brake valve is placed in full release position the triple piston reverses the slide valve, and the exhaust being thus opened the air in the cylinder flows back through ports *c* 1 in the check valve and out through the triple exhaust.

When an engineer wishes to do so he can keep his train brakes released and still have his engine and tender brakes set, when his engine is equipped with this special apparatus.

FIGS. 104, 105, 106 AND 107—THE STRAIGHT AIR-BRAKE VALVE.

The Westinghouse straight air-brake valve has three positions: release, lap and application. Figs. 104 and 105 show it on lap. It is very simple, as the essential parts are the handle (4); the shaft (2), to which the handle is fastened, which operates two check valves (8 and 9).

Check valve 8 controls the supply of air from the main reservoir to the brake cylinder, and valve 9 controls the exhaust from the cylinder.

Referring to Fig. 104, a movement of the handle to the right will cause the shaft to force valve 8 down and allow main reservoir pressure, which is always in chamber a, to flow under the valve into passage b and through b1, Fig. 106, b2 and X, Fig. 105, to the double

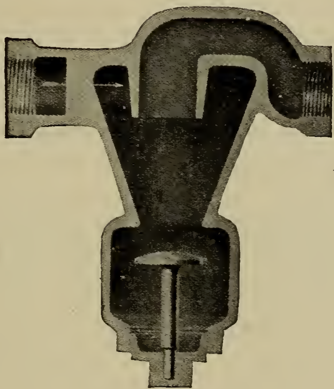


Fig. 108.

seat check valve and on into the cylinder, as explained under Fig. 102.

To release the brake, the handle is moved back to the extreme left, which causes the shaft to allow valve 8 to reseat, and forces valve 9 down, when the air from the cylinder passes back through X, b2, under valve 9, through passage c to the exhaust.

The slide valve feed valve is attached to the pipe leading to the double seat check valve, and when the handle is thrown to application position the flow of air from the main reservoir to the cylinder is shut off automatically at 45 pounds. Should the feed valve leak, or be set too high, the safety valve will allow the surplus pressure to escape, and should the safety valve not seat properly it would allow the cylinder pressure to leak off when either a partial straight air or automatic application was made.

The New York Straight Air Brake Valve has four positions which are described under their respective headings.

THE WHISTLE SIGNAL SYSTEM.

There are four essential things that go to make up the air-signal system, aside from the pipes, cut-out cocks, cords, etc.

Referring to Fig. 98, Fig. 1 is the signal valve, and stands in the same relation to the whistle as the auxiliary does to the brake cylinder, for it is in the signal valve that the air is stored for use in blowing the whistle.

Figure 2 is the car discharge valve, and stands in the same relation to the air signal as the conductor's valve does to the air brake, for when the car discharge valve is opened the air escapes from the signal pipe and causes the whistle to blow.

Figure 3 is the whistle.

Figure 4 is the improved reducing valve, which is to the air-signal what the feed-valve attachment is to the air brake, as it controls the pressure in the signal pipe and signal valve.

The reducing valve is identical in its operation with the old style feed-valve attachment. The regulating spring 13 is set at 40 pounds, the diaphragm piston (10) will keep the supply valve (4) off its seat until the main reservoir pressure (which flows in at A) has filled the signal pipe (B) to a fraction over 40 pounds, when the piston is forced down and allows the supply valve to shut off the main reservoir pressure until the signal-pipe pressure is again reduced, when the piston will

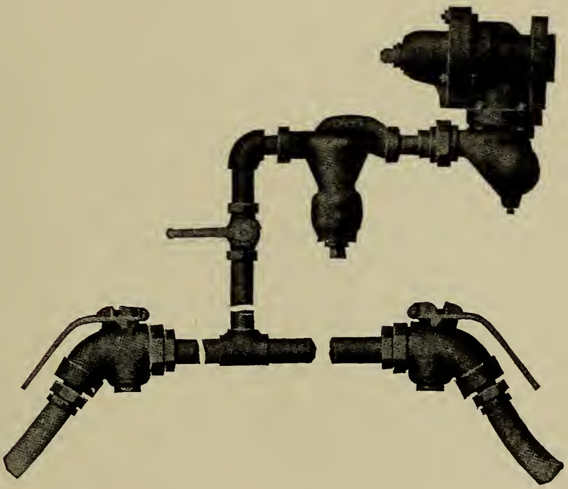


Fig. 109—Application of Centrifugal Dirt Collector to a Car. (Diagrammatic.)

again raise and unseat the supply valve to allow the main reservoir to quickly restore the pressure in the signal pipe, when the valve will again seat by the piston being forced away from it.

The signal valve is attached to the main signal pipe by a short branch pipe at Y, and whatever pressure is in the pipe the same is in chambers A and B, for as air passes through port d into chamber A, it also passes down passage C and raises the diaphragm stem (10) so that the small groove cut around the stem at f is above bushing 9, and as the side of the stem is flat as far up as the groove, when the stem is raised the air is free to enter chamber B, and when it equalizes with A the stem drops to its seat (7) by its own weight and closes port e. The stem is attached to a rubber diaphragm (12), and as the whistle is piped to the signal valve at X, whenever the lever (5, Fig. 2) of the car discharge valve is moved either to the right or left the small valve (3) is forced off its seat to allow the air to escape from the signal pipe, and when the pressure is thus reduced the air in chamber A is also reduced, and as the volume of B is so much greater than A the rubber diaphragm is forced up, which unseats the stem and allows the air in B, and some of the signal-pipe air to rush out through the bell-shaped whistle and cause it to blow.

In order to insure the whistle giving the proper blast it is necessary to make a sudden reduction, and as it is the air in the signal valve that blows the whistle, at least two seconds must be allowed between each pull of the cord to let chamber B fully recharge, and on a long train four seconds is better.

Plates 79 and 80 are diagrammatic illustrations showing (79) the Quick-Action Automatic Brake, and (80) the High-Speed Brake Equipment. These plates are remarkably complete in detail, and show at a glance the exact relation of each part to the other.

1¼-INCH PUMP GOVERNOR AND 1¼-INCH STEAM VALVE.

Many railroad companies having adopted the excellent practice of installing two air compressors on each locomotive, the Westinghouse air brake company have recently developed an enlarged type of pump governor having a steam valve with 1¼-inch connections instead

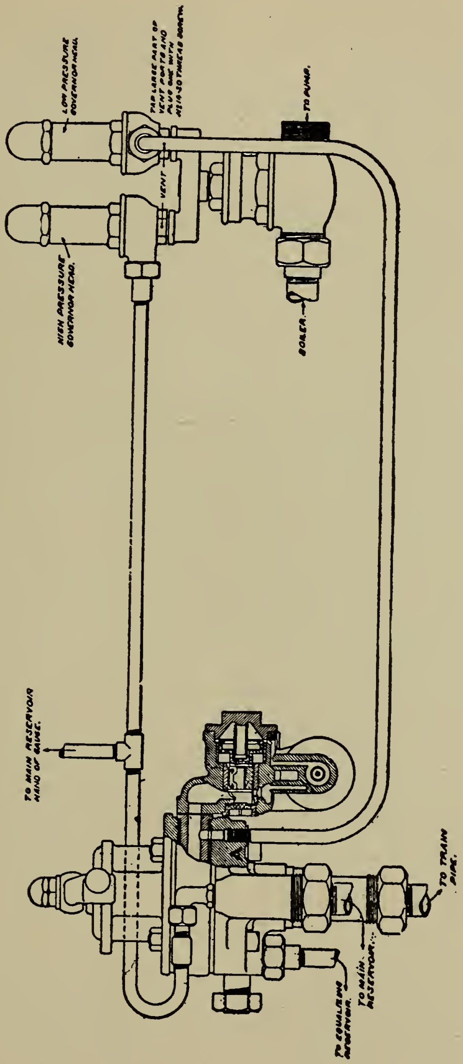


Fig. 110—Westinghouse Duplex Main Reservoir Control.

of the 1-inch connections heretofore employed with the 1-inch governor. This was deemed expedient when it was found that the standard 1-inch governor, and 1-inch steam valve had a tendency to unduly "throttle" or restrict the flow of steam required for satisfactory operation and, consequently, reduced the rate of speed and capacity of both compressors, especially under certain conditions frequently encountered in mountain-grade braking, where the greatest demand for air pressure comes at a time when the steam pressure may be more or less below normal.

Originally, a 1-inch governor complete was connected in the branch (steam supply) pipe to one compressor and a 1-inch governor steam-valve portion only (piped to the complete governor) connected in the branch pipe to the second compressor, the 1-inch steam valve being installed in the main steam supply pipe. This arrangement is superseded by the 1¼-inch governor and 1¼-inch steam valve (Figs. 99 and 100) which are of ample capacity for two 9½-inch, or two 11-inch compressors, and most satisfactory for the service in question. For two compressor installations the steam supply pipe should be 1¼-inch. The parts of the 1-inch, and 1¼-inch governors of similar type are interchangeable throughout with the exception of the steam valve portions. The diagrams, Figs. 99 and 100, will show clearly the connections of this new system of air pump regulation.

WESTINGHOUSE CENTRIFUGAL DIRT COLLECTOR.

This device is connected in the branch pipe between the brake pipe and triple valve as circumstances will permit, and is so constructed as illustrated in Fig. 108 that, due to the combined action of centrifugal force and gravity, all dirt and foreign matter is automatically eliminated from the air flowing through the collector, as when the brakes are applied or released, without in any way reducing the area of the passage way. The efficiency of this method of keeping dirt out of the brake system is remarkable, and the importance of this fact will be appreciated by those who are familiar with the undesirable results, and imperfect operation frequently produced by foreign matter when carried into the brake system, and especially the triple valves.

A strainer of any kind will clog in time and the more thoroughly it does the work it is designed to do the sooner this condition is reached; moreover it is necessary to break the pipe connections in order to clean or repair devices of this character. On the other hand the design of the Centrifugal Dirt Collector is such that not only does the normal opening through the device for the passage of air remain free and unrestricted at all times, but the dirt and foreign matter eliminated falls into the bottom chamber and by means of a small plug may be removed at intervals without breaking any pipe connections whatever.

Another result accomplished is that the use of the collector operates to reduce materially the work of cleaning and oiling air brake equipments, which, in connection with the general subject of air brake maintenance, is a very live railroad problem to-day.

QUESTIONS AND ANSWERS ON NO. 6 ET LOCOMOTIVE BRAKE EQUIPMENT.*

Q. What is the No. 6 ET Equipment?

A. It is a brake equipment for engine and tender adapted to all kinds of engines and classes of service and combines the operative features of the standard automatic, straight-air, high-speed, and double-pressure control brake equipments, with many additional features.

Q. Is the operation of the train brakes affected by the ET Equipment?

A. No; the operation of the train brakes is the same with this equipment as with former locomotive brake equipments.

Q. What is meant by the term *train* brakes?

A. All brakes in the train except those upon the locomotive from which the brakes are being handled.

Q. What is meant by the term *locomotive* brake?

A. The brake upon the engine and tender.

Q. What new features of operation are obtainable with the ET Equipment?

A. (a) Locomotive brake may be used with or independently of the train brakes, whether the train brakes are in use or not.

(b) Uniform and proper cylinder pressure is obtained regardless of piston travel or leakage.

(c) Cylinder pressure is automatically maintained regardless of brake cylinder leakage.

(d) Locomotive brake can be graduated on or off

*Formulated by the Air Brake Association.

with either the automatic or the independent brake valves.

(e) Increased flexibility in service operations, with increased braking power in emergency applications.

(f) Brakes on second locomotive or helper can be released or applied without in any way interfering with any other brakes in the train.

PARTS OF THE EQUIPMENT.

Q. Name the essential parts of the ET Equipment.

A. 1, Air Compressor; 2, Main Reservoir; 3, Duplex Pump Governor; 4, Feed Valve; 5, Reducing Valve; 6, Automatic Brake Valve with Equalizing Reservoir; 7, Independent Brake Valve; 8, Distributing Valve and Double Reservoir; 9, Two Duplex Air Gages; 10, Combined Air Strainer and Check Valve; 11, Choke Fitting; 12, Locomotive Brake Cylinders; also various cocks and fittings. (See Fig 58).

Q. What special parts are sometimes used?

A. (a) Quick-action Cylinder Cap for Distributing Valve.

(b) Combined Air Strainer and Check Valve for Train Air Signal System.

(c) Choke Fitting for Truck Brake.

Q. What furnishes the compressed air for the brake system?

A. The Air compressor.

Q. What operates the air compressor?

A. Steam from the locomotive boiler.

Q. After leaving the compressor, where does the air go?

A. Through the radiating pipes to the main reservoir.

Q. What is the purpose of the radiating pipe?

A. To cool the air after leaving the compressor.

Q. What is the purpose of the main reservoirs?

A. The main reservoirs provide a place for the storage of an abundant supply of compressed air for use in promptly releasing the brakes on the locomotive and train and for recharging the brake system. They also assist in cooling the compressed air and collect moisture, oil or other foreign matter, allowing only clean, dry air to pass to the brake system.

Q. What controls the air pressure in the main reservoirs?

A. The Duplex pump governor.

Q. How does the pump governor control the main reservoir pressure?

A. It automatically regulates the supply of steam to the compressor so as to maintain normal pressure in the main reservoirs.

Q. What connects the main reservoirs to the brake system?

A. The main reservoir pipe.

Q. What provision is made for cutting off the main reservoirs from the rest of the brake system?

A. A cock in the main reservoir pipe close to the main reservoir, known as the "main reservoir cut-out cock."

Q. Where do the pipe branches lead to from the main reservoir pipe?

A. (a) To the duplex pump governor.

(b) To the main reservoir hand of the duplex air gage.

(c) To the automatic brake valve.

(d) To the feed valve.
(e) To the reducing valve.
(f) To the distributing valve.
(g) To the dead engine fixtures.
(h) Other branches leading to various air-using devices on the locomotive, such as sanders, water-scoop, etc.

Q. What is the purpose of the feed valve?

A. To automatically maintain a predetermined pressure in the brake system, lower than that carried in the main reservoirs.

Q. To what does the feed valve pipe connect?

A. To the automtaic brake valve, and to the spring chamber of the excess pressure head of the duplex pump governor.

Q. What is the purpose of the reducing valve?

A. It automatically reduces the air pressure from the main reservoirs to the proper pressure used with the independent brake, and train air signal system.

Q. What is the purpose of the automatic brake valve?

A. (a) To allow air to flow from the brake system for charging it.

(b) To discharge air from the brake pipe to the atmosphere to apply the brakes.
(c) To prevent the flow of air to, or from the brake pipe when holding the brakes applied.
(d) To hold applied, or release the locomotive brake as desired while releasing train brakes.
(e) To allow air to flow to the brake system for the purpose of releasing the brakes and recharging the system.
(f) To control the flow of air to the diaphragm

chamber of the excess pressure head of the duplex pump governor.

(g) To allow main reservoir air to flow to the application cylinder of the distributing valve in *emergency* position.

Q. What is the purpose of the independent brake valve?

A. To operate the brakes on the engine and tender, independent of the train brakes.

Q. State briefly the purpose of the distributing valve.

A. (a) To automatically control the flow of air from the main reservoirs to the engine and tender brake cylinders when applying the brakes.

(b) To automatically maintain the brake cylinder pressure against leakage, keeping it constant, when holding the brake applied.

(c) To automatically control the flow of air from the engine and tender brake cylinders to the atmosphere when releasing the brake.

Q. What is the purpose of the brake cylinders?

A. The brake cylinder is that part of the air brake equipment in which the force contained in the compressed air is transformed into a mechanical force which is transmitted through a suitable combination of rods and levers to the brake shoes and applies them to the wheels.

H-6 AUTOMATIC BRAKE VALVE.

Q. How many positions has the H-6 Brake Valve?

A. Six.

Q. Name the positions beginning at the left.

A. *Release, Running, Holding, Lap, Service* and *Emergency* (see Figures 76 and 77).

Q. Name and describe the purpose of the pipe connections to the H-6 Brake Valve.

A. (a) Main Reservoir Pipe. To connect the main reservoirs to the chamber above the rotary valve and permit a free flow of high pressure air into the brake pipe when the brake valve handle is in *release* position.

(b) Feed Valve Pipe. To connect the feed valve to the underside of the rotary valve. When the brake valve handle is in *running* position this pipe is open to the brake pipe, thus permitting the feed valve to maintain a constant brake pipe pressure below that in the main reservoirs.

(c) Equalizing Reservoir Pipe. This connects the chamber above the equalizing piston to the equalizing reservoir and the equalizing reservoir gage.

(d) Brake Pipe. To connect the distributing valve on the locomotive and the triple valve on each car to the space underneath the equalizing discharge piston and the underside of rotary valve.

(e) Governor Pipe. This makes a connection from the rotary valve chamber (main reservoir pressure) to the underside of the diaphragm of the excess pressure governor head when the brake valve handle is in either *release, running* or *holding* positions.

(f) Distributing Valve Release Pipe. This makes a connection from the application chamber of the distributing valve (through the independent brake valve) to the underside of the automatic rotary valve, forming a connection to the atmosphere when both brake valve handles are in *running* position.

(g) Application Cylinder Pipe. This connects the underside of the automatic rotary valve directly to the application cylinder of the distributing valve. In *emergency* position of the brake valve handle this pipe is open to the chamber above the rotary valve (main reservoir pressure) through the blow-down timing port.

Q. When is *release* position used?

A. When it is desired to quickly charge the brake system and to release brakes on long trains.

Q. Explain the flow of air through the automatic brake valve when in *release* position.

A. Air from the main reservoirs flows directly to the brake pipe, equalizing reservoir and pump governor. Air from the feed valve flows through the warning port to the atmosphere.

Q. When is *running* position used?

A. When running along the road to maintain a predetermined brake pressure lower than that carried in the main reservoirs, to release the engine and tender brakes and also to release the brakes on short trains.

Q. Explain the flow of air through the automatic brake valve when in *holding* position.

A. (a) Air from the feed valve flows to the brake pipe and to the equalizing reservoir.

(b) Air from the main reservoirs flows directly to the diaphragm chamber of the excess pressure head of the duplex pump governor.

(c) Air from the distributing valve release pipe flows to the atmosphere.

Q. When is *holding* position used?

A. When it is desired to hold the engine and tender brakes applied by means of the automatic brake valve, while releasing and recharging the train brakes.

Q. Explain the flow of air through the automatic brake valve when in *holding* position.

A. The flow of air through the automatic brake valve when in holding position is the same as when in *running* position with one exception, namely: air from the distributing valve release pipe is prevented from flowing to the atmosphere.

Q. When is *lap* position used?

A. When holding all the brakes applied after an automatic application. The handle should never be carried in this position except while bringing the train to a stop.

Q. Is there any flow of air to the brake system through the automatic brake valve when in *lap* position?

A. No.

Q. When is *service* position used?

A. When it is desired to make an automatic application of the brakes.

Q. Explain fully the flow of air through the automatic brake valve when in *service* position.

A. In the automatic brake valve is a piston and valve called the equalizing discharge piston and valve, No. 15. Figures 76 and 77. The underside of this piston is directly connected to the brake pipe. The chamber *D*, above piston 15, is directly connected to the equalizing reservoir *ER* and to a small port *e* in the rotary valve seat called the preliminary exhaust port. In *service* position the preliminary exhaust port is open to the atmosphere through port *h* and exhaust cavity *o* (see small view plan of Rotary Valve at right, see Fig. 78), in the rotary valve, thus allowing air from the equalizing reservoir and the chamber *D* above the equalizing discharge piston to flow to the atmosphere. This reduces the pressure on the top of the piston below the brake pipe pressure on the underside, which raises the equalizing discharge piston 15 and permits brake pipe air to flow to the atmosphere through the service exhaust fitting *B. P. Ex.* The flow of air from the equalizing reservoir to the atmosphere continues until the brake valve handle is returned to *lap* position. This closes the preliminary exhaust port *e*, and prevents further decrease of pressure in the equalizing reservoir and chamber *D*. Air will continue to discharge from brake pipe until its pressure has been reduced slightly lower than that remaining in chamber *D*. The higher pressure on the top of the piston then forces the valve to its seat and prevents further reduction of brake pipe pressure.

Q. What is the purpose of the service exhaust fitting?

A. To fix the maximum permissible opening from the brake pipe to the atmosphere when making a service application.

Q. Is it important that all H-6 brake valves be provided with this fitting?

A. Yes.

Q. When is *emergency* position used?

A. When it is desired to make the shortest possible stop. In such case the handle should be moved to *emergency* position quickly and left there until the train stops.

Q. Should this position be used at any other time?

A. Yes; this position should be used in case of an emergency application of the brakes from an unknown cause, such as the opening of a conductor's valve, bursted hose, etc., in order to prevent loss of main reservoir pressure and to insure a full application of the brakes, and the handle should be left there until signal to release is given.

Q. Why should *emergency* position be used as explained in the last answer instead of *lap* position?

A. To insure the brakes remaining applied under all circumstances.

Q. Explain the flow of air through the automatic brake valve when in *emergency* position.

A. A large and direct opening is made from the brake pipe to the atmosphere, through the rotary valve, causing a quick and heavy reduction of brake pipe pressure. At the same time the air in the equalizing reservoir escapes to the atmosphere through ports in the rotary valve. Connection is made from air at main reservoir pressure above the rotary valve through a restricted port in the rotary valve to the application cylinder pipe leading to the application cylinder of the distributing valve. This port is known as the blow-down timing port, and assists in building up and regulating application cylinder pressure during emergency application.

S-6 INDEPENDENT BRAKE VALVE.

Q. How many positions has the S-6 Brake Valve?

A. Five.

Q. Name the positions beginning at the left.

A. *Release, Running, Lap, Slow-Application* and *Quick-Application* (see Figure 83).

Q. Name and describe the purpose of the pipe connections to the S-6 Brake Valve.

A. (a) Reducing Valve Pipe. This is the only source of air supply to the valve and connects the reducing valve to the chamber above the rotary valve, and through the rotary valve when the independent brake valve handle is in either *application position,* to the application cylinder and chamber of the distributing valve and also through the warning port to the atmosphere when the handle is in *release* position.

(b) Distributing Valve Release Pipe *to the distributing valve.* Connects the application chamber of the distributing valve to the underside of the independent brake valve. When the brake valve handle is in *running* position, this pipe is connected through ports in the seat and cavities in the rotary valve to the automatic brake valve.

(c) Distributing Valve Release Pipe to the *automatic brake valve.* This pipe connects the underside of the rotary valve of the independent brake valve to the underside of the rotary valve of the automatic brake valve. With both brake valve handles in *running* position, free passage is made from the application chamber of the distributing valve to the atmosphere through this pipe.

(d) Application Cylinder Pipe. Connects the application cylinder to the underside of the rotary valve of the independent brake valve When the handle is in either *application* position, air from above the rotary valve flows through this pipe to the application cylinder and chamber of the distributing valve. When the handle is in *release* position this pipe is connected to the atmosphere through ports in the rotary valve and seat.

Q. When is *release* position used?

A. Whenever it may be necessary to release the brake when the automatic brake valve handle is not in *running* position.

Q. Explain the flow of air through the independent brake valve when in *release* position.

A. Air from the application cylinder of the distributing valve flows direct through the application cylinder pipe and independent brake valve to the atmosphere. At the same time air from above the rotary valve (reducing valve pressure) flows through the rotary valve and warning port to the atmosphere.

Q. When is *running* position used?

A. When running along the road and to release the locomotive brake after an independent application, the automatic brake valve handle being in running position.

Q. Explain the flow of air through the independent brake valve when in *running position.* (Automatic brake valve handle in *running* position.)

A. Air from the application chamber of the distributing valve flows through the distributing valve release pipe and independent brake valve, then through the automatic brake valve to the atmosphere.

Q. When is *lap* position used?

A. When holding the engine and tender brake applied after an independent application.

Q. Is there any flow of air through the independent brake valve when in *lap* position?

A. No.

Q. When is *slow-application* position used?

A. When it is desired to apply the locomotive brakes lightly or gradually.

Q. Explain the flow of air through the independent brake valve when in *slow-application* position.

A. Air flows from the chamber above the rotary valve through the restricted service port and application cylinder pipe into the application cylinder and chamber of the distributing valve.

Q. When is *quick-application* position used?

A. When it is desired to apply the locomotive brakes promptly.

Q. Explain the flow of air through the independent brake valve when in *quick-application* position.

A. Air flows from above the rotary valve through a full open service port in the rotary valve and the application cylinder pipe to the application cylinder and chamber of the distributing valve.

Q. What prevents the independent brake valve handle from remaining in *release* position or in *quick-application* position unless held there?

A. A return spring.

Q. To what position does the return spring move the brake valve handle from *release* position?

A. To *running* position.

Q. Why is this necessary?

A. To prevent the possibility of the independent brake valve handle being left in *release* position, which would cause the engine and tender brakes to release whenever an automatic application was made.

Q. To what position does the return spring move the brake valve handle from *quick-application* position?

A. To *slow-application* position.

Q. Why is the spring used for this purpose?

A. To act as a stop, guarding against a quick application when only a slow application is intended, and to return the handle from *quick* to *slow-application* position.

Q. Why is this latter necessary?

A. In order to limit the flow of air to the application cylinder when the independent brake is to be left applied.

NO. 6 DISTRIBUTING VALVE WITH PLAIN CYLINDER CAP.

Q. What controls the brake cylinder pressure on the locomotive with No. 6 ET equipment?

A. The distributing valve.

Q. How does it do this?

A. It permits air to flow from the main reservoirs to the brake cylinders when applying the brake, from the cylinders to the atmosphere when releasing the brake, and automatically maintains the pressure against leakage, keeping it constant, when holding the brake applied.

Q. Is the amount of air flowing from the main reservoirs to the brake cylinders limited by the distributing valve?

A. Yes; the distributing valve acts as a reducing valve in supplying air from the main reservoirs to the locomotive brake cylinders.

Q. Facing the distributing valve, name the two pipes on the right hand side of the reservoir and state to what each one connects (see Figure 62).

A. (a) The upper pipe on the right is the brake cylinder pipe. It connects the distributing valve to all the brake cylinders on the engine and tender.

(b) The lower pipe on the right is the brake pipe branch pipe. It connects the distributing valve to the brake pipe.

Q. Name the three pipes on the left hand side of the reservoir and state to what each one connects (see Fig. 62).

A. (a) The upper pipe on the left is the supply pipe. It connects the distributing valve to the main reservoir pipe.

(b) The intermediate pipe is the application cylinder pipe. It connects the distributing valve to both the automatic and independent brake valves.

(c) The lower pipe is the release pipe, which connects the distributing valve to the independent brake valve and through it to the automatic brake valve.

Q. How many chambers has the distributing valve reservoir?

A. Two.

Q. Name them.

A. Pressure chamber and application chamber (see Figure 61).

Q. How many pistons has the distributing valve?

A. Two.

Q. Name them.

A. Application piston 10 and equalizing piston 26.

Q. How many slide valves has the distributing valve?

A. Four.

Q. Name them.

A. Application valve 5, exhaust valve 16, equalizing valve 31 and graduating valve 28.

Q. What valves are operated by the application piston?

A. The application valve and the exhaust valve.

Q. What valves are operated by the equalizing piston?

A. The equalizing valve and graduating valve.

Q. With the brake released what pressures are present in the distributing valve?

A. Main reservoir pressure, brake pipe pressure and atmospheric pressure.

Q. In what portion of the distributing valve is main reservoir pressure?

A. In chamber *a*, (see Figure 64), above the application valve.

Q. In what portion of the distributing valve is brake pipe pressure?

A. In the pressure chamber and in the chamber above the equalizing valve and graduating valve.

Q. In what portion of the distributing valve is atmospheric pressure?

A. In chamber *b* above the exhaust valve 16 and on the right hand side of the application piston 10; in chamber *g* on the left hand side of the application piston (called the application cylinder) and in the application chamber and the ports and cavities connecting with them.

Q. How is chamber *a* charged with air at main reservoir pressure?

A. Through the branch pipe leading from the main reservoir pipe to the connection marked *MR* on the distributing valve reservoir.

Q. Describe the operation of the distributing valve parts when an independent application of the brake is made.

A. Air is admitted to the application cylinder *g* and the application chamber from the reducing valve through the independent brake valve and the intermediate pipe on the left (application chamber pipe). This pressure will force the application piston 10 to the right (see Figure 69), lapping exhaust ports *d* and *e* with exhaust valve 16, and compressing graduating spring 20 and open supply port *b* through the application valve 5 to the brake cylinder chamber *b*, which is connected to the right of the application piston, obtaining a brake cylinder pressure slightly exceeding that in the application cylinder, when it and the graduating spring 20 then moves the piston 10 and the application valve 5 back to lap position (see Figure 70). The exhaust valve 16 will remain lapped, as there is sufficient clearance between the shoulders of the piston stem and the exhaust valve to permit the application valve to return to lap without moving the exhaust valve. At the same time cavity *s* in the equalizing valve 31 registers with ports *h* and *l* in the seat, thus connecting the application cylinder port *h* to the safety valve. *The equalizing piston and slide valve do not move during an independent application of the brake.*

Q. Describe the operation of the distributing valve parts when an independent release of the brake is made.

A. By a proper movement of the independent brake handle, air from the application cylinder *g*, and the application chamber is allowed to flow to the atmosphere, which reduces the pressure in chamber *g* below that in chamber *b*, causing the application piston 10 to move to the left, carrying with it application valve 5 and exhaust valve 16 until ports *d* and *e* are open past and through exhaust valve 16 (See Figure 64), permitting the air in the brake cylinders to flow through port *e* into chamber *b*, thence through ports *d* and *e* to the exhaust and atmosphere. *The equalizing piston and its valves do not move during an independent release of the brakes.*

Q. How is the pressure chamber charged with air at brake pipe pressure?

A. Through the branch pipe leading from the brake pipe to the connection marked BP on the distributing valve reservoir (See Figure 62), leading into chamber *p* (See Figure 64), then through feed groove *v* around top of piston 26 into the chamber above the equalizing valve 31 and through port *o* to the pressure chamber until the pressures on both sides of the piston are equal.

Q. From where do the application cylinder and chamber receive their air?

A. From the *reducing valve* through the independent brake valve during independent applications, and from the *pressure chamber* during automatic service applications.

Q. Describe the operation of the distributing valve parts when an automatic service application of the brake is made.

A. The brake pipe pressure in chamber *p* on the brake pipe side of equalizing piston 26 being reduced below that in the pressure chamber on the opposite side of the piston results in piston 26 being moved toward the right. The first movement of piston 26 closes the feed groove *v*, and at the same time moves the graduating valve 28 until it opens the service port *z* in the equalizing valve, and connects safety valve ports *r* and *s* in equalizing valve through cavity *t* in the graduating valve. As the piston continues its movement, the "spider" on the end of the piston stem engages the slide valve 31, which is then moved to the right until the supply port *z* in the equalizing valve registers with the application cylinder port *h* and through cavity *n* in the equalizing valve with application chamber port *w* in the seat. This permits the air in the pressure chamber to expand into the application cylinder. At the same time the safety valve is connected to the application cylinder and chamber by registering ports *r* and *s* in the equalizing valve with ports *h* and *l* in the seat and through the cavity *t* in the graduating valve, see Fig. 65. The amount of pressure obtained in the application cylinder and chamber depends upon the brake pipe reduction made. When the pressure in the pressure chamber is slightly reduced below that in the brake pipe, the piston and graduating valve are forced to the left until the collar on the piston stem comes in contact with the equalizing valve. This position is known as the "service lap," see Fig. 66. In this position the graduating valve has lapped port *z* between the pressure chamber and the application cylinder and has also lapped the safety valve port *l*. The air that expanded into the application cylinder and chamber will force the application piston 10 to the right, lapping the exhaust ports *d* and *e* with the exhaust valve 16, compressing graduating spring 20 and opening the supply port *b* through the application valve 5 to brake cylinder, as already explained.

Q. Describe the operation of the distributing valve when the brake is released with the independent brake valve, after an automatic application.

A. With the independent brake valve handle in *re-*

lease position, air in application cylinder *g*, and the application chamber flows direct to the atmosphere through the application cylinder pipe. This reduces the pressure in chamber *g* below that in chamber *b*, causing supply valve piston 10 to move to the left, carrying with it application valve 5 and exhaust valve 16 to *release* position, (see Fig. 71) thus releasing the brake.

Q. Do the equalizing parts of the distributing valve operate at this time?

A. No.

Q. Describe the operation of the distributing valve parts when making an automatic release of the brakes.

A. The brake pipe pressure in chamber *p* on the brake pipe side of equalizing piston 26 being increased above that in the pressure chamber on the opposite side of the piston results in the piston being moved toward the left, carrying with it graduating valve 28 and equalizing valve 31 to release position. In this position cavity *k* in equalizing valve 31 registers with ports *w*, *h* and *i* in the seat. This allows air from the application cylinder *g*, and the application chamber to flow through the ports mentioned to the distributing valve release pipe IV and to the atmosphere. At the same time the reduction of pressure in chamber *g* below that in chamber *b* causes the supply piston 10 to move to the left, carrying with it exhaust valve 16 to release position, (see Fig. 62) thus releasing the brake.

Q. Describe the operation of the distributing valve parts when an automatic emergency application of the brake is made.

A. Brake pipe pressure in chamber *p* on the brake pipe side of equalizing piston 26 is suddenly reduced below that in the pressure chamber on the opposite side of the piston. The considerable difference in pressure thus created on the two sides of equalizing piston 26 is sufficient to move it to its extreme position to the right, compressing graduating spring 46, see Fig. 67. In this position port *h* is open directly to the chamber above equalizing valve 31, past the end of the valve, so that air from the pressure chamber flows through port "o," through the chamber above equalizing valve to port "h" and the application cylinder "*g*." The application port *w* is blanked by the equalizing valve 31 and the safety valve port *l* is connected through port *r* and restricted port *q* in valve 31 to port *h* of the application cylinder. The air that expanded into the application cylinder from the pressure chamber will force the application piston 10 to the right opening the application valve 5 as in service application and obtaining cylinder pressure equal to that in the application cylinder, when the application valve will lap, see Fig. 68.

Q. What brake cylinder pressure is obtained from a full automatic service application of the brake from a 70 pound brake pipe pressure? (Safety valve set at 68 pounds.)

A. Fifty pounds.

Q. What brake cylinder pressure is obtained with an automatic emergency application from a 70 pound brake pipe pressure? (Safety valve set at 68 pounds.)

A. About seventy pounds.

Q. How is the difference between service and emergency brake cylinder pressure obtained?

A. With all automatic service applications the pressure chamber is connected to both the application chamber and application cylinder, the relative volumes of which are such that the air in the pressure chamber at 70 pounds pressure will equalize with the combined volumes of the application chamber and cylinder at 50 pounds pressure, which is, therefore, the maximum which can be obtained with an automatic service application. With all emergency applications the pressure chamber is not connected to the application chamber, but to the application cylinder only. The air in the pressure chamber then expands into the application cylinder, equalizing at about 65 pounds from a 70 pound brake pipe pressure. During emergency application air is admitted through a small port in the automatic brake valve (called the blow-down timing port) and the application cylinder pipe to the application cylinder. The size of the blow-down timing port in the brake valve is proportioned to the restricted port in the equalizing valve leading to the safety valve so as to give the proper time of blow-down of brake cylinder pressure.

Q. Will piston travel or brake cylinder leakage affect the brake cylinder pressure on the engine and tender?

A. No.

Q. How is a predetermined brake cylinder pressure obtained and maintained in the engine and tender brake regardless of piston travel and leakage?

A. As the brake cylinders receive their air from the main reservoirs they have practically an unlimited supply to draw from. The distributing valve and its reservoir volumes are constant, so that with a given brake pipe reduction, a given application cylinder pressure will be obtained (about 2½ pounds application cylinder and chamber pressure for every pound brake pipe reduction). The air that is admitted to the application cylinder forces the application piston and its valves to the right (see

Fig. 65), closing the exhaust ports and allowing air from the main reservoir branch pipe to flow to the brake cylinders until brake cylinder pressure becomes equal to that in the application cylinder, regardless of what the piston travel is, the number of cylinders, or the amount of leakage. When this pressure has been obtained, if brake cylinder leakage exists, the drop in cylinder pressure will reduce the pressure in chamber *b* on the right of piston 10 below that in application cylinder *g* on the opposite side of the piston. This will cause application piston 10 to again move to the right, opening application valve 5 and allowing air to flow from the main reservoirs to the brake cylinders until the brake cylinder pressure again equalizes with that in the application cylinder, when the application piston 10 and supply valve 5 will move to lap position (see Fig. 66). This action will continue indefinitely until the brakes are released.

SAFETY VALVE.

Q. What is the purpose of the safety valve? No. 34, see Fig. 61.

A. To prevent abnormal brake cylinder pressure and to act as a high speed reducing valve for the locomotive brake cylinders.

Q. To what is the safety valve connected?

A. To the application cylinder.

Q. When is the safety valve connected to the application cylinder?

A. At all times except in automatic service lap position of the distributing valve.

Q. For what pressure is the safety valve adjusted?

A. Sixty-eight pounds, except when the locomotive is transported light over the road, when it is ordinarily adjusted to 35 pounds.

Q. How does the safety valve act as a high speed reducing valve?

A. When an automatic service application is made and the equalizing valve and graduating valve are in service positions, the safety valve is connected to the application cylinder and chamber through large ports, and will therefore prevent the brake cylinder pressure rising above that for which the safety valve is adjusted. During emergency application the connection between the application cylinder and the safety valve is smaller than during service application, so that the flow of air frcm the application cylinder to the safety valve is restricted, which, in conjunction with the blow-down timing port, regulates the time of blow-down of brake cylinder pressure.

QUICK-ACTION CYLINDER CAP.

Q. Where is the quick-action cylinder cap located?

A. On the brake pipe end of the distributing valve (see Fig. 73), replacing the plain cylinder cap 23, see Fig. 68.

Q. What is its purpose?

A. To vent brake pipe air into the locomotive brake cylinders when an emergency position of the brake is made.

Q. Does it operate at any other time?

A. No.

Q. Why is this cap used?

A. To assist in obtaining an emergency application of the brakes in the train when double heading.

Q. Then the quick-action cylinder cap performs the same function in actuating quick-action as a quick-action triple valve on the tender with other types of locomotive brakes?

A. Yes.

Q. Does the air flowing to the brake cylinders through the quick-action cylinder cap increase the brake cylinder pressure, as is the case with the quick-action triple valve?

A. No; as the brake cylinder presssure is governed by the pressure in the application cylinder of the distributing valve.

Q. What advantage has this device over quick-action triple valves on the tender?

A. It is less liable to cause undesired quick-action than a triple valve, as it is much less sensitive.

Q. Why is it possible to use a valve less sensitive to quick-action than a triple valve?

A. As the quick-action cylinder cap is always located close to the automatic brake valve being operated; when an emergency application is made the quick-action cylinder cap is subjected to a more rapid brake pipe reduction than is the case with a triple valve located at a considerable distance from the brake valve, and consequently need not be so sensitive in order to accomplish its purpose.

Q. When the distributing valve is provided with a quick-action cap, how should the automatic brake valve handle be operated?

A. Exactly the same as when the distributing valve has plain cylinder cap.

Q. Describe the operation of the quick-action cylinder cap.

A. When the automatic brake valve handle is moved to emergency position, equalizing piston 26 (see Figure 72, moves to the right, which movement causes the knob on the piston to strike the graduating stem 50, causing it to compress graduating spring 55, moving emergency valve 48 so as to open port *j*. Brake pipe pressure in chamber *p* then flows to chamber X, unseats check valve 53 and passes to the brake cylinders through port *m* in the cap and distributing valve body.

Q. What duty does the check valve 53 perform?

A. When the brake cylinder and brake pipe pressures become equal, the check valve is forced to its seat by spring 54, thus preventing air in the brake cylinders from flowing back into the brake pipe.

Q. What takes place when a release is made?

A. Piston 26 is moved back to *release* position, spring 55 forces graduating stem 50 and emergency valve 48 back to the position shown in Figure 72.

Q. Are there any other differences in the operation of the distributing valve having this cap?

A. No; in all other respects the operation of the distributing valve is the same as described under the heading "No. 6 Distributing Valve With Plain Cylinder Cap."

THE B-6 FEED VALVE.

Q. How does the B-6 feed valve differ from that used with former automatic brake equipments?

A. The B-6 feed valve is made adjustable for either high or low brake pipe pressure and can easily be changed from one to the other. Otherwise, except for improvements in the mechanical design of the valve, it is the same as that used with former equipments.

Q. How is the change in adjustment accomplished?

A. The adjusting nut is provided with a hand wheel, having a lug, working between two adjustable stops on the body of the valve. These stops are adjusted for the high and low brake pipe pressure which it is desired to carry and the change of pressure from one to the other is accomplished by simply turning the hand wheel from one stop to the other.

Q. Where is the feed valve located?

A. On a bracket interposed between the main reservoir and feed valve pipes.

Q. Why is this bracket used?

A. To support the valve and permit it to be easily removed and replaced.

Q. What are the essential working parts of the feed valve?

A. The supply valve and actuating piston, the regulating valve, diaphragm, regulating spring and supply valve piston spring.

Q. Explain the general arrangement of the feed valve?

A. The feed valve consists of two sets of parts designated as the supply parts and the regulating parts. The supply parts, which control the flow of air through the valve consist of the supply valve 9 (see Figure 88), and its spring 10, supply valve piston 8 and supply valve piston spring 6. The regulating parts consist of the regulating valve 12, regulating valve spring 13, diaphragm 14, diaphragm spindle 16 and regulating spring 17.

Q. What is the normal position of this valve?

A. Closed, as shown in Figure 88.

Q. Explain the duty of the various operative parts.

A. Supply valve 9 is for the purpose of opening and closing port *c* in its seat. Piston 8 is for the purpose of moving the supply valve 9. Spring 6 is for the purpose of moving the piston and closing the supply valve when the pressures have equalized on both sides of piston 8.

Q. What are the duties of the regulating parts?

A. To control the action of the supply valve piston and supply valve when opening and closing the supply port *c* in the seat.

Q. Explain the operation and flow of air through the feed valve when open.

A. By referring to Figure 88, which is a diagrammatic view of the valve in its closed position, air entering through port *a* from the main reservoir is free to pass into the supply valve chamber "B" causing the supply valve piston 8 to be moved to the left, compressing piston spring 6, as shown in Figure 89, by which movement the supply valve 5 uncovers port *c* in the valve seat, thereby permitting air to pass directly through ports *c* and *dd* to the feed valve pipe at the same time air is passing by the supply valve piston 8, which is not an airtight fit, to chamber *G*, thence through port *hH* by the regulating valve 12, and through port *K* to diaphragm chamber *L* and on through ports *edd* to the feed valve pipe.

Q. What will cause a valve to close and stop the flow of air from the main reservoir to feed valve pipe?

A. When the pressure in the feed valve pipe and chamber L slightly exceeds the tension of the regulating spring 17, the diaphragm 14 will yield and allow regulating valve 12 to move to its seat, closing port *K*, and preventing the flow of air from chamber *G*. As the air continues to leak by supply valve piston 8, it will equalize the pressure on both sides of the piston and allow supply valve piston spring 6, which was previously compressed, to react and move the piston and supply valve to the position shown in Figure 89, closing port *c* in the supply valve seat.

Q. With the feed valve closed, and the pressure equalized on each side of the supply valve piston, what will cause it to open to supply the feed valve pipe when the pressure has been reduced?

A. Diaphragm chamber *L* is always in direct communication with the feed valve pipe; therefore, any reduction in feed valve pipe pressure reduces the pressure in chamber *L*, which allows the tension of the regulating spring to overcome the diminished air pressure in chamber *L*, and force the diaphragm 14 to the left. This unseats the regulating valve 12, permitting the accumulated air pressure in chamber *G* to escape to the feed valve pipe through ports *hH* and through port *K*, diaphragm chamber *L* and ports *edd*. The equilibrium of pressure on the two sides of the supply valve piston now being destroyed, the main reservoir pressure which is present in supply valve chamber *B* forces the supply valve piston 8 to the left, which moves the supply valve 9 with it, opening port *c* and again permitting the air to pass to the feed valve pipe until the pressure has been restored to the proper amount.

Q. The supply valve then maintains practically a wide open port until maximum pressure is obtained?

A. Yes; and when maximum pressure is obtained, the supply valve closes the supply port quickly.

C-6 REDUCING VALVE.

Q. What is the difference in the construction and operation of the C-6 reducing valve, see Figure 90, and the B-6 feed valve?

A. The only difference between it and the B-6 feed valve just described is in the convenience of adjustment, the C-6 reducing valve having the ordinary adjusting nut and cap nut used on former types of feed valves instead of the hand adjusting wheel 22 used with the B-6 feed valve shown in Figure 89. It is called a "Reducing Valve" simply to distinguish it from the B-6 feed valve.

SF-4 PUMP GOVERNOR.

Q. Where is the SF-4 pump governor located?

A. In the pipe supplying steam to the air compressor.

Q. Explain the general arrangement of the pump governor.

A. It consists of a standard steam portion, with Siamese fitting, and two diaphragm portions, as illustrated in Figure 91.

Q. How are these diaphragm portions designated?

A. That having two pipe connections the *excess pressure head* and that having a single pipe connection the *maximum pressure head.*

Q. What are the pipe connections of the governor?

A. *B*, to the boiler; *P*, the air compressor; *MR*, main reservoir; *AB*, the automatic brake valve; *FVP*, the feed valve pipe; *W*, waste pipe.

Q. When does the excess pressure head govern the operation of the air compressor?

A. At all times when the automatic brake valve handle is in *release, running* or *holding* positions.

Q. When does the maximum pressure head govern the operation of the air compressor?

A. During the time the automatic brake valve handle is in *lap, service,* or *emergency* positions.

Q. Explain the flow of steam through the governor.

A. Steam enters at *B*, passes by steam valve 5 to the connection *P*, and on to the air compressor.

Q. With the automatic brake valve handle in *release*, *runinng* or *holding* position, what pressures act on the diaphragm 28 of the excess pressure head?

A. Air from the main reservoir flows through the automatic brake valve to the connection marked *ABV*, to chamber *d* under diaphragm 28. Air from the feed valve pipe enters at connection *FVP* and flows to chamber *f* above diaphragm 28. In addition to this, regulating spring 27 also acts upon the upper side of the diaphragm.

Q. What is the adjustment of this spring?

A. About 20 pounds.

Q. What total pressure is, therefore, acting upon the upper side of diaphragm 28?

A. Whatever pressure the feed valve pipe may have, plus the tension of the regulating spring 27.

Q. What pressure in chamber *d* below diaphragm 28 will be required to overcome that acting on the upper side of the diaphragm?

A. A pressure slightly higher than that in the feed valve pipe plus the spring pressure. For example, with a pressure of 70 pounds in the feed valve pipe, about 90 pounds pressure below diaphragm 28 will be required to overcome that acting upon the upper side of the diaphragm.

Q. How does a variation in feed valve adjustment affect the governor?

A. When the feed valve adjustment is changed from one amount to another as where the locomotive is used alternately in high speed brake and ordinary service, the excess pressure head of the governor automatically changes the main reservoir pressure so as to maintain the same excess pressure (20 pounds).

Q. Why is this of advantage?

A. Because it insures that the main reservoir pressure will always be 20 pounds higher than that of the feed valve pipe.

Q. Explain the operation of the governor when main reservoir pressure in chamber *d* below diaphragm 28 becomes slightly higher than that acting on top of the diaphragm.

A. Diaphragm 28 will rise, unseat its pin valve 33, and allow air to flow to chamber *b* above the governor piston 6, forcing the latter down, compressing piston spring 9 and restricting the flow of steam past steam valve 5 to a point where the compressor will just supply the leakage in brake system.

Q. How long will the flow of steam through the governor be restricted in this manner?

A. Until main reservoir pressure in diaphragm chamber *d* becomes reduced slightly below the combined spring and air pressure in chamber *f* above the diaphragm, which will then force diaphragm down, seating its pin valve.

Q. How does this effect the flow of steam through the governor?

A. As chamber *b* is always open to the atmosphere through the small vent port *c*, the air pressure in chamber *b* above the governor piston 6 will then escape to the atmosphere and allow piston spring 9, and the steam pressure below valve 5 to raise it, and the governor piston 6 to the position shown. See Figure 91.

Q. With the automatic brake valve handle in *release, running* or *holding* position, does the maximum pressure head operate?

A. No; as during this time its diaphragm pin valve remains seated.

Q. To what is chamber *a* in the maximum pressure head always connected?

A. To the main reservoir.

Q. When does the maximum pressure head of the governor control the operation of the compressor?

A. When the automatic brake valve handle is in *lap*, *service* or *emergency* position, or when the main reservoir cut-out cock is closed.

Q. With the automatic brake valve handle in *lap*, *service* or *emergency* position, or when the main reservoir cut-out cock is closed, what pressures act on the diaphragm 20 of the maximum pressure head?

A. Main reservoir pressure which flows directly to chamber *a* on the underside of diaphragm 20 and the pressure of regulating spring 19 on the upper side.

Q. What is the adjustment of spring 19?

A. Spring 19 is adjusted to the maximum pressure which is desired in the main reservoirs.

Q. Explain the operation of the governor when main reservoir pressure in chamber "a" exceeds the tension of spring 19.

A. When main reservoir pressure in chamber *a* slightly exceeds the adjustment of spring 19, diaphragm 20 will rise, unseat its pin valve 33, and allow air to flow into chamber *b* above the governor piston, forcing it down, compressing its spring 9 and restricting the flow of steam past steam valve 5 to a point where the compressor will just supply the leakage in brake system.

Q. How long will the flow of steam through the governor be restricted in this manner?

A. When main reservoir pressure in chamber *a* becomes slightly reduced, the spring 19 forces diaphragm 20 down, seating its pin valve. As chamber *b* is always open to the atmosphere through the small vent port *c*, the pressure in chamber *b* above the governor piston 6 will then escape to the atmosphere and allow the piston spring 9 and steam pressure below valve 5 to raise the valve and governor piston to the position shown. See Figure 91.

Q. Is the maximum pressure head of the governor in any way controlled by the automatic brake valve?

A. No; as the chamber *a* below the diaphragm is in no way connected to the brake valve.

Q. With the automatic brake valve handle in *lap*, *service* or *emergency* positions or when the main reservoir cut-out cock is closed why does not the excess pressure head operate instead of the maximum pressure head?

A. Because under these conditions, communication from the main reservoir to chamber *d* is cut off by the brake valve and at the same time connection from the feed valve pipe to chamber *f* above diaphragm 28 still remains open, so that the combined air and spring pressure on top of the diaphragm holds the pin valve to its seat, rendering the excess pressure head inoperative.

Q. Under ordinary running conditions, why is only a moderate excess pressure desirable?

A. Because most of the time the automatic brake valve handle is in *running* position, (keeping the brakes charged) but little excess pressure is needed and the governor regulates the main reservoir pressure to about 20 pounds above the brake pipe pressure, thus relieving the compressor of unnecessary work.

Q. When an application of the brakes is made, why is the higher excess pressure of advantage?

A. To insure a prompt release of the brakes and recharge of the system.

DEAD ENGINE FIXTURES.

Q. What are the parts composing the dead engine fixtures?

A. A ⅜-inch pipe connecting the brake pipe and main reservoir pipe, a combined strainer and check valve with choke fitting, and a ⅜-inch cut-out cock.

Q. What is the purpose of the "Dead Engine" feature of the ET Equipment?

A. To enable the compressor on a "live" engine to charge the main reservoir on a "dead" engine, so that the brake on the dead engine may be operated with the other brakes in the train.

Q. How is this done?

A. Air from the main reservoir of the live engine passes through the brake pipe and dead engine fixtures to the main reservoirs of the dead engine.

Q. When is this apparatus used?

A. Only when the air compressor on the locomotive is inoperative.

Q. Should the cut-out cock always be closed except when the compressor is inoperative?

A. Yes.

Q. Describe the flow of air through the combined strainer and check valve. See Figure 92.

A. With the cut-out open, air from the brake pipe enters at *BP*, passes through the curled hair strainer, lifts check valve 4, held to its seat by a strong spring 2, passes through the choke bushing, and out at *MR* to the main reservoir pipe.

Q. Why is the "strong" spring 2 used in this valve?

A. This spring over the check valve insures the valve seating and keeps the main reservoir pressure somewhat lower than the brake pipe pressure, yet assures ample pressure to operate the locomotive brakes.

Q. What is the object of the choke fitting?

A. It prevents a sudden drop in brake pipe pressure and the application of the brakes in the train, as might otherwise occur with uncharged main reservoirs cut into a charged brake pipe or if for any reason the main reservoir pressure was lower than the brake pipe pressure.

Q. How can the maximum brake cylinder pressure be regulated on a dead engine?

A. By the adjustment of the safety valve on the distributing valve.

Q. Can the brake on a dead engine be controlled with the independent brake valve the same as on a live engine?

A. Yes, if it becomes necessary.

Q. When the dead-engine feature is used, in what position should the automatic and independent brake valve handles be carried?

A. *Running* position.

Q. What should be the position of the double heading cock?

A. Closed.

Q. Is it sometimes desirable to keep the braking power of a locomotive below the standard?

A. Yes; when there is no water in the boiler.

Q. How is this done?

A. By adjusting the safety valve on the distributing valve to the maximum brake cylinder pressure which is desired in the locomotive brake cylinders.

AIR GAGES.

Q. How many and what type of gages are used in connection with the ET Equipment?

A. Two duplex gages, designated—No. 1, Large Duplex Air Gage; No. 2, Small Duplex Air Gage. (See Figure 79).

Q. What pressures are indicated by gage No. 1?

A. Red Hand, Main Reservoir Pressure; Black Hand, Equalizing Reservoir Pressure.

Q. What pressures are indicated by gage No. 2?

A. Red Hand, Brake Cylinder Pressure; Black Hand, Brake Pipe Pressure.

Q. Which gage hand shows the amount of reduction being made during a service application of the brakes?

A. Black Hand, Gage No. 1.

Q. Why, then, is the black hand of gage No. 2 necessary?

A. To show brake pipe pressure when engine is second in double-heading or a helper.

Q. What pressure is indicated by the red hand of gage No. 2 when operating the automatic or independent brake valve?

A. Brake cylinder pressure.

CUT-OUT COCKS.

Q. What provision is made for cutting off the main reservoir from the brake system?

A. The main reservoir cut-out cock in the main reservoir pipe.

Q. What takes place when this cock is closed?

A. The flow of air from the main reservoir is cut off and the air in the brake system back of it is exhausted to the atmosphere.

Q. When this cock is closed can air flow from the main reservoir to any part of the system?

A. Yes; to the maximum pressure head of the pump governor.

Q. Why is this necessary?

A. To provide for the automatic control of the compressor when the cut-out cock is temporarily closed.

Q. What provision is made for cutting out the driver brake?

A. A ¾-inch cut-out cock located in the pipe leading from the distributing valve to the driver brake cylinders.

Q. What provision is made for cutting out the tender brake?

A. A ¾-inch cut-out cock located in the pipe between the distributing valve and the hose connection leading to the tender brake cylinder.

Q. What difference is there between this cock and the ¾-inch cocks generally used?

A. It has a choke fitting.

Q. Why is this choke fitting used?

A. To prevent a loss of driver and truck brake cylinder pressure in the event of a hose or tender brake cylinder pipe bursting.

Q. Is there another cock with choke fitting sometimes used in connection with this apparatus?

A. Yes; when a truck brake is used a ½-inch cock is located in the pipe leading from the distributing valve to the truck brake cylinder with choke fitting.

Q. For what purpose is the ¾-inch cut-out cock in the main reservoir supply pipe to the distributing valve?

A. To cut off the supply of air from the main reservoirs to the distributing valve to permit of inspection and repairs.

Q. For what purpose is the one-inch double heading cock underneath the brake valve?

A. To cut off the flow from the automatic brake valve to the brake pipe, or vice versa.

Q. What is the purpose of the brake pipe air strainer?

A. To prevent foreign matter entering the distributing valve, which might seriously interfere with its proper operation.

AIR SIGNAL SYSTEM.

Q. From what source is the supply of air to the signal system obtained with the ET Equipment?

A. From the reducing valve pipe between the reducing valve and the independent brake valve, as shown in Figure 58.

Q. Why is this supply taken from the reducing valve pipe?

A. That the one reducing valve may govern the pressure for both the independent brake valve and the signal system.

Q. What device is interposed between the reducing valve pipe and the air signal pipe?

A. A combined strainer and check valve.

Q. Why is the strainer necessary?

A. To protect the check valve and signal system from foreign matter.

Q. Why is the check valve employed?

A. To prevent a back flow of air from the signal pipe to the reducing valve pipe.

Q. In what way does this combined strainer and check valve differ from that used with the dead engine fixtures?

A. Only in the tension of the check valve spring.

GENERAL OPERATION OF THE NO. 6 EQUIPMENT

NOTE.—Details of construction and operation of the various devices will be found under their respective headings.

Q. What is the proper position of the brake valve handles and cut-out cocks before starting the compressor?

A. The automatic and independent brake valve handles in *running* position all cut-out cocks must be open, except the ⅜-inch cut-out cock in the dead engine connection and the angle and stop cocks at the front, and rear end of the locomotive.

Q. Explain the charging of the ET Equipment.

A. While the compresssor is operating, the main reservoir pressure continues to rise until it reaches the point for which the governor is adjusted. The governor then automatically stops the compressor. From the main reservoirs air flows through the main reservoir pipe to the chamber above the application valve of the distributing valve. It also flows to the feed valve which reduces the pressure of the air to that carried in the brake pipe. The air at this reduced pressure flows through the automatic brake valve to the brake pipe and thence through the branch pipe and distributing valve to the pressure chamber charging it up to brake pipe pressure. Air also flows from the main reservoirs through the reducing valve to the independent brake valve and air signal system.

Q. What must be done to make an automatic service application of the brake?

A. Move the automatic brake valve handle to *service* position.

Q. How does this apply the brake?

A. It starts a reduction of brake pipe pressure which causes the distributing valve to operate so as to allow air to flow from the main reservoirs into the brake cylinders.

Q. How is the application of the brake limited to any desired cylinder pressure?

A. By returning the automatic brake valve handle to *lap* position.

Q. What must be done to make an emergency application of the brakes?

A. Move the automatic brake valve handle to *emergency* position.

Q. How does an emergency application of the brake differ from a service application?

A. Brake pipe reduction takes place more rapidly, brake cylinder pressure rises more quickly and a higher brake cylinder pressure is obtained than in service applications.

Q. In what position should the automatic brake valve handle be placed to release the locomotive brake?

A. *Running* position.

Q. Is there any position besides *running* position in which the locomotive brake can be released by the use of the automatic brake valve?

A. No.

Q. Can the locomotive brake be applied otherwise than by using the automatic brake valve?

A. Yes. By the independent brake valve.

Q. In what position should the independent brake valve handle be placed to apply the locomotive brakes?

A. *Application* position.

Q. How does this apply the brake?

A. It allows air to flow from the reducing valve through the independent brake valve to the distributing valve, causing it to operate, and allow air to flow from the main reservoirs into the brake cylinders at a reduced pressure.

Q. Is the operation of the train brakes affected in any way by the independent application of the locomotive brakes?

A. No.

Q. How is the independent application of the locomotive brake limited to any desired cylinder presssure?

A. By returning the independent brake valve handle to *lap* position.

Q. How can the locomotive brake be released by the independent brake valve?

A. (a) If the automatic brake valve handle is in *running* position, move the independent brake valve handle to *running* position.

(b) If the automatic brake handle is *not* in *running* position, the independent brake valve handle must be moved to *release* position.

Q. Can the locomotive brake be released without in any way interfering with the train brakes under any and all conditions?

A. Yes; by placing the independent brake valve handle in *release* position.

TESTING AND OPERATING THE ET EQUIPMENT. TESTING LOCOMOTIVE BRAKE.

Q. Preparatory to making a test of the brake what should be done?

A. Blow out the brake pipe and signal pipe by opening and closing quickly a number of times the angle and stop cocks, both at the pilot and rear of the tender.

Q. Why is this done?

A. To remove scale and other foreign matter that may be in the brake and signal pipes.

Q. What observations should the engineer make before taking the engine to the train?

A. He should observe by the gages that the proper pressures are present in different parts of the system. This will show that the regulating devices (governors, feed valves, etc.) are properly adjusted. He should also observe that the brake is in proper condition generally.

Q. What test should then be made?

A. The brake should be applied and released with both the automatic and independent brake valves, to determine if the brake is in proper operative condition.

MANIPULATION OF LOCOMOTIVE AND TRAIN BRAKES.

Q. What is the proper position of the automatic and independent brake handles when not being operated?

A. *Running* position.

Q. After attaching the engine to the train in what position should the automatic brake valve be carried while charging the train brakes?

A. *Release* position.

Q. How long should the brake valve handle be left in this position?

A. Until the brake pipe system is charged to the pressure to be carried.

Q. How should the automatic brake valve be handled when testing the brakes.

A. A full service application of the brakes should be made and the handle then moved to *lap* position.

Q. How should the brakes be released?

A. Place the brake valve handle in *release* position for the proper length of time, then return it to *running* position, leaving it there.

Q. If the brakes apply in emergency from an unknown cause, while train is running, what should be done?

A. Move automatic brake valve handle quickly to *emergency* position and leave it there until train stops.

Q. Why is this done?

A. To insure the brakes remaining applied and to prevent loss of main reservoir pressure.

Q. What must be done in the event of sudden danger?

A. Move the automatic brake valve handle quickly to *emergency* position and leave it there until the train stops and the danger is past.

Q. With brakes applied in emergency, would anything be gained by moving the independent brake valve handle to *application* position?

A. No. Because in an application of this kind the application cylinder pressure is higher than the maximum pressure obtainable with the independent brake.

Q. If, in making a stop, the driving wheels slide, can they be released?

A. Yes; by placing the independent brake valve handle in *release* position and holding it there until the wheels again revolve, reapplying the brakes, if desired, with this brake valve.

Q. In the event of releasing and reapplying the locomotive brake in this manner, in what position should the independent brake valve handle be left after the application is made?

A. *Running* position.

Q. Why?

A. Because if left in any other position the locomotive brake cannot be released by the automatic brake valve.

Q. Does the releasing and reapplying of the engine and tender brakes with the independent brake valve in this way have any effect on the train brakes?

A. No; as the operation of the independent brake valve does not interfere with the train brakes.

Q. In making a service application, how should the automatic brake valve be handled?

A. The same as with the older type of brake valves.

Q. In making the first release of a two-application stop, how should the brake valve be handled?

A. (a) With short passenger trains release the brakes by moving the brake valve handle to *running* position a sufficient length of time to start the locomotive and train brakes releasing, then to *lap* position.

(b) With the long passenger trains the brake valve handle should be moved to *release* position for about three seconds to start the train brakes releasing, then to *running* position to partly release the locomotive brake, then to *lap*.

Q. In making the final release of a two-application stop, how should the automatic brake valve be handled?

A. (a) With short passenger trains, release the brakes just before coming to a stop by moving the brake valve handle to *running* position and leaving it there.

(b) With long passenger trains, the brakes should be held applied until the train stops.

Q. In making a release after a one-application stop, how should the brake valve be handled?

A. The same as a final release of a two-application stop, as just explained.

Q. Why is it necessary to move the automatic brake valve handle promptly to *running* position after going to *release* in releasing the brakes?

A. Because with the brake valve in *release* position, the locomotive brake is held applied.

Q. What is the only position of the automatic brake valve which will permit the release of both the locomotive and train brakes together?

A. *Running* position.

Q. Is there any other position besides *running* position which will release train brakes?

A. Yes; *release* position and *holding* position.

Q. Is there any other than running position in which the locomotive brake can be released by the automatic brake valve?

A. No.

Q. Can the locomotive brake always be released by placing the automatic brake valve handle in *running* position?

A. No.

Q. Why?

A. Because if the independent brake valve handle is not in *running* position, the locomotive brake cannot be released by the automatic brake valve.

Q. If the driving wheels pick up and slide while making a stop, what should be done?

A. Release with the independent brake valve.

Q. In handling a light locomotive, which brake valve should be used?

A. The independent brake valve.

Q. For a gradual application of the locomotive brake, how should the independent brake valve be used?

A. Place the brake valve handle in *slow-application* position until the brake is sufficiently applied; then return it to *lap* position.

Q. How operated if a quick application of the locomotive brake is desired?

A. Place the independent brake handle in quick-application position until the brake is sufficiently applied, then return it to *lap* position.

Q. Should the independent brake valve be used in completing a train stop?

A. No.

Q. Why?

A. Because to apply the locomotive brake with the train brakes released will cause slack to run in and produce shocks.

Q. In case of emergency, should the independent brake valve be used on a light locomotive?

A. No; in *all* cases of emergency, move the *automatic* brake valve handle to *emergency* position.

Q. Why?

A. Because a considerably higher brake cylinder pressure is obtained than would be possible with the use of the independent brake valve.

Q. How can the locomotive brake always be released regardless of the position either brake handle may be in?

A. By placing the independent brake valve handle in *release* position.

Q. How can the locomotive brake be held applied while releasing the train brakes?

A. By moving the automatic brake valve handle to either *release* or *holding* positions.

Q. Can this be done in any other way?

A. Yes; by placing the independent brake valve handle in *lap* position.

Q. Why should not the independent brake valve be used for this purpose?

A. First—Because it is better to use the automatic brake valve alone instead of in conjunction with the independent brake valve. Second—Because if the independent brake valve issued for this purpose, it may be left in *lap* position by mistake and the proper operation of the brakes by the automatic brake valve interfered with.

Q. Why should the automatic brake valve handle never be left in *lap* position except while bringing the train to a stop?

A. Because if the handle is left in *lap* position when the brakes are not applied, brake pipe leakage may materially reduce the brake pipe and auxiliary reservoir pressures, so that full braking power cannot be obtained and because the driver brakes are likely to apply as the outlet from the application chamber is closed.

Q. If, after a brake application, the automatic brake valve handle is moved to *release* position and returned to *lap* position, what will be the result?

A. The locomotive brake will remain applied.

Q. What is the advantage of having the locomotive brake remain applied under these conditions?

A. It would serve as a warning in case of neglect to move the handle to the proper position.

Q. Would anything be gained by moving the automatic brake valve handle to *release* position for a short time just before making an application of the brakes?

A. No; this should never be done.

Q. Why?

A. Because by placing the automatic brake valve handle in *release* position the brake pipe will be charged higher than the pressure in the auxiliary reservoirs; consequently, the brakes cannot be applied until after this difference in pressure has been drawn off.

FREIGHT BRAKING.

Q. What feature of the No. 6 ET Equipment is of particular advantage in handling trains on long, descending grades?

A. The ability to handle the locomotive brake with, or entirely independent of the train brakes.

Q. What is gained by this?

A. The locomotive and train brakes can be alternated without interfering with each other.

Q. With all the brakes applied, can the locomotive brake be released without releasing the train brakes?

A. Yes.

Q. How can this be done?

A. By placing the handle of the independent brake valve in *release* position, holding it there until the brake is released.

Q. After releasing in this manner, where should the handle of the independent brake valve be placed?

A. *Running* position.

Q. If it is then desired to release the train brakes and recharge the reservoirs, and reapply the locomotive brakes, in order to assist the retaining valves, in holding the train, how can this be accomplished?

A. Place the independent brake valve handle in *application* position until the desired locomotive brake cylinder pressure is obtained, then return it to *running* position, then move the automatic brake valve handle to *release* position and leave it there until the train is charged.

Q. What is the maximum pressure obtainable in the brake pipe under these conditions?

A. As the excess pressure head of the duplex governor will be in control, the maximum pressure obtainable will be twenty pounds above that ordinarily carried in the brake pipe.

Q. When reapplying the train brakes, how can excessive locomotive brake cylinder pressure be prevented?

A. By partially releasing the locomotive brake with the independent brake valve before reapplying the train brakes.

Q. How can the overheating of the driving wheel tires be prevented?

A. By either holding the independent brake valve handle in *release* position when making an automatic application or by releasing immediately with the independent brake valve after the automatic application.

Q. When releasing the brakes on a freight train when in motion should the automatic brake valve be handled in the same manner as with passenger trains?

A. No; the brake valve handle should be moved to *release* position and allowed to remain there for a period of time, according to the length of the train, but not to exceed twenty seconds.

Q. Why should this be done?

A. To insure a proper release of the train brakes and hold the locomotive brake applied, thus preventing the slack of the train running out.

Q. In making releases on long trains, after the brake valve handle has been returned to *running* position, should it again be moved to *release* position for an instant?

A. Yes; after being in *running* position for about three seconds.

Q. Why?

A. Because in making such a release some of the head brakes may have been overcharged and may reapply.

BROKEN PIPES.

Q. What would be the result if the brake pipe branch to the distributing valve broke off?

A. The locomotive and train brakes would apply.

Q. What should be done if this happens on the road?

A. Plug the end leading from the brake pipe; release the locomotive brake by placing the independent brake valve handle in *release* position and proceed.

Q. Would it be possible to use the locomotive brake in this case?

A. Yes; with the independent brake valve, always using *release* position to release the brake.

Q. What would be the result if any of the pipe connections between the distributing valve and the brake cylinders broke off?

A. It would permit a constant escape of air when the brake is applied and may cause the release of one or more of the locomotive brake cylinders, depending on where the break occurs.

Q. What should be done in a case of this kind?

A. If the pipe cannot be repaired close the cut-out cock in the pipe leading to the broken pipe. If breakage occurs next to the distributing valve reservoir, close the cut-out cock in the distributing valve supply pipe.

Q. What would be the effect if the supply pipe to the distributing valve broke off?

A. It would permit main reservoir pressure to escape and prevent the use of the locomotive brake.

Q. What should be done?

A. If repairs cannot be made to the pipe, the cut-out cock in the supply pipe should be closed or the pipe plugged.

Q. What would be the effect if the application cylinder pipe to the distributing valve broke off?

A. It would be impossible to apply the locomotive brake.

Q. What should be done?

A. The connection to the distributing valve should be plugged and the brake could then be applied, but with the automatic brake valve only.

Q. With this opening plugged and the brake automatically applied, can it be released with the independent brake valve?

A. No. It can only be released by placing the automatic brake valve handle in *running* position.

Q. If the release pipe to the distributing valve breaks off, what would be the effect?

A. It would cut out the holding feature of the automatic brake valve.

Q. With this pipe broken off would it interfere with the independent operation of the brake?

A. Yes; if an independent application was made and the equalizing parts of the distributing valve were in release position, it would allow the independent brake to release when the independent valve was moved to lap position.

Q. With this pipe broken off and the brakes automatically applied, can they be released with the independent brake valve?

A. Yes.

Q. Should any delay be occasioned by the breaking off of this pipe?

A. No. Proceed and operate the brake with the automatic brake valve but without attempting to use the holding feature.

Q. What would be the effect if the pipe connection to the spring chamber of the excess pressure head of the pump governor broke off?

A. The compressor would not operate when the main reservoir pressure was about forty pounds or over.

Q. What should be done in this case?

A. Plug the broken pipe and place a blind gasket in the pipe leading to the chamber below the diaphragm of the excess pressure head.

Q. What should be done if the pipe connection leading to the chamber below the diaphragm of the excess pressure head breaks off?

A. Plug the broken pipe and proceed.

Q. With the lower pipe to the excess pressure head plugged, or with both pipes plugged, what would control the compressor?

A. The maximum pressure head.

Q. What should be done in the event of the pipe connection to the maximum pressure head breaking off?

A. Plug the pipe.

Q. What would control the compressor?

A. The excess pressure head.

Q. In such a case, would the excess pressure head control the compressor at all times?

A. No; only with the automatic brake valve handle in *release, running,* or *holding* positions.

Q. What would happen if the handle were left in *lap,* *service* or *emergency* positions or it became necessary to close the main reservoir cut-out cock for any length of time?

A. The governor then being out of commission, the compressor will continue to run until air pressure and steam pressure become approximately equal.

Q. What precaution should be taken with the governor out of commission in this way?

A. Compressor should be throttled so that too high a main reservoir pressure could not be obtained, and in case of main reservoir cock being closed compressor should be shut off.

Q. What should be done if the equalizing reservoir pipe breaks off?

A. Plug the equalizing reservoir pipe to the brake valve and the service exhaust opening. The brakes should then be applied in service by a careful use of the *emergency* position.

Q. Why should extreme care be used when operating the brake valve in this manner?

A. To avoid causing quick-action and to prevent the head brakes "kicking" off when returning to *lap* position.

ROUND HOUSE INSPECTOR'S TEST.

General:

Q. What are the objects of these tests?

A. To determine the condition of the detail parts of the ET Equipment.

Q. What should be done by the round house air-brake inspector when testing the brakes preparatory to turning out the engine on the road?

A. The following cocks must be closed: The drain cocks in the main reservoirs, the brake pipe angle cocks and the signal pipe cut-out cocks at each end of the locomotive, and the ⅜-inch cut-out cock in the dead engine pipe.

The following cocks must be opened: Main reservoir cut-out cock, distributing valve cut-out cock, the double-heading cock and cut-out cocks in the brake cylinder pipes.

Both the automatic and independent brake valve handles should be in *running* position before starting the compressor.

Q. When the locomotive brake system has become fully charged what should first be done?

A. Blow out the brake pipe and signal pipe by opening and closing quickly a number of times the angle and stop cocks, both at the pilot and rear of the tender.

Q. Why is this done?

A. To remove scale and other foreign matter that may be in the brake and signal pipes.

Q. What pressure should there be in the brake pipe and distributing valve before testing the brake?

A. The standard brake pipe pressure for the service in which the locomotive is to be used.

Q. What are the parts that should be tested first?

A. The air gages.

Q. What method should be employed to test the air gages?

A. Use a test gage that is known to be correct. This gage should be coupled to the front or to the rear brake pipe hose; then with system charged and automatic brake valve in *release* position, note if main reservoir, equalizing reservoir and brake pipe presssure as indicated by the air gages correspond with the pressure indicated on the test gage.

Q. How should the brake cylinder gage be tested?

A. Connect the test gage to the brake cylinder, make a brake application, and see that the brake cylinder gage registers with the test gage.

Q. What test should follow the gage test?

A. A test of the pump governor.

Q. How should this test be made?

A. Place the automatic brake valve handle in *running* position. In this position main reservoir pressure should register twenty pounds higher than that in the brake pipe. Then place the handle in *lap* position. In this position the main reservoir pressure should register the maximum pressure standard on the road for the class of service to which the engine is assigned.

Q. What should next be done?

A. The feed valve should be tested.

A. How should the feed valve be tested?

A. Place the automatic brake valve handle in *running* position to see that the feed valve regulates the brake pipe pressure to the proper standard.

Q. What test should follow the feed valve test?

A. A test of the automatic rotary valve for leakage.

Q. How should this be tested?

A. Make a 20-pound service reduction, place the handle on *lap* position and close the double-heading cut-out cock under the brake valve. Harmful rotary valve leakage will be denoted in a few seconds by a material increase of pressure in the equalizing reservoir (shown on a gage) or by the equalizing piston lifting.

Q. Would any other defect cause the equalizing piston to lift?

A. Yes; a leak from the equalizing reservoir, which will be shown on the gage, will cause this. If the piston lifts, due to a rotary valve leak, however, the gage hand does not fall.

Q. What should next be done?

A. The locomotive brake pipe should be tested for leakage.

Q. How should test be made for break pipe leakage?

A. Charge the brake pipe and system to maximum pressure, then make a five-pound service application and observe the fall in brake pipe pressure as indicated by the *brake pipe gage,* not by the equalizing reservoir gage.

Q. What should the limit of this leakage be?

A. It should not exceed five pounds per minute.

Q. What test should be made to determine if the brake is in good order?

A. Apply the brake by making a full service application with the automatic brake valve, and if it applies properly, release by placing the automatic brake valve handle in *running* position and note if the brake shoes properly clear the wheels and the cylinder pistons return to the end of the cylinder.

Q. What other test should be made?

A. Apply the brake with the independent brake valve, noting that a full application (forty-five pounds) is registered by the red hand of the small air gage and that the hand returns to zero when the brake is fully released.

Q. With the independent brake valve handle in *quick-application* position how long should it take to get forty-five pounds of cylinder pressure?

A. From two to four seconds.

Q. How long should it then take from the time the independent brake valve handle is placed in *release* position until the flow of air from the application chamber at the brake valve ceases?

A. From two to three seconds.

Q. What should be observed regarding piston travel?

A. That the piston travel is only sufficient to give proper brake shoe clearance.

Q. What is usually about the proper piston travel?

A. Driver brakes about four inches; engine truck brake about six inches, and tender brake about seven inches standing travel.

Q. Why is too long piston travel objectionable?

A. It may cause a loss of the brake due to the piston striking the head or levers fouling, which will lengthen the time of release of the brake and cause a waste of air.

PUMP GOVERNOR TEST.

Q. Before adjusting the pump governor, what should be observed?

A. That all air pipe connections are tight and that the vent port and drain port are open.

Q. What would be the effect of a stopped-up vent port?

A. There might be a considerable drop in main reservoir pressure before the compressor would start.

Q. If, in addition to a stopped-up vent port, either diaphragm pin valve were leaking, what would be the effect?

A. The compressor would not operate when the main reservoir pressure was about forty pounds or over.

Q. What would be the effect of a stopped-up drain port?

A. The governor would not shut off the compressor.

Q. If, with the handle of the automatic brake valve in *running* position, the main reservoir and brake pipe pressures do not stand 20 pounds apart, where is the trouble?

A. In the adjustment of the excess pressure head of the pump governor.

Q. What should then be done?

A. The excess pressure head of the pump governor should be properly adjusted.

Q. Before commencing to adjust the excess pressure head, what is it important to note?

A. First—That the maximum pressure head is adjusted higher than the standard main reservoir pressure to be carried with the handle of the brake valve in *running* position. Second—That the air brake pressure is known to be correct. Third—That there is no obtsruction either in the main reservoir connection to the chamber under the diaphragm of the excess pressure head or in the pipe connection to the spring chamber.

Q. How should the adjustment of the excess pressure head be made?

A. Remove the cap nut from the excess pressure head and screw the regulating nut up or down, as may be required.

Q. With the automatic brake valve handle in *lap* position if the main reservoir pressure varies from the maximum employed on the road, where is the trouble?

A. In the maximum pressure governor head.

Q. If such variation exists, what should be done?

A. The maximum head should be properly adjusted.

Q. In case of a steady blow of air from the vent port when the compressor is operating, where is the trouble?

A. A leak past the seat of one or both of the diaphragm pin valves.

FEED VALVE TEST.

Q. How should the B-6 feed valve be tested?

A. With brake released and system charged to standard pressure, open the angle cock at the rear of the tender sufficiently to represent a brake pipe leakage of from seven to ten pounds per minute and observe the brake pipe gage pointer.

Q. With this amount of brake pipe leakage, what should the brake pipe gage do?

A. It should fluctuate.

Q. What does this fluctuation of the gage pointer indicate?

A. The opening and closing of the supply valve of the feed valve.

Q. If the gage hand does not fluctuate, what does it indicate?

A. That the supply valve piston is too loose a fit, and that the brake pipe leakage is being supplied past this piston and the regulating valve.

Q. How much variation should there be between the opening and closing of the feed valve supply valve?

A. Not more than two pounds.

Q. If the variation is more than two pounds, what does it indicate?

A. Undue friction of the parts, or a sticky or dirty condition of the operating parts of the valve, causing insufficient opening past the piston.

Q. If the feed valve charges the brake pipe to a pressure higher than that for which it is adjusted, what does it indicate?

A. That the piston has been made too tight a fit by oil or water.

Q. If the feed valve charges the brake pipe too slowly when nearing its maximum, what does it indicate?

A. Either a loose fitting piston or a gummy condition of the regulating valve.

REDUCING VALVE TEST.

Q. How should the C-6 reducing valve be tested?

A. First, with the system charged to standard pressure, fully apply the independent brake (handle in *slow-application* position) and note the amount of brake cylinder pressure obtained.

Q. What should this pressure be?

A. Forty-five pounds.

Q. If, in this test, the brake cylinder pressure is other than forty-five pounds, what does it indicate?

A. A leaky supply valve, a leaky regulating valve, or that the reducing valve is out of adjustment.

Q. After completing the test, what next should be done?

A. Release the brake and make an application in *quick-application* position.

Q. How can the reducing valve be tested for sensitiveness?

A. By applying a test gage to the signal line hose, and produce a leakage of from seven to ten pounds per minute in the signal line pipe and note the fluctuation of the gage pointer.

Q. What is important in making this test?

A. It must be known that the combined strainer and check valve is in a condition to permit a free flow of air through it.

Q. What other diseases might affect the operation of the reducing valve?

A. Those given in questions relating to the feed valve.

AUTOMATIC BRAKE VALVE TEST.

Q. What should be observed concerning the automatic brake valve?

A. That all its pipe connections are tight and that the handle moves freely between its various positions and that the handle latch and its spring are in good condition.

Q. If the handle does not operate easily, what are the probable causes?

A. A dry rotary valve seat, a dry valve key gasket or a dry handle latch.

Q. What should be done?

A. Rotary valve and seat, rotary valve key and handle latch should be properly lubricated.

Q. What is the proper method of lubricating the valve and seat?

A. Close the double-heading cock under the brake valve, then the main reservoir cut-out cock and after the air pressure has escaped, remove the oil plug in the valve body and fill the oil hole with valve oil.

Q. After filling the oil hole and before replacing the oil plug, what should be done?

A. The handle should be moved a few times between *release* and *emergency* positions to permit the oil to work in between the rotary valve and its seat. The oil hole should then be refilled and the oil plug replaced.

Q. How should the rotary valve key and gasket be lubricated?

A. Remove the cap nut from the rotary valve key and fill the oil hole.

Q. Before replacing the cap nut, what should be done?

A. Push down on the key and rotate the handle a few times between *release* and *emergency* positions; then refill the oil hole and replace the cap nut.

Q. If the handle latch becomes dry, what should be done?

A. Lubricate the sides of the latch and the notches on the quadrant.

Q. If, with the handle in *release, running, holding* or *lap* positions, there is a leak at the brake pipe service exhaust, what does it indicate?

A. That the equalizing piston valve is unseated, probably due to foreign matter.

Q. How can this leak usually be stopped?

A. By closing the double-heading cut-out cock under the brake valve, making a heavy service application and returning the brake valve handle to *release* position. This will cause a heavy blow at the service exhaust fitting and usually remove the foreign matter and allow the valve to seat.

Q. With the handle of the automatic brake valve in *service application* position, brake pipe pressure seventy pounds, how long should it take to reduce the equalizing reservoir pressure twenty pounds?

A. From six to seven seconds.

Q. From a brake pipe pressure of 110 pounds, how long should it take?

A. From five to six seconds.

Q. In case the equalizing reservoir pressure reduces considerably faster than the time given, what is the probable cause?

A. Either an enlarged preliminary exhaust port, leakage past the rotary valve, seat, lower gasket, or in the equalizing reservoir and its connections to the brake valve or gage.

Q. If the reduction is materially slower than the figures given, what is probably the cause?

A. A partial stoppage of the preliminary exhaust port or leakage into the equalizing reservoir.

Q. How should test be made for a leaky rotary valve?

A. By placing the brake valve handle in *service* position and allowing it to remain there until the brake pipe gage pointer drops to zero; then close the double-heading cock under the brake valve and place the brake valve handle on *lap*. If a blow starts at the brake pipe exhaust, it indicates a leak by the rotary valve into the brake pipe; if an increase of pressure is noted on the equalizing reservoir gage it indicates a leak past the rotary valve, or body gasket into the chamber above the equalizing piston and reservoir.

Q. During this test, if an increase of brake cylinder pressure results, or the safety valve blows intermittently, what does it indicate.

A. A leak by the rotary valve into the application cylinder of the distributing valve.

Q. With the brake valve handle on *lap* position after making a service application, if the brake pipe service exhaust continues to blow and the air gage indicates a fall in pressure in both the equalizing reservoir and brake pipe, where should the trouble be looked for?

A. In the equalizing reservoir and its connections, both to the brake valve and to the air gage, and also the inner tube of the gage.

INDEPENDENT BRAKE VALVE TEST.

Q. What are the important things to observe in connection with the independent brake valve?

A. That no external leakage exists in the brake valve or its pipe connections and that the handle and return spring work freely and properly.

Q. What can cause the handle to move hard?

A. Lack of lubrication of the rotary valve and seat, rotary valve key and gasket or handle latch, same as with the automatic brake valve.

Q. What should be done to make the handle move freely?

A. Follow the same recommendations as prescribed for the automatic brake valve.

Q. Should the handle continue to work hard after the parts have been lubricated, where is the trouble?

A. Probably something is wrong with the return spring or its housing.

Q. How should test for leaky rotary valve be made?

A. Make a partial independent application of the brakes, place the handle on *lap*, and note if brake cylinder pressure increases gradually to the limit of adjustment of the reducing valve.

Q. Should the handle fail to automatically return to *running* position or to *slow-application* position, what is the probable cause?

A. Too much friction of the moving parts or a weak or broken return spring.

DISTRIBUTING VALVE TEST.

Q. With the system charged to standard pressure, if a five-pound service reduction in brake pipe pressure fails to apply the locomotive brake, what is the probable cause?

A. Excessive friction in one or more of the operative parts of the distributing valve.

Q. How should the test be made to determine which of the operating parts caused the trouble?

A. By recharging, and then making a slow independent application. If the brake applies properly, the indications are that the trouble is in the equalizing portion of the distributing valve; if it does not, the indications are that it is in the application portion.

Q. How frequently should the distributing valve be cleaned and oiled?

A. At least every six months.

Q. What parts of the distributing valve should be lubricated?

A. All operating parts.

Q. If water is found in the distributing valve, what is usually the cause?

A. Improper piping on the locomotive; not sufficient length of radiating pipe between the compressor and reservoirs.

Q. How should the equalizing piston, slide valve and graduating valve be removed from the distributing valve?

A. Remove the equalizing cylinder cap, and carefully pull out the piston and valves so as not to injure them.

Q. How should the application piston, application valve and exhaust valve be removed?

A. First take off the application valve cover and remove the valve, then take out the application valve pin, after which the application cylinder cover should be removed and the piston and exhaust valve carefully pulled out.

Q. Must the application valve pin always be removed before attempting to take out the application piston and exhaust valve?

A. Yes; if this is not done, damage will result, as the piston *cannot* be taken out unless the pin is removed.

Q. With the valves removed from the distributing valve, what should be done?

A. Air should be blown through the ports and passages to remove any foreign matter.

Q. Before assembling the parts, what should be done?

A. All seats and bushings should be thoroughly cleaned and carefully examined to see that no lint is on the seats.

Q. What else should be given attention?

A. The feed groove in the equalizing piston bushing should be carefully cleaned out.

Q. What should be the resulting brake cylinder pressure from a ten-pound brake pipe reduction?

A. About twenty-five pounds.

Q. For each pound reduction of brake pipe pressure, what should be the resulting brake cylinder pressure?

A. About two and one-half pounds.

Q. If, after a partial service application has been made and the brake valve lapped, the brake cylinder pressure continues to increase, what are the causes?

A. The most probable cause is brake pipe leakage. Others may be a leak past the automatic rotary valve, the independent rotary valve, the equalizing valve, or the graduating valve in the distributing valve.

Q. What brake pipe pressure should be used when testing the ET Equipment?

A. Seventy pounds.

Q. Why?

A. With seventy pounds brake pipe pressure the point of equalization is below the adjustment of the safety valve. With 110 pounds pressure the point of equalization is above the adjustment of the safety valve and therefore leakage could not be so easily discovered.

Q. How is the source of leaks determined?

A. By making a partial service application and observe to what figure the brake cylinder pressure rises. If it increases to fifty pounds and remains constant, it indicates brake pipe leakage.

Q. If the increase in the brake cylinder pressure is due to a leaky rotary in the automatic brake valve, how may it be detected?

A. The brake cylinder pressure will increase up to the limit of adjustment of the safety valve, causing it to blow.

Q. If brake cylinder pressure increases to forty-five pounds and stops, where may the trouble be looked for?

A. In the independent brake valve, due to a leaky rotary.

Q. With the safety valve removed and the brake applied with a partial service application, if a continuous leak exists at the safety valve connection to the distributing valve, what would probably be the cause?

A. A leaky graduating or equalizing valve.

Q. If the equalizing valve leaks, how can it be detected?

A. By a steady discharge of air through the exhaust port of the automatic brake valve when the handle of both this brake valve and the independent brake valve is in *running* position.

Q. If, with a service application there is an intermittent blow at the brake cylinder exhaust port, what does it indicate?

A. A leaky application valve, provided the application cylinder and the application cylinder pipe is tight

Q. What indicates exhaust valve leakage?

A. A continuous discharge of air from the exhaust port when the brake is applied.

Q. If after a service application the equalizing piston, slide valve and graduating valve move to release position because of graduating valve leakage, will the locomotive release?

A. On the engine from which the brakes are being operated the locomotive brake will not release, but on the second engine in double headers or helpers with the brake valves cut out (double-heading cock closed) the locomotive brake will release.

Q. Why does not the brake release on the locomotive from which the brakes are being operated?

A. Because under these conditions the automatic brake valve is on *lap;* consequently the air cannot exhaust from the application chamber.

Q. Why will the brake release on the second locomotive or helper?

A. Because the release pipe is open to the atmosphere.

Q. If the brake released after an automatic application, when the handle is placed in *release* or *holding* position, but remains applied after an independent application, where would you look for the trouble?

A. It is caused by a leak from the distributing valve release pipe, between the automatic and the independent brake valves.

Q. If the brake releases after an independent application, but remains applied after an automatic application, what would cause the trouble?

A. A leak in the distributing valve release pipe between the distributing valve and the independent brake valve.

Q. If the brake releases after either an automatic or an independent application, what would cause the trouble?

A. A leak from the application cylinder pipe or past the application cylinder cap gasket.

Q. How could a weak or broken application piston graduating spring be detected?

A. If this spring becomes weak or broken, the application portion of the distributing valve would not be as sensitive to graduation.

Q. How should test for leakage in the application cylinder pipe be made?

A. Make a *service* application of the brake, lap the handle and note if the brake remains applied. If it does not, it indicates that the application cylinder pipe or possibly that the application cylinder cap gasket is leaking.

Q. To determine if the release pipe is leaking, how should test be made?

A. Make a service application of the brake with the automatic brake valve. If the brake remains applied with handle in *lap* position but releases when handle is returned to *holding*, it indicates release pipe leakage.

Q. If the brake cylinder pressure does not remain at that to which it is applied, what is the cause?

A. Leakage from application chamber, application cylinder or their pipe connections.

BRAKE CYLINDER LEAKAGE TEST.

Q. Can brake cylinder leakage be readily determined with ET Equipment?

A. Yes.

Q. How?

A. By noting the number of strokes which the compressor makes in a given period of time. Then apply the brake with the independent brake valve and after the compressor has restored the main reservoir pressure again note the number of strokes. The difference in the number of strokes indicates the amount of leakage in the brake cylinders.

Q. Is there any other method of determining brake cylinder leakage?

A. Yes; apply the brake with the independent brake valve, then close the cut-out cock in the distributing valve supply pipe and observe the brake cylinder gage. The gage will indicate the amount of leakage from the brake cylinders.

Q. Can it be determined which of the brake cylinders is leaking?

A. Yes.

Q. How?

A. Apply the brake with the independent brake valve and close the cut-out cock in the distributing valve supply pipe, then close the cut-out cocks in the pipes leading to the truck brake cylinder, driver brake cylinder and tender cylinder in order, noting the gage after each cock is closed.

SAFETY VALVE TEST.

Q. What attention should be given the E-6 Safety Valve?

A. It should be noted that the safety valve is screwed properly in place, that the cap nut is screwed down on the regulating nut, making an air tight joint with the body, and that all vent holes and ports are open.

Q. If the cap nut is not screwed down properly, what would be the effect?

A. The valve and its stem would have too much lift and the leakage of air around the threads of the regulating nut to the atmosphere would interfere with its proper operation.

Q. How should the safety valve be tested to determine if it is properly adjusted?

A. Make an emergency application of the brake, allowing the handle to remain in *emergency* position, and note if the proper brake cylinder pressure is obtained.

Q. What brake pipe pressure should be used when testing the safety valve?

A. 110 pounds.

Q. Within what limits should the safety valve limit the locomotive brake cylinder pressure?

A. Between 68 and 70 pounds.

Q. If the safety valve is adjusted at 68 pounds, and the pressure increases above 70 pounds, what would be the cause?

A. The holes leading from the spring chamber of the valve are restricted, or the piston valve has worn loose.

Q. If the safety valve permits the pressure to reduce considerably below 68 pounds before closing, what would be the trouble?

A. The holes leading from the spring chamber of the valve have been enlarged or gum or dirt has made the piston valve too close a fit.

Q. Within what limits should the safety valve limit the locomotive brake cylinder pressure for ordinary service applications (110 lbs. brake pressure)?

A. Between 65 and 70 pounds.

AIR SIGNAL SUPPLY SYSTEM TEST.

Q. In testing the air signal, what should first be done?

A. The signal pipe should be charged and all stop cocks, joints and unions carefully examined for leakage.

Q. How can it be determined whether the proper pressure is being carried in the signal line?

A. By attaching a test gage to the signal line hose.

Q. What would a too high signal pipe pressure indicate?

A. That the reducing valve was improperly adjusted or was leaking.

Q. What effect might this have?

A. In combination with a leaky signal line it might cause the signal whistle to blow when an independent application of the brake is made.

Q. How can reducing valve leakage be determined?

A. By making a signal pipe reduction and noting if the pressure gradually increases after the standard maximum signal pipe pressure has been attained.

Q. With a reasonably tight signal pipe, if the whistle blows when an independent application of the brake is made, what would be the cause?

A. A leaky check valve in the combined strainer and check valve.

Q. If, in charging up the signal pipe the test gage indicates a too slow increase of pressure, where should the trouble be looked for?

A. Probably an obstruction in the strainer or choke fitting or a loose fitting feed valve piston.

Q. If, with the signal system of the locomotive fully charged, the signal whistle blows, what is the probable cause?

A. Leakage in the signal system and a sluggishly operating reducing valve.

Q. What is the high speed brake?

A. A more powerful brake, designed to meet the heavy brake work required on high speed passenger trains.

Q. Does the adoption of the high speed brake require any great change in the brake apparatus usually found on a locomotive or car?

A. No; simply increasing the pressure in the train pipe and auxiliary reservoirs and the use of a high speed reducing valve connected to the brake cylinders, performs the conversion.

Q. What is the standard high speed brake pressure carried in the train pipe auxiliary reservoirs?

A. One hundred and ten pounds.

Q. How much shorter distance will the high speed brake stop a train than the old standard 70-pound brake?

A. About 30 per cent., in emergency stops.

Q. Is it understood that this brake is primarily an emergency brake?

A. Yes; but it also greatly improves the service brake work.

Q. What advantage is this brake in making service stops?

A. It enables two or three full service applications to be made without recharging the train pipe and auxiliary reservoirs, and still have sufficient pressure in the auxiliary reservoirs for an emergency application if it is desired.

Q. What per cent. of brake power is used on passenger equipment cars?

A. Ninety per cent., figured from a cylinder pressure of 60 pounds.

Q. But does not the use of 110 pounds auxiliary reservoir pressure give more than 60 pounds cylinder pressure?

A. Yes; if applied in emergency, but not during ordinary service applications.

Q. What pressure will an emergency application develop in the brake cylinders?

A. About 88 pounds, if the piston travel is adjusted properly.

Q. Why will the cylinder pressure not exceed 60 pounds during a service application, if a heavy train pipe reduction is made?

A. The high speed reducing valves attached to each brake cylinder are so designed that they will vent brake cylinder pressure to the atmosphere if it exceeds 60 pounds.

Q. If the brakes are applied in emergency, which results in giving about 88 pounds cylinder pressure, will this high pressure remain in the brake cylinder until the train is stopped?

A. No; the principle of the brake is to give a high cylinder pressure when the speed is high, and to gradually reduce the pressure as the speed reduces.

Q. Then the braking power is greatest at the beginning of the application, or when the speed of the train is high, and lowest when the speed is lowest?

A. Yes; the braking force is variable, being greatest when the train speed is highest, and, reducing gradually, is least when the train speed is lowest.

Q. It is well known that to slide a wheel at high speed is next to impossible. Was it with this knowledge in view that the high speed brake was designed?

A. Yes; advantage is taken of this fact to apply the brakes with extraordinary force when the speed is high and the wheels are rapidly revolving, and to have the braking force decrease as the train speed decreases, ending with a still powerful, yet safe braking force as the train comes to a standstill. Thus the variable braking force is practically fitted to the variable speed.

Q. Why is a variable cylinder pressure desired when stopping a train?

A. Because the friction between the brake shoes and wheels varies with the speed, it being low at high speed and high at low speed.

Q. Have any tests been made to prove that such is the case?

A. Yes; the Westinghouse-Galton tests, made in England in 1878, were the first along this line, but of later years many tests have been made, all of which proved that the faster the wheel revolved against the brake shoe the less the friction between the two, but as the speed of the wheel decreased, the friction increased.

Q. In stopping a wheel from revolving, what two forces are acting against the wheel in opposite directions?

A. The adhesion, or friction, between the wheel and the rail acts upon the wheel in one direction, tending to keep it revolving, while the friction between the brake shoe and the wheel is acting in the opposite direction, tending to stop it from revolving.

Q. As has been described, the brake shoe friction varies with the speed. Does not the rail friction, or adhesion, also vary with the speed?

A. No; tests which have beeen made to determine this prove that it is constant, regardless of the speed.

THE AUTOMATIC REDUCING VALVE.

Q. What is the purpose of the automatic reducing valve?

A. To so manipulate the brake cylinder pressure that a variable braking power may be had during the period of a train stop.

Q. How is this variable pressure regulated?

A. The automatic reducing valve is so constructed that when the maximum pressure is held in the brake cylinder, the pressure is slowly vented to the atmosphere, gradually reducing that pressure faster and faster, until the minimum pressure is reached, at which time the venting is much more rapid than at the beginning.

Q. What parts compose the automatic high speed reducing valve?

A. A piston, the top of which is always exposed to any pressure in the brake cylinder, regulating spring under the piston, which is adjusted by regulating nut; a slide valve, which separates the brake cylinder pressure from the atmosphere through the automatic reducing valve.

Q. Explain the action of the automatic reducing valve.

A. As the brake cylinder pressure is always on top of the piston, there is a tendency for the piston to descend, equal to the pressure exerted thereon. On the under side of the piston is the regulating spring, adjusted by regulating nut, which has an upward pressure of 60 pounds, the standard adjustment pressure.

Q. Brake cylinder pressure then has a tendency to force the piston downward against the resistance of the regulating spring?

A. Yes; and when the brake cylinder pressure on the top side of piston is greater than the resistance of regulating spring, the piston will descend, carrying with it the slide valve.

Q. In an emergency application of the brake, how does the automatic reducing valve operate?

A. The pressure on the upper face of the piston overcomes the tension of the spring, forces the piston to its lowermost limit and draws the slide valve along with it, making a communication between the brake cylinder and the atmosphere through the apex of a triangular shaped port.

Q. How does the automatic reducing valve operate in service application of the brake?

A. As the auxiliary reservoir air is sent by the triple valve to the brake cylinder and to the upper side of piston, no effect is had on the reducing valve until such time as the brake cylinder pressure reaches a higher point than the adjustment of the regulating spring, then the piston slowly descends until the base of the triangular port b is opposite the exhaust port a, and brake cylinder pressure is quickly vented to the atmosphere.

Q. What is the advantage of such an operation after service application of the brake?

A. It prevents an over-accumulation of brake cylinder pressure, which might result in the sliding of wheels.

Q. Is the use of the high speed brake confined exclusively to through fast express trains?

A. No; it has now come into general use on local as well as through trains, and is being made the standard for all passenger equipment trains on the leading railway lines.

Q. What is the purpose of having two feed valves on this system?

A. They are to permit of changing the pressures readily from high speed to the standard pressure without the necessity of readjusting the pump governor and feed valve.

Q. How is this accomplished?

A. Turning the handle of the reversing cock to the left cuts in the 70-pound feed valve; turning the handle to the right cuts in the 110-pound feed valve. The small ¼-inch cock in the governor pipe must also be opened or closed to change the pump governor control.

Q. What pressures are the pump governor heads adjusted for?

A. The low pressure head should be set at 90 pounds, and the high pressure head at 130 pounds, slight modifications are sometimes made in connection with this pressure to suit the local conditions.

Q. Is there more than one way of coupling up the pump governor heads?

A. Yes; the low pressure head is sometimes coupled to the reversing cock, such as it is with "Schedule U."

Q. In handling the high speed brake, should it be operated in a similar manner as the old standard 70-pound brake?

A. Yes; the rules covering the handling of the 70-pound pressure brake on passenger trains apply to the high speed brake, they being heavy initial reductions and the two application stop.

Q. What style of triple valve is used on tenders with the high speed brake?

A. Quick action triple valve.

Q. When the engine is equipped with a truck brake, is a separate reducing valve used with the truck brake cylinder?

A. No; the apparatus is so arranged that one reducing valve takes care of the driver and truck brake cylinders.

Q. In making an application of the brakes when the high speed pressure is used, will a 20-pound reduction give any more braking power than if the same reduction were made with the 70-pound pressure?

A. No; it appears, however, to give a little more, but this is due to the air entering the cylinder a little quicker.

Q. If when making a brake test a 20-pound reduction is made, one of the reducers commences to blow, what would this indicate?

A. It is either not adjusted properly, or else the car has very short piston travel, the latter being the usual trouble.

Q. What would be the per cent. of braking power on a car if an emergency application is made and 88 pounds cylinder pressure is had?

A. If the car is braked on a basis of 90 per cent., with 60 pounds cylinder, 88 pounds of cylinder pressure would give about 130 per cent. of braking power to the weight of the car braked.

Q. In handling a light engine, should the high speed brake pressure be used?

A. No; the reversing cock handle should be turned to the left and the 70-pound pressure used.

Q. Why are the recent reducing valves supplied with a long, straight cap nut on the lower end instead of the usual round cap form?

A. It was found that in cold weather water would drip to the lower extremity of the cap, hang there in drops and finally freeze, thus stopping up the small port in the cap nut. The straight sided cap nut prevents freezing of the hole in the cap.

Q. Why is this hole placed in the cap nut?

A. To permit any leakage of brake cylinder pressure past the piston into the spring case to escape.

Q. What harm would the accumulation of such leakage amount to if permitted to accumulate in the spring case?

A. It would add its pressure to that of the regulating spring, thereby tending to force the piston upward, thereby closing ports b and a, too early, and holding too high a pressure in the brake cylinder.

Q. Is it important then that the hole in the cap should be kept open?

A. Yes; sometimes this becomes stopped up, either carelessly or purposely, and the valve is given the erratic action already described.

Q. In high speed brake service is it necessary that greater care should be given the triple valve and other parts?

A. Yes; the greater pressure on the back of the slide valve of the triple valve in high speed brake service tends to squeeze out the lubrication from between the face and seat of the slide valve, thus rendering those parts dry, and creating greater friction, which prevents as smooth an operation of the slide valve on its seat as would the 70-pound brake. Sometimes more frequent lubricating is necessary on this account.

Q. What other difficulties are encountered in the triple valve in high speed brake service?

A. That resulting from moisture in the air reaching the triple valve, which assists in washing off the lubricant, and creating a film of ice in cold weather between the slide valve and its seat, thus creating undue friction of the parts which create a tendency for the triple valve to give undesired quick action.

Q. Are there any other points to be watched on high speed brake service with respect to undesired quick action?

A. Yes; the equalizing piston of the brake valve should be kept in good condition to operate smoothly, else undesired quick action may be caused.

Q. What attention should be given the high speed reducing valves?

A. On engines and tenders they should be cleaned and oiled every six months, on cars once a year.

Q. What kind of oil should be used in lubricating the reducing valves?

A. The same as is used in the triple valves; a high grade mineral oil.

Q. In cleaning the reducing valve is it necessary to relieve the tension on the adjusting spring?

A. No; the lower case can be removed and replaced without changing the adjustment mechanism.

WESTINGHOUSE HIGH PRESSURE CONTROL SYSTEM, "SCHEDULE U."

Q. What is the "Schedule U" or "High Pressure Control System?"

A. It consists of a duplex device designed to meet the needs of special air brake service, where the pressures ordinarily employed may be quickly changed to higher pressures to meet more difficult conditions, such as controlling trains made up of heavily loaded cars.

Q. For what class of service is this device particularly designed?

A. For coal, iron and other mineral carrying roads in mountainous districts, where loads are carried down hill and empties hauled up. The usual pressure may be employed on the light train up the grade where little braking power is demanded or needed, and by merely reversing a cock the apparatus may be changed to give a predetermined higher pressure with which to operate the loaded train down the grade.

Q. Briefly describe the "Schedule U," or "High pressure control system?"

A. It is simply a modification of the usual equipment used on an engine with the addition of a duplex pump governor, two feed valves, reversing cock and bracket, and safety valves connected to a driver and tender brake cylinders.

Q. Describe the operation of the apparatus.

A. The two pump governor heads are adjusted for 90 and 110 pounds respectively. Likewise, the two feed valve attachments are set for 70 and 90 pounds. To operate the low or ordinary pressure feature, the handle of the reversing cock is turned to the left. This cuts out the 110-pound governor and 90-pound feed valve, and renders operative the 90-pound governor and the 70-pound feed valve. Thus the high pressure control parts are cut out and the low pressure cut in. By reversing the position of the reversing cock handle, the low pressure parts are cut out and the high pressure parts cut in.

Q. How are the two feed valves arranged so that they can both be connected to the brake valve?

A. They are attached to the reversing cock, which in turn is connected to the brake valve by pipes and special pipe bracket. However, only one valve has any connection with the brake valve at one time, this depending upon the position of the reversing cock handle.

Q. Does turning the reversing cock handle change the pump governor control as well as the feed valve?

A. Yes; this is arranged by having the low pressure head of the governor attached to the low pressure side of the reversing cock.

Q. When making the application of the brakes when the 90 pounds train pipe pressure is used, how much of a reduction should be made to fully equalize the power with standard 8-inch piston travel?

A. About 27 pounds.

Q. Does a 5, 10 or 15-pound service application with the 90-pound train pipe pressure develop any greater braking power than it would if only 70-pound train pipe pressure is used?

A. No; the brake power will be about the same and no gain had unless the train pipe reductions are continued beyond what would be necessary to fully equalize the 70-pound train pipe pressure.

Q. Would not the high pressure permitted by the 110-pound governor and 90-pound feed valve tend to loosen driving wheel tires by excessive heating and slide wheels under a tender partly relieved of its coal and water?

A. No; as safety valves are supplied for the driver and tender brakes to limit the pressures there to 50 pounds. On very long and heavy grades, it is generally desirable to cut out the driver brakes and use the water brake on the engine to assist the tender and train brakes.

Q. If the reversing cock should leak, what would happen?

A. A leakage or mingling of pressures would follow and interfere with the proper operation of the device. This part should be looked after with the same care given the other parts in ordinary service.

Q. Does the use of "Schedule U," or high pressure control apparatus require any change to be made in the car brake equipment?

A. No; the standard car brake apparatus is used and operated in the usual manner.

Q. If all cars in the train were loaded except two or three, would it be safe to use the high pressure?

A. No; as the wheels on the light cars may slide. It, however, might be advantageous to cut out the brakes on these few cars and use the high pressure on the others.

WESTINGHOUSE DUPLEX MAIN RESERVOIR CONTROL.

Q. In what respect does this main reservoir control arrangement differ from what is usually found on a locomotive?

A. In the use of a duplex pump governor, in which one head is adjusted for a low pressure, and one for a high pressure as shown, and connected to different parts of the brake valve.

Q. What is the object of this arrangement?

A. To permit of accumulating a high main reservoir pressure with which to release the brakes and recharge the auxiliary reservoirs, and only requiring the pump to operate against this high pressure for the short time the brakes are held applied.

Q. What pressures are the governor heads usually adjusted for?

A. The low pressure head for 85 pounds, the high pressure head for 110 pounds.

Q. By what means is the pump control transferred from one head to the other?

A. By the movement of the brake valve handle.

Q. In what positions of the brake valve does the low pressure head control the pump?

A. In running position, or full release.

Q. Explain how the pump governor heads are coupled up in this arrangement.

A. The high pressure head is coupled to the usual main reservoir connection of the brake valve, while the low pressure head is connected to port A in the brake valve, which leads to the running position port.

Q. Explain how the control of the pump can be transferred from one head to the other.

A. As the low pressure head is coupled to the running position port f of the brake valve, it is, therefore, subject to main reservoir pressure when the brake valve is in running or release position, which allows the air pressure to pass to the low pressure head, causing the pump to stop when the main reservoir pressure is equal to the adjustment of this head. However, in placing the brake valve in lap, service or emergency positions, the main reservoir pressure, being cut off from the feed valve, is also cut off from the low pressure governor head, which permits the pump to run until the pressure in the main reservoir is equal to the adjustment of the high pressure head, which will then stop the pump.

Q. In the description of the brake valve it was stated that the running position port f was closed in release position, therefore, how can the air pressure reach the low pressure governor head to cause it to stop the pump?

A. While it is true the running position port f is closed in release position, air pressure reaches the low pressure governor head by passing back from the train pipe through the feed valve attachment.

Q. Will the pipe connection and port A be found in all brake valves?

A. No; however, all brake valves supplied recently have this connection, but it can be readily placed in any of the standard form of valves.

Q. With this duplex governor arrangement is it necessary to have one of the governor vent ports plugged?

A. Yes; one of these ports must be closed in all cases where the duplex pump governor is used.

THE WESTINGHOUSE COMBINED AUTOMATIC AND STRAIGHT AIR BRAKE.

Q. What is the combined automatic and straight air brake?

A. A device by which either the automatic brake, or the straight air brake may be operated on the engine and tender, at the discretion of the engineer, without the operation of one brake being interfered with by the other.

Q. Is it necessary to prepare one brake, by cut-out cocks, movement of brake valve handles, or otherwise, to operate either brake?

A. No; the arrangement of the parts is such that the engineer may go from one brake to the other brake without any preparatory movement.

Q. Each brake then is independent of the other?

A. Yes; although they are combined and attached to the same common system, still they are entirely independent of each other in their action.

Q. What comprises the combined automatic and straight air brake?

A. The addition of a straight air brake valve and a few simple parts, which permit the use of the straight air on the engine and tender, without interfering with the automatic brake apparatus, both brakes being cut in at all times.

Q. The combined automatic and straight air brake then is merely the straight air brake apparatus added to the automatic brake which is already on the engine and tender?

A. Yes; and while they are combined, yet they are strictly separate.

Q. Describe the operation of the combined automatic and straight air brake.

A. Connection with the automatic brake is made by the straight air brake at three points, viz., to the main reservoir, and to the brake cylinder pipes of both driver and tender brakes.

Q. From where is the straight air supply taken?

A. From the main reservoir pipe to the automatic brake valve, where clean, dry air is insured.

Q. Trace the course of the air used to operate the straight air brake.

A. The pressure is taken from the main reservoir pipe supplying the automatic brake valve, is passed through a reducing valve which is set at 45 pounds, then through the engineer's straight air valve to the double seated check valve and to the brake cylinders.

Q. Describe the release of the straight air brake.

A. When the straight air brake valve is placed in release position, a direct opening is made from the cylinders, through the double seated check valve to the straight air brake pipe, thence through the engineer's straight air brake valve to the atmosphere.

Q. Where is the double seated check valve located?

A. One of these valves is inserted on both the engine and tender, in the pipe leading from the triple valve to the brake cylinders, so that in brake operation, either automatic or straight, the pressure will have to pass through the check valve in going to and from the brake cylinders.

Q. Name the principal parts of the combined automatic and straight air brake.

A. Assuming that the automatic parts are already well known, the remaining parts, those of the straight air portion, are the automatic reducing valve, the engineer's brake valve, the double seated check valves, the safety valve and the special hose connection.

Q. What is the purpose of the special hose connection?

A. It is a special single hose which connects the straight air brake pipe between the engine and tender. It is subject to the low pressure only at 45 pounds, and is, therefore, less liable to burst. This low pressure insures greater length of life of the hose.

Q. Describe the construction of the double seated check valve?

A. It consists of a suitable casing holding the piston, which has, at each end, a leather face. These leather faces make an air-tight joint. The piston valve is shorter than the distance between the two seats b and d, and the bush in which it works has two series of ports, c and c1. With the piston valve against seat b, ports c afford a free passage for the air from the straight air brake valve to the brake cylinder. The opening leading to the triple valve, which is now in release position, is closed so no straight air leakage can occur.

Q. With the straight air brake valve in release position, where it should be when not in use, assume that an automatic brake application is made. Describe the passage of the air.

A. The air from the triple valve, on entering the double seated check valve, will force the piston valve to the right, against seat d, thus preventing any escape of pressure at the straight air brake valve and opening ports c1 so the air can flow uninterrupted into the brake cylinder.

Q. Should this double seated check valve be located in any particular position?

A. Yes; in a horizontal position, so this piston valve will not be subject to gravity effect, and only be moved by air pressure. Then the mere act of making either an automatic or straight air application will cause the piston valve to automatically move to the proper position.

REDUCING VALVE AND PIPE BRACKET.

Q. Describe the location and operation of the reducing valve and its pipe bracket.

A. The reducing valve and its pipe bracket are located in the main reservoir pipe, leading to the straight air brake valve. The reducing valve is the well known slide valve feed valve attachment to the brake valve.

Q. What is the purpose of the reducing valve?

A. To reduce the main reservoir pressure used, to a safe amount. It should be set at 45 pounds, so that no more than that pressure can reach the brake cylinders.

Q. In a straight air application should more than 45 pounds of pressure get to the brake cylinder, where should we look for the trouble?

A. In the slide valve reducing valve.

THE SAFETY VALVE.

Q. What is the purpose of the safety valve?

A. In the event of the reducing valve getting out of order, due to dirt or any foreign substance deranging it, and an over pressure getting to the brake cylinder, the safety valve, being screwed into either the brake cylinder or the brake cylinder pipe, will blow off the surplus pressure.

ENGINEER'S STRAIGHT AIR BRAKE VALVE.

Q. Describe the action of the straight air brake valve?

A. This valve is practically a three-way cock in its operation, but is, on account of its special construction, much superior to the three-way cock. There is no friction to it, and opportunity for leakage is reduced to a minimum. The engineer is able to tell by the touch of the valve just how much of an opening is made. It is designed to run for a long time without repairs.

Q. How should the straight air brake valve be connected up?

A. Within convenient reach of the engineer, both in running ahead, and looking back when switching. The letters cast on the body indicate respectively the main reservoir, train pipe and exhaust connections.

Q. How many positions has the straight air brake valve?

A. Three; Release, Lap and Application.

Q. Name the essential parts of this valve?

A. The handle, the shaft, to which the handle is connected, two check valves which are operated by the shaft.

Q. What are the functions of the check valves?

A. One controls the supply of air from the main reservoir; the other controls the exhaust from the cylinder.

WESTINGHOUSE 1¼-INCH PUMP GOVERNOR.

Q. What is the object in applying this enlarged type of governor to the system?

A. On locomotives where two air compressors are in use it has been found that the standard 1-inch governor will not allow sufficient steam to pass to the pump under certain conditions when there is a great demand for air pressure.

Q. Describe the arrangement in use with the 1-inch governor for two compressors.

A. A 1-inch governor complete is connected in the steam supply pipe to one compressor, while a 1-inch governor steam valve portion only is connected in the branch pipe to the second compressor.

Q. Describe the improved system of regulation.

A. A 1¼-inch governor, and 1¼-inch steam valve replace the 1-inch governor and valve.

Q. What advantage is gained by this arrangement?

A. It has ample capacity for two 9½-inch, or two 11-inch compressors.

WESTINGHOUSE CENTRIFUGAL DIRT COLLECTOR.

Q. Where is this device connected?

A. In the branch pipe between brake pipe and triple valve.

Q. What is its function?

A. To collect all dirt and foreign matter in the brake pipe, and prevent its passing into the triple valve.

Q. Describe the operation of this dirt collector.

A. It is so constructed that, due to the combined action of the centrifugal force, and gravity, the dirt, etc., is automatically eliminated from the air passing through the collector, and is deposited at the bottom of the device.

Q. How is the collector cleaned?

A. By removing a small plug at the bottom, and this can be done without breaking any pipe connections whatever.

Q. What other advantage attends the use of this device?

A. It operates to materially reduce the work of cleaning and oiling the brake equipment to which it is attached.

WESTINGHOUSE "PC" PASSENGER BRAKE EQUIPMENT.

With the introduction of heavy (125,000 lbs. to 150,000 lbs.) passenger equipment cars in steam road service, the brake force required to control such heavy cars with approximately the same effectiveness as is obtainable with the apparatus used on lighter cars became so great as to exceed the capacity of a single brake cylinder even with the highest brake cylinder pressure and greatest multiplication of its power by leverage that could be permitted. The increased speed and weights of trains and the economy of time necessary for the highest operative efficiency under modern severe traffic demands, together with the increase in length of trains and the much greater volume of air which must be handled through the brake pipe, have imposed conditions which the type of brake which was adequate for past conditions has been unable to meet satisfactorily.

While a high maximum emergency stopping power is required to insure the safety of passengers and rolling stock, the ordinary service functions and automatic safety and protective features became hardly secondary in importance.

Briefly stated, the requirements recognized as essential in a satisfactory brake for this modern service are as follows:

1. Automatic in action.

2. Efficiency not materially affected by unequal piston travel or brake cylinder leakage.

3. Certainty and uniformity of service action.

4. Graduated release.

5. Quick recharge and consequent ready response of brakes to any brake pipe reduction made at any time.

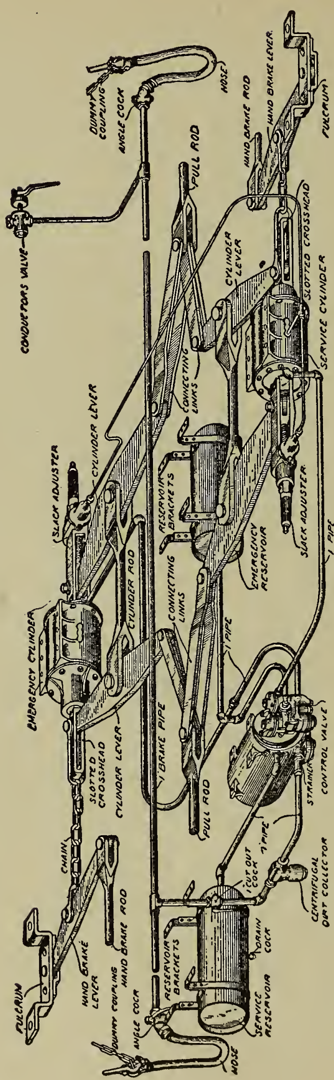


Fig. 111—PC Passenger Brake Equipment. Cylinders Pointing in Opposite Directions.

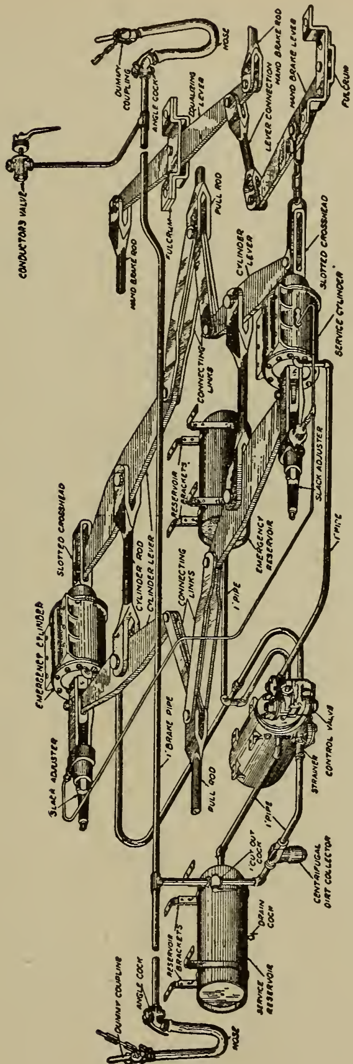


Fig. 112—PC Passenger Brake Equipment. Cylinders Pointing in Same Directions.

6. Maximum possible rate of recharging the brake pipe alone (rate of rise of brake pipe pressure when releasing, limited only by length of brake pipe, not by necessity for recharging *reservoirs* as well as brake pipe, before rear brakes in train can be released).

7. Predetermined and fixed flexibility for service operation.

8. Maximum sensitiveness to release, consistent with stability, combined with minimum sensitiveness to the inevitable fluctuations in brake pipe pressure tending to cause undesired light service applications, brakes creeping on, etc., and yet guard against the attainment of too high a difference of pressure between the brake pipe and pressure chamber (auxiliary reservoir).

9. Full emergency pressure obtainable at any time after a service application.

10 Full emergency pressure applied automatically after any predetermined brake pipe reduction has been made after equalization.

11. Emergency braking power approximately 100% greater than the maximum obtainable in service applications.

12. Maximum brake cylinder pressure obtained in the least possible time.

13. Maximum brake cylinder pressure maintained throughout the stop.

14. Brake rigging designed for maximum efficiency.

15. Adaptability to all classes and conditions of service.

That certain of these requirements demanded radical changes in the valve device used on the car is evident if a comparison of the above is made with the functions of previous types of brakes in general service. These considerations led to the development of the equipment known as the Westinghouse Improved Brake Equipment, Scheduled "PC," employing what is known as a Control Valve in the place of a triple valve.

NOVEL FUNCTIONS.

1st. *Graduated release and quick recharge,* obtained as with previous improved types of triple valves (*e. g.* Type L). The air supply to assist in recharging and to accomplish the graduations of the release is taken from the emergency reservoir.

2nd. *Certainty and uniformity of service action* secured by insuring that the valve parts move so as to close the feed grooves on the slightest brake pipe reductions, the design of the valves being such as to then require the necessary and proper differential to be built up to move the parts to service position as the brake pipe reduction is continued.

3rd. *Quick rise in brake cylinder pressure* provided for by insuring a prompt movement of the parts and direct and unrestricted passage from reservoirs to brake cylinders during applications.

4th. *Uniformity and maintenance of service brake cylinder pressure* during the stop, provided for in the same manner as by the application portion of the distributing valve.

5th. *Predetermined limiting of service braking power* fixed by the equalization of the pressure and application chambers of the control valve. This eliminates the safety valve feature of previous equipments and is both positive and uniform. After such equalization has taken place, any further brake pipe reduction causes the moving parts of the valve to travel slightly beyond the service position to the "over-reduction" position. Air then flows from the pressure chamber to the reduction limiting chamber until equalization takes place between these two chambers, if the brake pipe reduction is continued far enough. During this time the application chamber remains at the first equalization pressure and the brake cylinder pressure is maintained accordingly.

The maximum service brake cylinder pressure (service equalization) is fixed at 86 lbs., instead of at 50 lbs. as with previous equipments. On this account it is possible to use a much lower total leverage ratio (which is necessary if the required efficiency of the foundation brake rigging for the classes of cars considered, is to be maintained). This equalization pressure corresponds to a reduction of 24 lbs. from 110 lbs. brake pipe pressure, which is the reduction required with high speed brake equipment to give maximum service brake cylinder pressure (60 lbs., corresponding to the opening point of the high speed reducing valve). *This insures uniformity of service operation of old and new equipments mixed in the same train.*

6th. *Automatic emergency application on depletion of brake pipe pressure.* If the brake pipe reduction is still further continued below the point at which the pressure and reduction limiting chambers equalize, the parts move to emergency position and cause both the quick action and emergency portions to operate, starting serial quick action throughout the train and obtaining emergency brake cylinder pressure.

7th. *Full emergency braking power at any time.* As the operation of the emergency and quick action portions just described is dependent only upon the movement of the parts to emergency position and, as this can be caused at any time by making an emergency application with the brake valve, conductor's valve, etc., it follows that *full emergency braking power can be obtained at any time, irrespective of a service application previously made.*

8th. The *service and emergency features being separated* permits the necessary flexibility for service applications to be obtained without impairing in the slightest the emergency features of the equipment.

9th. *A low total leverage ratio,* with correspondingly greater overall efficiency, is made possible by the use of two brake cylinders per car, and also higher service equalization pressure.

10th. *Less sensitiveness to the inevitable fluctuations in brake pipe pressure,* which tend to cause undesired light applications of the brake. This insures against brakes creeping on or dragging, burning of brake shoes, delays to the train and so on.

11th. *Maximum rate of rise of brake pipe pressure* possible with given length of *brake pipe* with consequently greater certainty of brakes releasing when a release is made. With non-graduated release equipments or previous graduated release equipments operating with graduated release feature *cut-out,* the recharging of the brake pipe toward the rear end of a train of any length may become very slow due to the draining away of the air from the forward end of the brake pipe by the large reservoirs with large sized feed grooves which take their entire supply from the brake pipe only. The quick recharge feature of the "PC" equipment overcomes this difficulty, with graduated release cut in, by restoring the pressure to the pressure chamber on each car at as rapid a rate as the brake pipe pressure *alone* can be raised by the flow of air through the brake valve. Consequently up to the point of equalization of the pressure chamber and the emergency reservoir under each car (about 5 lbs. less than normal brake pipe pressure), no air is being drawn from the brake pipe. This insures a *prompt* and *certain release* of the brakes, and a rapid recharge and prompt response to successive reductions which may be made, because (1) practically no air is drawn from the brake pipe; (2) pressure chamber and brake pipe recharge at the same rate; and (3) with graduated release cut out, no air is supplied to pressure chamber except from brake pipe.

12th. *Greatly increased sensitiveness to release,* as demanded by the changed conditions already referred to, which tend to produce a very slow rate of rise of brake pipe pressure when releasing and recharging, especially toward the end of a long train of heavy cars having large reservoirs. It then becomes necessary to provide the maximum sensitiveness to an increase in brake pipe pressure, in order to insure all valves in the train responding as intended.

13th. *The elimination of the graduated release feature* is especially provided for in the construction of the valve. During the transition period when graduated release equipment is likely to be handled in the same train with cars not equipped with a graduated release brake, especially where long trains are handled and the air supplied from the brake pipe likely to be limited in any way from any cause, it is usually best to cut out the graduated release feature until all cars are furnished with this type of brake. All that is required to change the "PC" equipment from the graduated to a direct release brake or vice versa, is the loosening of a bolt and turning of the

"Direct and Graduated Release Cap" on the front of the control valve head until the desired position is indicated, the bolt being then retightened. (See Figs. 114 and 116.)

It should be further stated, that all the functions mentioned have been so combined that the requirements of interchangeability with existing equipments have been fully satisfied.

PARTS OF THE "PC" EQUIPMENT.

The following is a list of the parts which make up the equipment with a short description of each:

1. The *control valve* which corresponds in a general way to the triple valve of the old style passenger equipment or more closely to the distributing valve of the "ET" locomotive brake. It operates to control the admission of air to and release of air from the brake cylinders.

2. *Two brake cylinders* (one for service and both for emergency applications) with pistons and rods so connected through the brake levers and rods to the brake shoes that when either piston is forced outward by air pressure, this force is transmitted through said rods and levers to the brake shoes and applies them to the wheels.

3. *Two supply or storage reservoirs* denoted as the *service* and *emergency* reservoirs respectively, according to the brake cylinders to which they are related.

4. A *centrifugal dirt collector,* connected in the branch pipe between the brake pipe and control valve as near the control valve as circumstances will permit, for the purpose of preventing pipe scale, sand, cinders or foreign particles of any kind from reaching the control valve.

5. A *branch pipe air strainer,* inserted in the branch pipe close to the control valve for further protection to this valve.

6. A *conductor's valve* placed inside each car by means of which the brakes may be applied by the conductor in case of accident or emergency.

7. Various *cut-out cocks, angle cocks, hose couplings, dummy couplings,* etc., the location and uses of which will be readily understood from the isometric views of the equipment, Figs. 111 and 112, and the descriptions which follow.

8. While not a fundamental part of the equipment each brake cylinder is usually provided with an *Automatic Slack Adjuster.* This is a simple mechanism by means of which a predetermined piston travel, and consequently a uniform cylinder pressure is constantly maintained, compelling the brakes on each car to do their full share of work, thus securing the highest efficiency and reducing the danger of flat wheels which are likely to accompany a wide range of piston travel. This device establishes the running piston travel; that is, the piston travel occurring when the brakes are applied while the car is in motion; and since this is the time during which the brakes perform their work, the running travel is most important.

LOCATION, ADJUSTMENT AND OPERATION OF PARTS.

The *No. 3-E control valve* consists of four portions:

(1) Equalizing Portion.
(2) Application Portion.
(3) Emergency Portion.
(4) Quick Action Portion.

These valve portions are supported upon the *compartment reservoir* which is bolted to the underframing of the car, all pipe connections being made permanently to this reservoir so that no pipe connections need to be

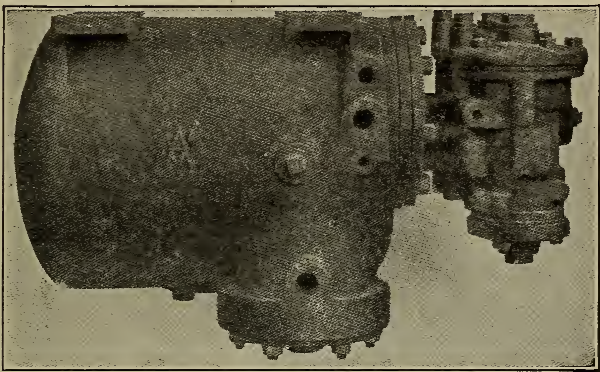


Fig. 113—No. 3-E Control Valve, Side View.

disturbed in the removal or replacement of any one of the operating portions of the control valve.

The *compartment reservoir* is made up of the following chambers:

Pressure Chamber.
Application Chamber.
Reduction Limiting Chamber.

The *equalizing portion* is similar, in a general way, to the equalizing portion of the distributing valve used with the "ET" equipment, or the plain triple valve of the old style brake. It is the portion which is directly affected by variations in brake pipe pressure and it controls (either directly or indirectly, through the medium of the other portions of the control valve), the desired charging of the reservoirs, the application of the brake, whether in service or emergency, and the release of the brake.

The *application portion* corresponds to the application portion of the distributing valve used with the "ET" equipment. It controls the flow of air only from service reservoir to service brake cylinder and the release of same, and has nothing to do with the emergency reservoir or the emergency brake cylinder.

The *emergency portion* contains a double piston and slide valve which controls the flow of air from the emer-

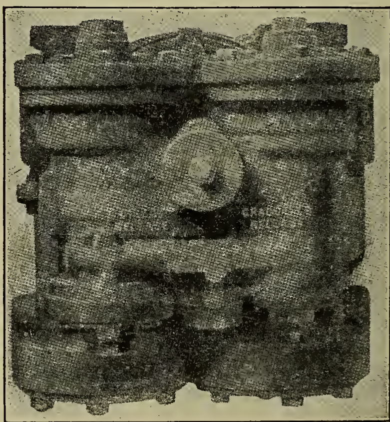


Fig. 114—No. 3-E Control Valve, Front View.

gency reservoir to the emergency cylinder, and the release of same to the atmosphere.

The *quick action portion* corresponds in general design and function to the quick action portion of a triple valve. It operates only when an emergency application of the brakes is made, vents brake pipe air to the atmosphere locally on each car and closes the vent to the atmosphere automatically after the desired brake pipe reduction has been made.

A full description of the functions and detailed operation of the control valve will be given later.

Fig. 113 is a view of the No. 3-E control valve assembled, complete, taken from the side on which the *quick action portion* is located.

Fig. 114 is a photograph of the equalizing portion

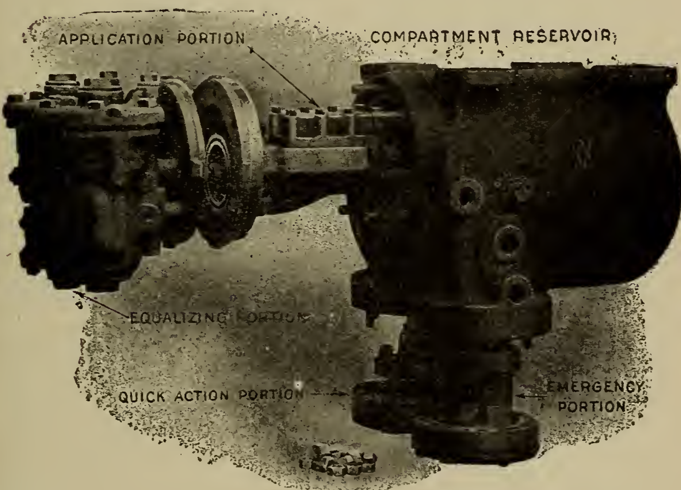


Fig. 115—No. 3-E Control Valve, Showing the Different Portions of the Valve.

mounted on the triple compartment reservoir, taken from directly in front. The direct and graduated release cap, with its pointer and positions for cutting graduated release in or out, is clearly shown.

Fig. 115 is a photograph from the opposite side with the portions separated from each other to show their relative location and method of assembling.

Referring to Fig. 117, which shows actual sections through the portions of the control valve and the triple compartment reservoir, the following are the names of the detail parts (*the numbers given are reference numbers only, to assist in identifying the names of the parts. These numbers should not be used in ordering new or repair parts. The proper parts can be furnished only when the order specifies the correct piece number, which is given in the regular part catalog price lists covering this device*):

EQUALIZING PORTION: 2, Equalizing Body; 3, Release Piston; 4, Release Slide Valve; 5, Release Slide Valve Spring; 6, Release Graduating Valve; 7, Release Graduatting Valve Spring; 8, Release Piston Cap Nut; 9, Release Piston Ring; 10, Release Cylinder Cap; 11, Release Cylinder Cap Gasket; 12, Square Head Cap Screw; 13, Release Piston Graduating Sleeve; 14, Release Piston Graduating Spring; 15, Release Piston Graduating Nut; 16, Check Valve; 17, Check Valve Cap Nut; 18, Direct and Graduated Release Cap; 19, Stud and Nut for Direct and Graduated Release Cap; 20, Equalizing Piston; 21, Equalizing Piston Ring (Large); 22, Equalizing Slide Valve; 23, Equalizing Slide Valve Spring; 24, Equalizing Graduating Valve; 25, Equalizing Graduating Valve Spring; 26, Large Equalizing Cylinder Cap; 27, Large Equalizing Cylinder Cap Gasket; 28, Square Head Cap Screw; 29, Equalizing Piston Stop Sleeve; 30, Equalizing Piston Stop Spring; 31, Equalizing Graduating Nut; 32, Equalizing Piston Ring (Small); 33, Small Equalizing Cylinder Cap; 34, Gasket for Small Equalizing Cylinder Cap; 35, Square Head Cap Screw; 36, Cap Nut for Small

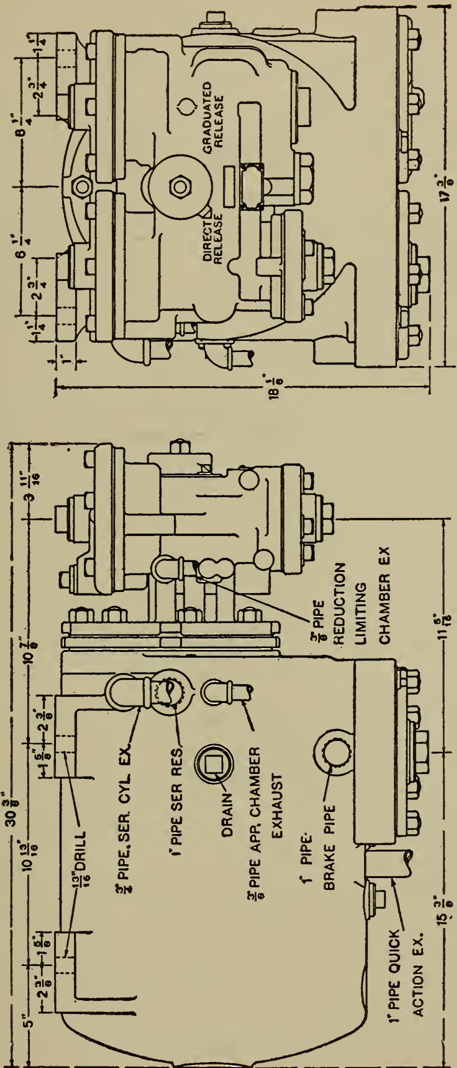


Fig. 116—No. 3-E Control Valve, Outline.

Equalizing Cylinder Cap; 37, Small Equalizing Piston Bush; 38, Service Reservoir Charging Valve; 39, Charging Valve Piston Ring; 40, Charging Valve Piston Ring; 41, Charging Valve Seat; 42, Charging Valve Washer; 43, Internal Charging Valve Nut; 44, External Charging

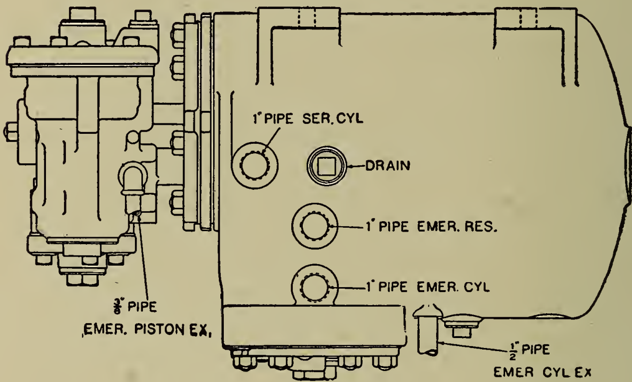


Fig. 116*a*—No. 3-E Control Valve, Outline.

Valve Nut; 45, Gasket for Direct and Graduated Release Cap.

Application Portion: 75, Body; 76, Piston Stem; 77, Piston Ring (Small); 78, Piston Head; 79, Piston Seal; 80, Piston Ring (Large); 81, Piston Follower; 82, Piston Packing Leather; 83, Piston Packing Leather Expander; 84, Piston Nut; 85, Piston Cotter; 86, Exhaust Valve; 87, Exhaust Valve Spring; 88, Application Valve; 89, Application Valve Spring; 90, Application Piston Bolt; 91, Spring Box; 92, Piston Spring Sleeve; 93, Piston Spring; 94, Graduating Nut; 95, Application

Valve Cover; 96, Application Valve Cover Gasket; 97, Square Head Screw for Application Valve Cover.

EMERGENCY PORTION: 107, Body; 108, Piston complete; 109, Piston Ring; 110, Slide Valve; 111, Slide Valve Spring; 112, Small Cylinder Cap; 113, Large Cylinder Cap; 114, Small Cylinder Cap Gasket; 115, Large Cylinder Cap Gasket; 116, Piston Spring; 117, Square Head Cap Screw for Small Cylinder Cap; 118, Oval Fillister Head Cap Screw; 119, Emergency Piston Bush.

QUICK ACTION PORTION: 130, Body; 131, Piston complete; 132, Piston Ring; 133, Quick Action Valve; 134, Quick Action Valve Seat; 135, Quick Action Valve Nut; 136, Quick Action Valve Spring; 137, Quick Action Valve Cap Nut; 138, Quick Action Valve Cover; 139, Quick Action Closing Valve; 140, Quick Action Closing Valve Spring; 141, Cover Cap Nut; 142, Cover Gasket; 143, Square Head Cap Screw for Cover.

RESERVOIR: 153, Triple-compartment Reservoir; 154, Cap Nut; 155, Stud with Hex. Nut; 156, Stud with Hex. Nut; 157, Emergency Cylinder Gasket; 158, Quick Action Cylinder Gasket; 159, Large Reservoir Gasket; 160, Equalizing Cylinder Gasket.

Figs. 118, 119 and 120 show views of the seats and faces of the equalizing and release slide and graduating valves and of the emergency slide valve. The chambers, etc., to which the ports in the seats connect are as follows:—

EQUALIZING SLIDE VALVE SEAT: 1, Emergency Reservoir Check Valve (under side); 2, Brake Pipe; 3, Direct and Graduated Release Cap (open only when cap is adjusted for graduated release); 4, Reduction Limiting Chamber Exhaust; 5, Small End (chamber G) of Service Reservoir Charging Valve; 6, Reduction Limit-

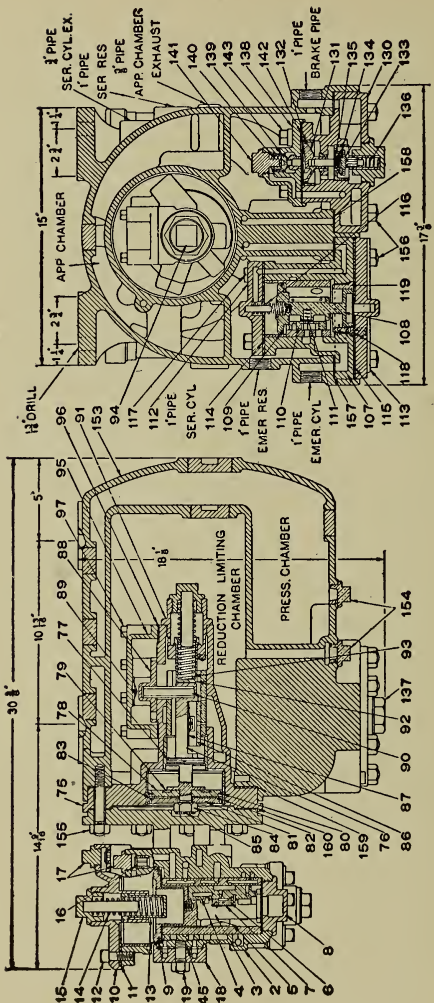


Fig. 117—No. 3-E Control Valve, Actual Sections.

ing Chamber; 7, Large End (chamber K) of Service Reservoir Charging Valve; 8, Release Slide Valve Chamber (chamber E); 9, Application Chamber and Front of Application Piston (chamber C); 10, Emergency Reservoir; 11, Pressure Chamber; 12, Slotted Port; 27, Small Equalizing Piston (chamber F).

RELEASE SLIDE VALVE SEAT: 13, Large Emergency Piston (chamber P); 14, Small Emergency Piston (chamber S); 15, Direct and Graduated Release Cap (open only when cap is adjusted for graduated release); 16,

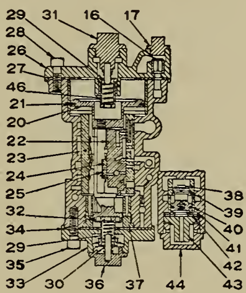


Fig. 117*a*—No. 3-E Control Valve, Equalizing Portion.

Emergency Piston Exhaust; 17, Direct and Graduated Release Cap (open only when cap is adjusted for direct release); 18, Application Chamber Exhaust, also Direct and Graduated Release Cap (the latter open only when cap is adjusted for direct release); 19, Application Chamber; 20, Quick Action Closing Valve; 21, Emergency Reservoir; 22, Small Equalizing Piston (chamber F).

EMERGENCY SLIDE VALVE SEAT: 23, Service Brake Cylinder; 24, Back of Application Piston (chamber M);

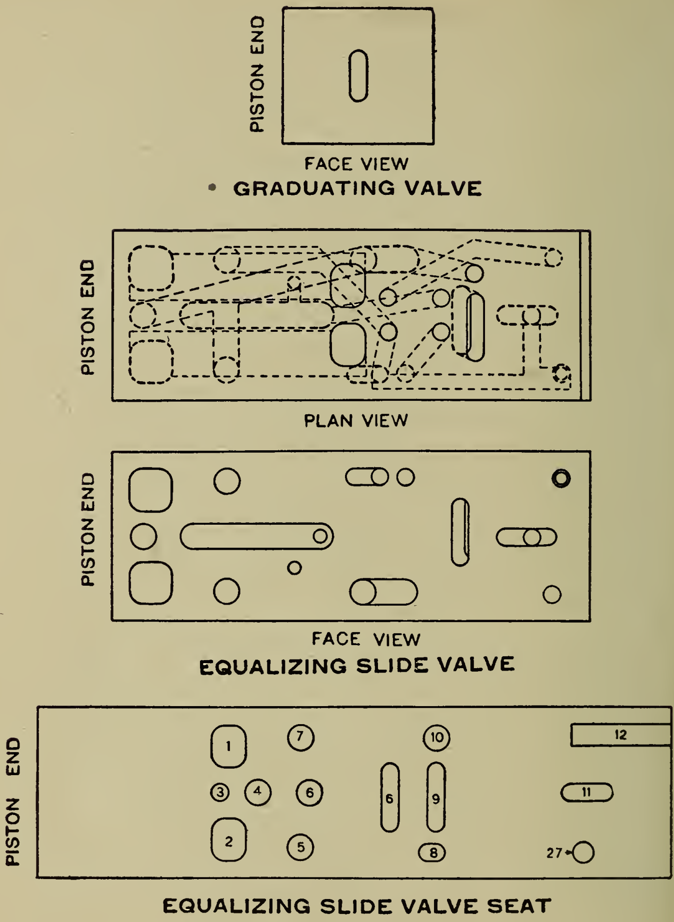


Fig. 118—Equalizing Graduating Valve, Slide Valve and Slide Valve Seat.

25, Emergency Cylinder Exhaust; 26, Emergency Cylinder.

Fig. 121 shows the flanges of the different portions of the control valve and the seats on which these flanges

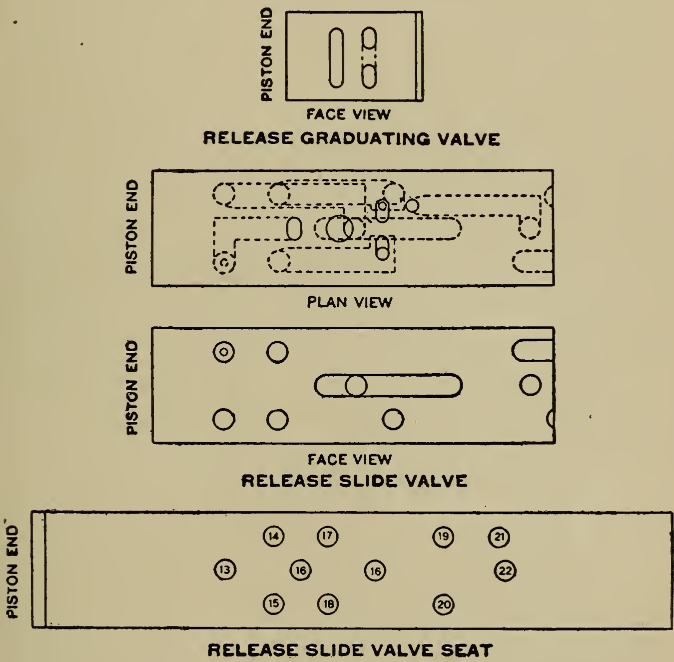


Fig. 119—Release Graduating Valve, Slide Valve and Slide Valve Seat.

fit, with all ports marked so as to assist in readily locating to what portions or chambers the openings are connected.

The diagrammatic drawings, Fig. 122, and those following, have been made up to assist in describing the different operations of the various parts of the control valve. They illustrate diagrammatically only those parts of the valve which come into play as the various operations are performed. For the sake of clearness, the actual construction of the parts has been disregarded. All ports and parts of the valve concerned in the performance of the particular function to be described have been shown as if located in the same plane, with the connections indicated as clearly as possible and without attempting to follow the actual construction of the valve.

Furthermore, it will be noted that all ports and passages which are not operative in the various positions, have been omitted in the corresponding diagrammatic views, so that in considering each successive position of the valve, the functions being performed by the valve will be more easily explained and understood by the reader than if those ports which exist, but which are not operative in the position shown, were allowed to remain.

NORMAL POSITION.

Before taking up the various positions assumed by the valve, reference should be made to Fig. 122, showing diagrammatically all of the ports and operative parts of the control valve in Normal Position. This is the position which the various parts of the valve would occupy with all parts properly assembled, but before any air has been admitted to the brake pipe, and is shown here in order to indicate the relation of all the ports and detail parts of the valve which will not be shown complete in any of the succeeding views.

All of the chambers, connections and detail parts of the valve are clearly indicated so that further explanation will be unnecessary. It will be noted that the various chambers, etc., have been designated either by name or by letter, but that the ports have not been designated. In describing the operation of the valve in detail, the portions from and to which the air moves in the various positions have been carefully explained but with only such

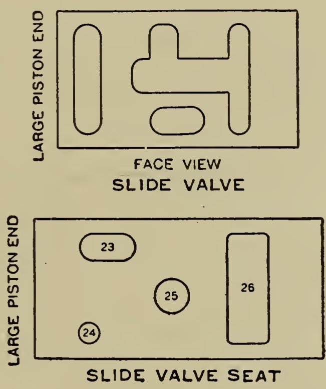


Fig. 120—Emergency Slide Valve, and Slide Valve Seat.

references to the path pursued as will enable its course to be easily followed by reference to the illustrations. It should, therefore, be constantly borne in mind that the descriptive matter is incomplete without constant reference to the diagrammatic illustrations, and that only by a study of both the text and the diagrams can a clear understanding of the manner in which the functions of the control valve are performed, be obtained.

It will be noted that in Fig. 122, the direct and graduated release cap is shown in its *Graduated Release* position. Just below it is shown the position which the cap occupies when adjusted for direct instead of graduated release. In all the succeeding views, except Fig. 134, the cap is considered to be adjusted for graduated release. Fig. 134 with the accompanying explanation, refers to the operation of the valve with the cap adjusted for direct release.

RELEASE AND CHARGING POSITION.

Fig. 123 shows diagrammatically only those parts and ports which are operative while the brake is being released and the *pressure chamber,* and *emergency* and *service reservoirs* are being charged.

In charging the empty equipment, air from the *brake pipe* entering the control valve at the point indicated, passes to *chambers B* and *A* and forces the equalizing and release pistons of the equalizing portion, with their attached valves, to *Release* position. Brake pipe air then passes from *chamber B,* lifting the equalizing check valve, and by way of the equalizing slide valve into *chamber D.* Air from *chamber D* then flows through the equalizing graduating and slide valve, (so shown in the diagrammatic drawing for the sake of clearness. In this and a number of instances following, this port in actual valves opens *past the end* of instead of *through* the graduating valve), past the emergency reservoir check valve and thence in two directions, (1) to *chamber R* and to the *emergency reservoir* and (2) through the equalizing slide valve to two different ports connecting (1) to the *service reservoir charging valve,* thence to the *service reservoir* and, (2) by way of the direct and graduated release cap and through the release slide valve and past the end of the release graduating valve to *chamber E.*

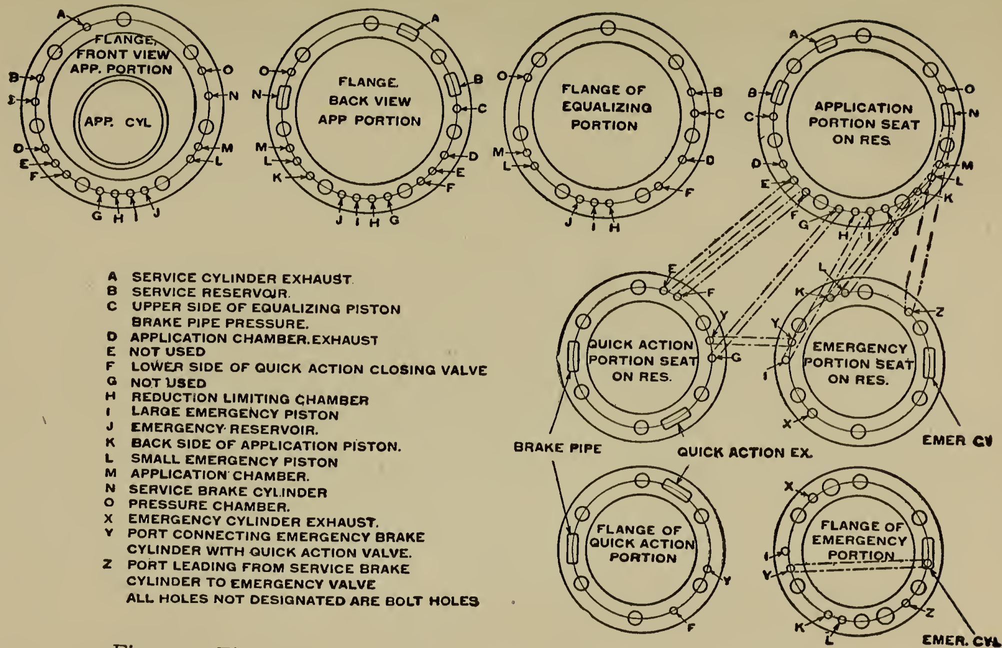


Fig. 121—Flanges of, and Seats for No. 3-E Control Valve Portions.

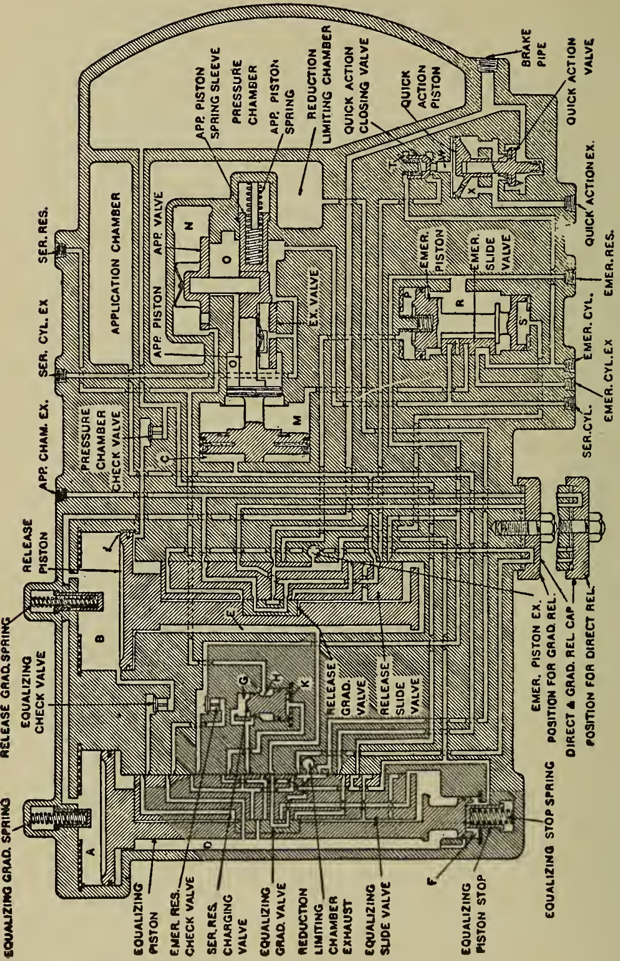


Fig. 122—No. 3-E Control Valve. Normal Position.

Air from the *brake pipe* and *chamber B* also flows through *feed groove i* and charges *chamber E.*

From *chamber E,* the air flows by way of the equalizing slide valve in two directions, (1) to the *pressure chamber* direct (which is thus charged to brake pipe pressure) and (2) to *chamber K.* With substantially the same pressures (brake pipe pressure as explained) in *chambers G* and *K,* and a lower pressure (service reservoir pressure) in *chamber H,* the service reservoir charging valve remains in the position shown in Fig. 123, being held in this position until the recharging is completed, since *chamber K* is relatively small and the ports leading to it of ample capacity to charge it more quickly than the pressure can be built up in *chambers G* and *H.*

Referring to Fig. 122, it will be noted that the pressure chamber check valve prevents the air in *chamber E* from flowing directly to the *pressure chamber.* Consequently this check valve is not shown in Fig. 123. It allows, however, a free passage of air in the opposite direction. That is to say, when charging or recharging, air reaches the *pressure chamber* only by way of the equalizing slide valve but during an application of the brakes (to be explained later) the *pressure chamber* and *chamber E* are to all intents and purposes one and the same and may then be referred to as such.

Chamber F at the small end of equalizing piston is connected through the release slide valve to the emergency piston exhaust and *atmosphere,* thus holding the equalizing piston and its valves positively in *Release* position.

Chamber S at the small end of the emergency piston is connected through the release slide valve to the emergency piston exhaust and the *atmosphere* in *Release*

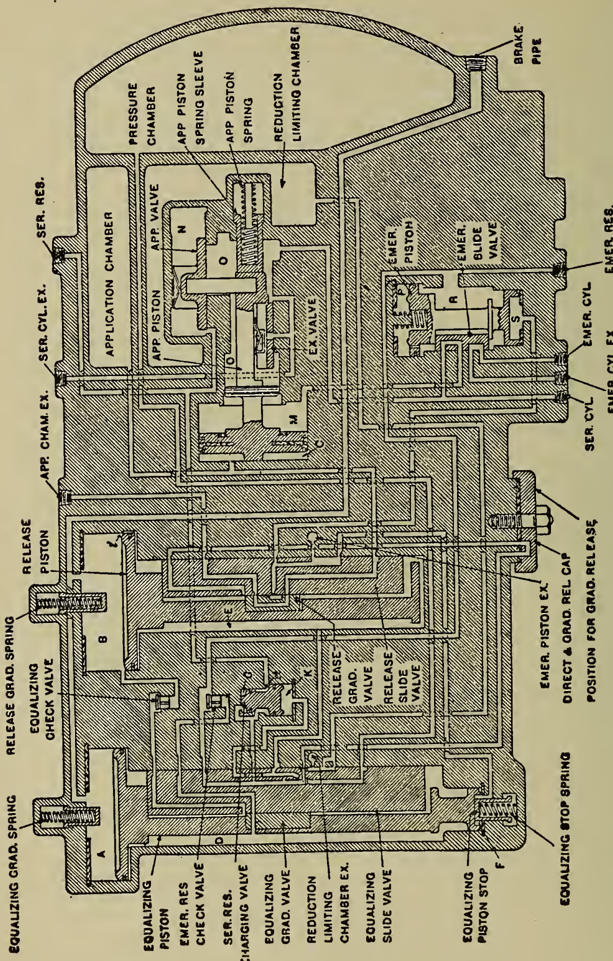


Fig. 123—No. 3-E Control Valve. Release Position, Charging Pressure Chamber, Emergency and Service Reservoirs.

position, thus holding the emergency piston and its valve positively in the proper position.

The *reduction limiting chamber* is connected through the equalizing slide valve to the reduction limiting chamber exhaust and *atmosphere.*

The *application chamber* and *chamber C* are connected through the release slide valve and graduating valve to the application chamber exhaust port leading to the *atmosphere.*

The *service brake cylinder* is connected through the exhaust slide valve of the application portion to the service brake cylinder exhaust port leading to the *atmosphere.*

The *emergency brake cylinder* is connected through the emergency slide valve to the emergency cylinder exhaust port leading to the *atmosphere.*

It will be noted that Fig. 122 and some that follow show a small cavity in the release graduating valve. This cavity is connected to the emergency piston exhaust in all positions of the valve, but has no other connection. The purpose of this cavity is merely to insure that, under all conditions, there will be sufficient differential pressure acting on the graduating valve to hold it to its seat.

SERVICE APPLICATION.

a. Preliminary Service Position.

With the equipment fully charged as explained above, the result of a service reduction in brake pipe pressure will be to lower the pressure in *chambers A* and *B* below that in *chambers D* and *E,* thus creating a differential pressure on the equalizing and release pistons. Since *chamber F* is open to the *atmosphere* (see Fig. 123), the

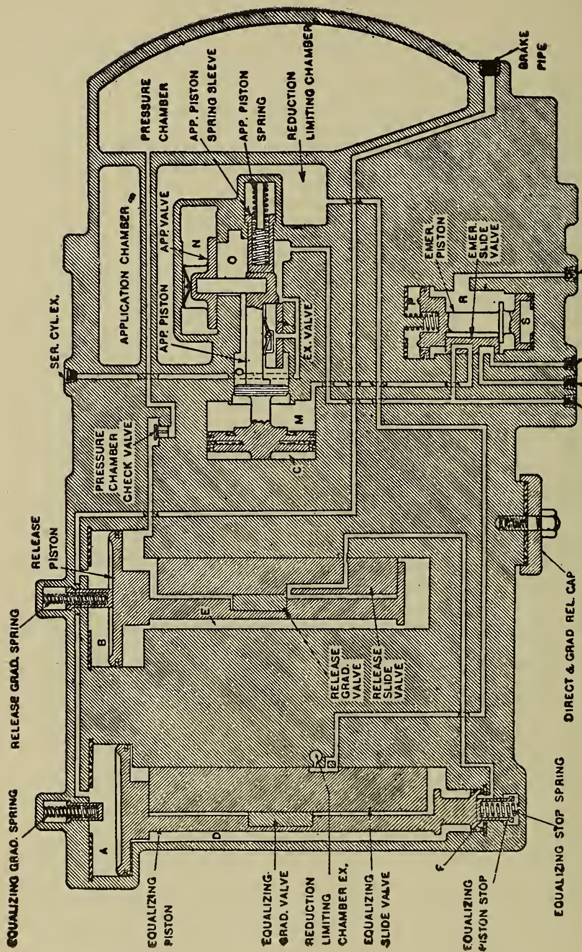


Fig. 124—No. 3-E Control Valve. Preliminary Service Position.

release piston will move on a much less differential than the equalizing piston. There is a small amount of lost motion between the release piston and release graduating valve, and somewhat more between release piston and release slide valve, so that during the first movement of the release piston, the release slide valve still remains in its *Release* position, thus keeping *chamber F* open through the emergency piston exhaust port to the *atmosphere.* The release piston, therefore, is the first to move when a brake pipe reduction is made, and it carries with it the release graduating valve and finally moves the release slide valve to the position shown in Fig. 124, called *Preliminary Service* position. In this position the piston has closed the feed groove *i* (which is therefore not shown in Fig. 124) and just touches the release graduating piston sleeve.

The function of the valve in this position is to close the port leading from the *application chamber* to the *atmosphere* (which is therefore not shown in Fig. 124) to close the port connecting *chamber F* to the *emergency piston exhaust* and to open this latter port, connecting *chamber E* past the end of the release graduating valve and through the release slide valve to *chamber F. Pressure chamber* air is therefore free to flow past the pressure chamber check valve to *chamber F,* thus balancing the pressures in *chambers F* and *D* on the opposite sides of the small end of the equalizing piston.

The other connections shown in Fig. 124, which remain as shown in Fig. 123, continue to perform the same functions as explained with reference to Fig. 123 and consequently do not need to be again referred to.

This position, it should be understood, is assumed only momentarily and should be regarded as the first stage

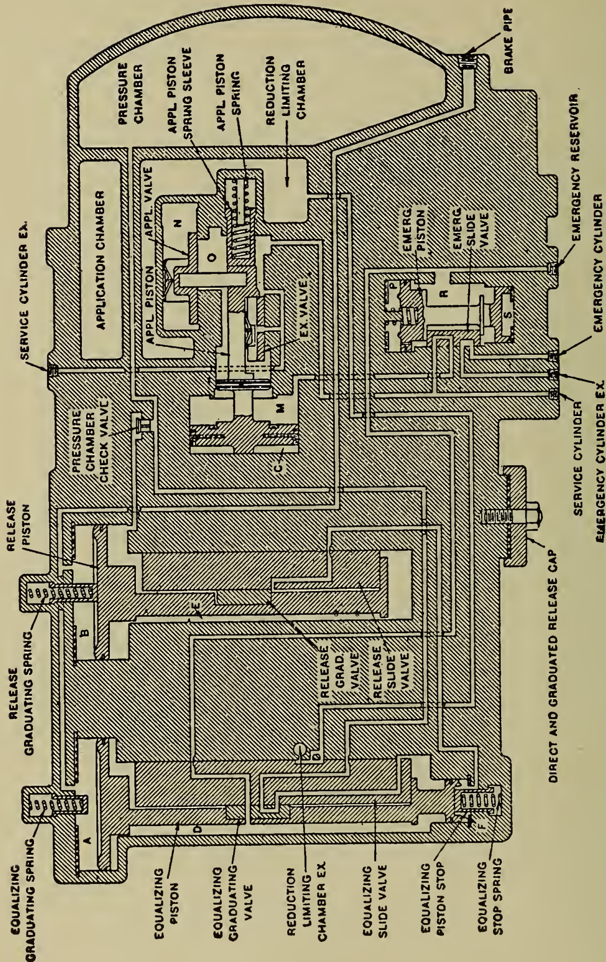


Fig. 125—No. 3-E Control Valve. Secondary Service Position.

only of the complete movement of the parts from *Release and Charging* to the *Service* position of the parts.

b. Secondary Service Position.

The balancing of the pressures in *chambers F* and *D,* as explained, permits the equalizing piston to move in accordance with the difference of pressure already existing between *chambers D* and *A.* When the shoulder on the end of the piston stem comes in contact with the equalizing slide valve, as shown in Fig. 125, a connection is momentarily made from the *emergency reservoir* through the equalizing slide valve and past the end of (although shown as *through* in the diagrammatic view) the graduating valve to *chamber D.* The purpose of this connection (which is cut off, it will be observed, as soon as the equalizing piston is moved beyond the equalizing piston stop sleeve) is to prevent a drop in pressure in *chamber D* which would otherwise take place on account of the movement (displacement) of the equalizing piston. The displacement of the equalizing piston is sufficiently great, compared with the volume of *chamber D,* to require the provision just explained.

At the same time, the *pressure chamber* is connected through the equalizing slide valve and graduating valve to *chamber D,* thus keeping the pressures in these two chambers equal.

The other connections remain as explained under the heading "Preliminary Service Position."

c. Service Position.

The differential between the brake pipe pressure in *chamber A* and the pressure in *chamber D* (*pressure*

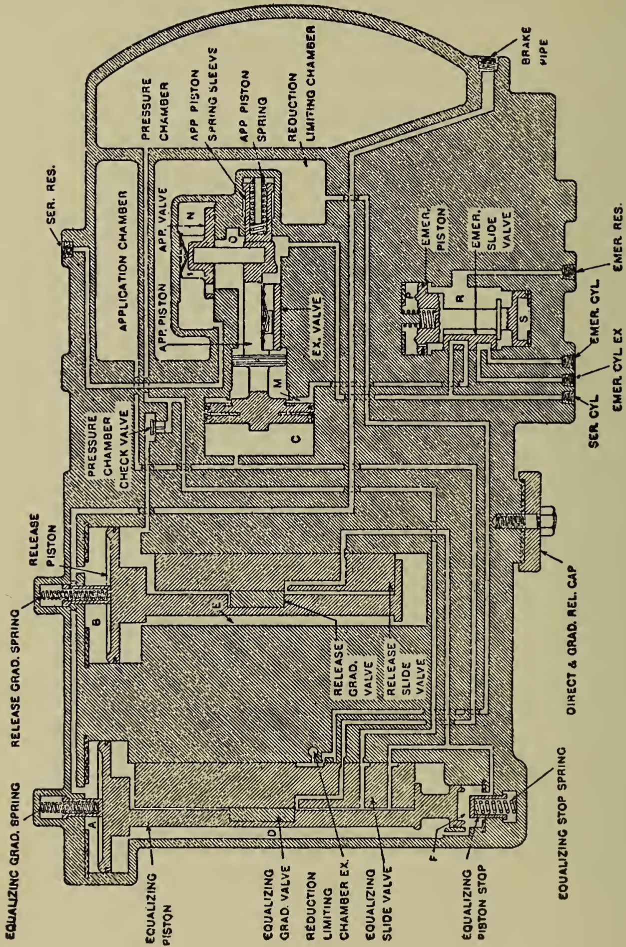


Fig. 126—No. 3-E Control Valve. Service Position.

chamber pressure as explained) is sufficient to move the equalizing piston and its valves past the intermediate secondary service position into *Service* position (Fig. 126) in which the equalizing piston just touches the equalizing graduating spring sleeve.

Chambers F and *D* are in communication by way of a feed port around the small end of the equalizing piston.

The *pressure chamber* is connected to *chamber D* through two channels, first, by way of the *pressure chamber* check valve to *chamber E* and thence past the end of the release graduating valve through the release slide valve to *chamber D* by way of a port past the end of (shown as *through* in cut) the equalizing slide valve, as well as through *chamber F,* and, second, the *pressure chamber* is also connected directly to the seat of the equalizing slide valve and past the end of (shown as *through* in cut) the slide valve direct to *chamber D.*

From *chamber D,* air from the *pressure chamber* can flow past the end of the equalizing graduating valve and through the equalizing slide valve to the *application chamber* and *chamber C* on the face of the application piston.

The pressure of the compressed air thus admitted to *chamber C* causes the application piston to move to its *Application* position, compressing the application piston spring in so doing.

In this position the brake cylinder exhaust slide valve closes the brake cylinder exhaust ports (which, therefore, are not shown in Fig. 126) and the application slide valve opens the application port, permitting air from the *service reservoir (chamber N)* to flow to *chamber O* and the *service brake cylinder,* thus applying the brakes. The air flowing thus to the *service brake cylinder* also flows

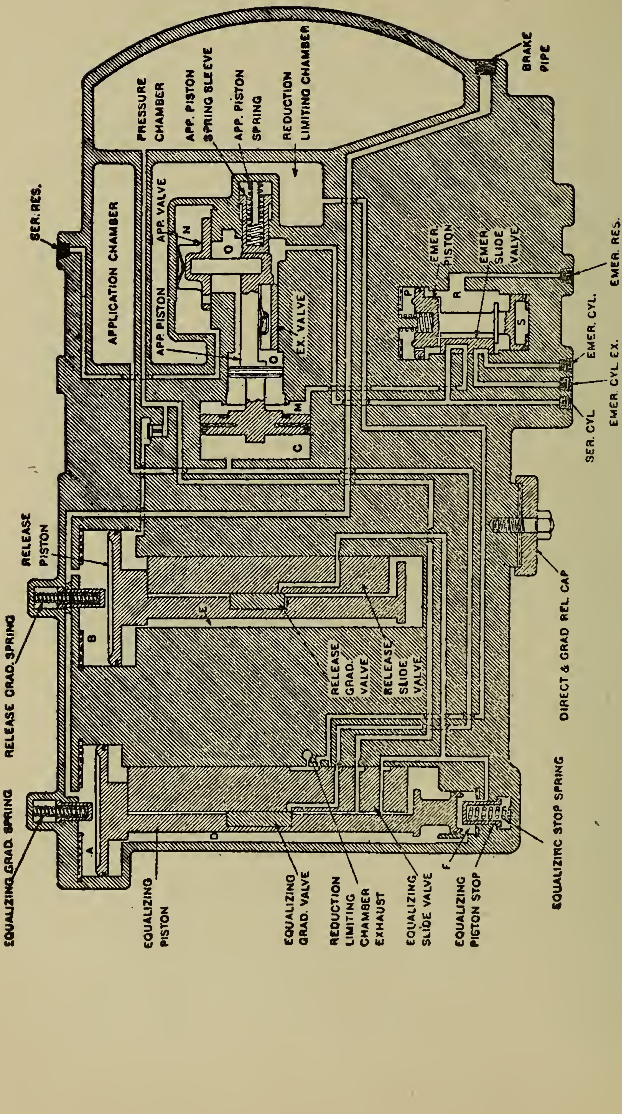


Fig. 127—No. 3-E Control Valve. Service Lap Position.

by way of the emergency slide valve to *chamber M,* in which the pressure is increased equally with that of the *service brake cylinder.* The flow of air from the *service reservoir* to the *service cylinder* continues, therefore, until the pressure in the *service brake cylinder* and in *chamber M* becomes substantially equal to that in the *application chamber* on the opposite side of the application piston. The application piston spring then returns the piston and the application slide valve back to *Lap* position (see Fig. 127), thus holding the brakes applied with a *service brake cylinder* pressure substantially equal to that put into the *application chamber,* as before mentioned.

It will be noted that in *Service* position, the *reduction limiting chamber* and *emergency brake cylinder* still remain connected to the *atmosphere,* as explained under the heading "Release Position."

d. Service Lap Position.

In case that less than a full service reduction is made, that is to say, that the brake pipe pressure is not reduced below the point at which the *pressure chamber* and *application chamber* pressures equalize, the flow of air from the *pressure chamber* to the *application chamber* as explained under the heading "Service Position" will finally reduce the pressure in *chamber D* to slightly below that to which the *brake pipe* pressure is reduced. The slightly higher brake pipe pressure in *chamber A* then causes the equalizing piston and graduating valve to return to their *Service Lap* positions (Fig. 127) and close communication from the *pressure* to the *application chamber* and holding whatever pressure was built up in *chamber C* and the *application chamber.*

It will be plain that any decrease in brake cylinder pressure, due to leakage, will now reduce the pressure in *chamber M* below that which is bottled up in the *application chamber* (*chamber C*). The differential pressure thus established on the application piston will cause it to move again toward its *Service* position and open the application valve port, as shown in Fig. 128, just enough to supply a sufficient amount of air from the *service reservoir* to the *service brake cylinder* to restore the depleted brake cylinder pressure to its original amount, following which the application valve will be again lapped as already explained. In this way, the *brake cylinder pressure will be maintained constant, regardless of leakage, up to the capacity of the service reservoir.*

The release piston and graduating valve may, or may not return to their *Lap* positions at the same time as, and in a manner similar to the movement of, the application piston and valves, but they perform no function in either case.

Otherwise the parts remain the same as in *Service* position.

e. Over Reduction Position.

If the brake pipe reduction is carried below the point at which the *pressure* and *application chambers* equalize (86 lbs. when using 110 lbs. brake pipe pressure and 54 lbs. with 70 lbs. brake pipe pressure), such an over reduction results in lowering the pressure in *chamber A* below that in *chamber D (pressure chamber pressure).* The equalizing piston consequently moves beyond its

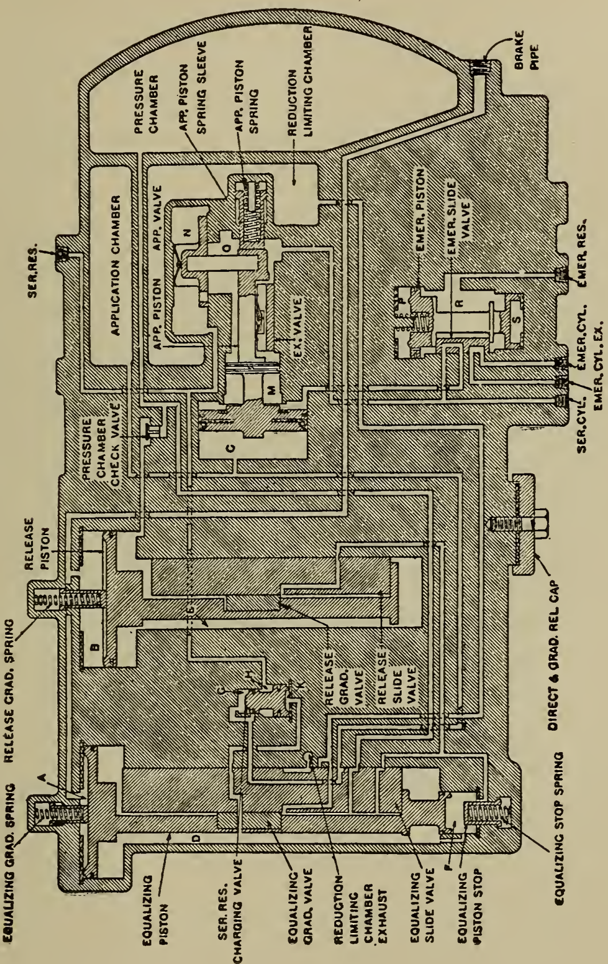


Fig. 128—No. 3-E Control Valve. Over Reduction Position.

Service position (Fig. 126) carrying with it the equalizing slide valve and graduating valve to what is called the "Over Reduction Position." (Fig. 128.)

The relative resistances of the release and equalizing graduating springs is such that the release piston and its valves still remain as in *Service,* although for the moment the same differential between *pressure chamber* and *brake pipe* pressure is acting upon the release piston as was sufficient to move the equalizing piston and its valves to the *Over Reduction* position.

The result is that air from the *pressure chamber,* (which is still connected to *chamber D* in substantially the same manner as explained under "Service Position") now flows past the end of the equalizing graduating valve and through the equalizing slide valve to the *reduction limiting chamber* instead of to the *application chamber* as in *Service* position.

The *reduction limiting chamber* being at atmospheric pressure, permits the pressure in the *pressure chamber* (and *chambers E* and *D*) to drop in accordance with the continued over reduction of brake pipe pressure, to the point of equalization of the *reduced pressure chamber pressure* and the *reduction limiting chamber pressure.* Otherwise the condition of the pressures in the reservoirs and brake cylinders controlled by the control valve is unchanged, except that in the movement of the equalizing slide valve to *Over Reduction* position, a connection is made from the *application chamber* and *chamber C* by way of the equalizing slide valve to the top *(chamber G)* of the service reservoir charging valve, and from *chamber D* (pressure chamber pressure) past the end of the equalizing graduating valve and through slide valve to *chamber K.* Since the pressure in the *pressure chamber* is being reduced, as already explained, while that in the *application chamber* and *service reservoir* is equalized, or practically so, at about 86 lbs. pressure, the service reservoir charging valve is not lifted, but is held down to its seat.

With the parts in this position, it will be noted that the *service reservoir* and the *application chamber* are separated only by the ring in the small end of the service reservoir charging valve. If there is any slight leakage which tends to cause a drop in *application chamber* pressure (which is relatively small compared with the *service reservoir* volume), the air in the *service reservoir* will gradually find its way around the ring in the small end of the service reservoir charging valve and prevent any material drop in *application chamber* pressure, thus practically eliminating the possibility of the brakes gradually leaking off, due to *application chamber* leakage.

The application valve port is shown partly open, supplying brake cylinder leakage, as already explained.

f. Over Reduction Lap Position.

Provided the brake pipe reduction is not carried below the equalizing point of the *pressure chamber* and *reduction limiting chamber,* a slight reduction of the pressure in the *pressure chamber* (and *chambers D* and *E*) below that held in the *brake pipe,* resulting from the continued flow of air from the *pressure* to the *reduction limiting chamber,* will cause the equalizing piston and graduating valve to be returned to *Over Reduction Lap* position (Fig. 129). This closes the port from the *pressure chamber* to the *reduction limiting chamber* and prevents further flow of air in this direction, but otherwise all parts and pressures are as explained above under heading

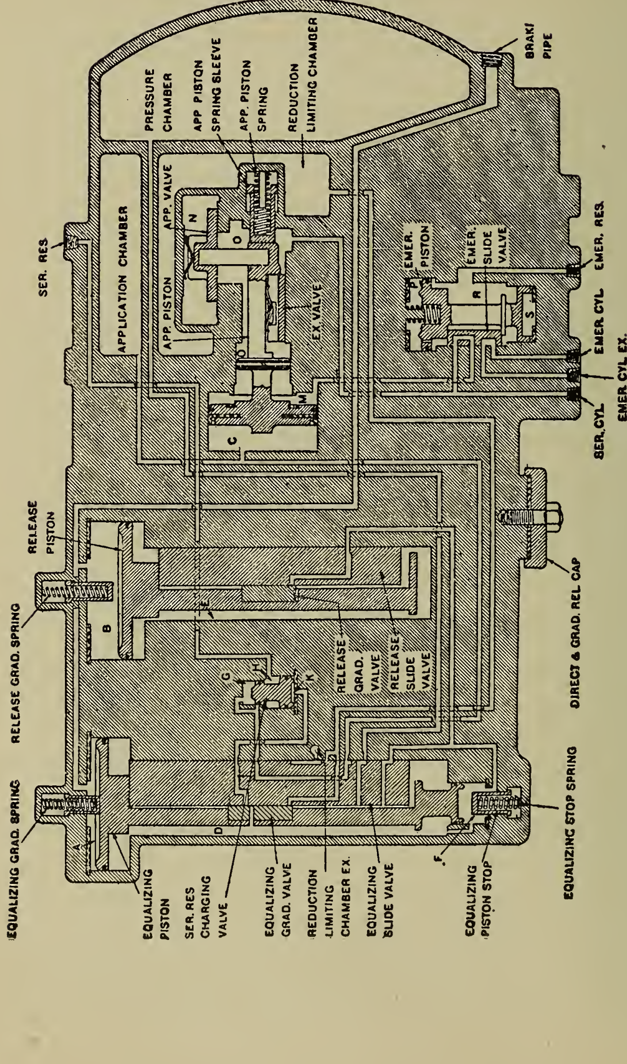


Fig. 129—No. 3-E Control Valve. Over Reduction Lap Position.

"Over Reduction Position," except that the port connecting *chamber D* past the end of the equalizing graduating valve and through slide valve to *chamber K* is blanked by the movement of the equalizing graduating valve.

Should the brakes be held applied in *Over Reduction Lap* position for a sufficient length of time with an *application chamber* leakage so great that the air from the service reservoir could not get past the ring in the small end of the service reservoir charging valve fast enough to supply such leakage (in the manner explained in connection with Fig. 128), the service reservoir charging valve will finally be lifted, making wide open connection from the *service reservoir* to the *application chamber*.

From what has been said, it will be plain that if the brake pipe reduction is continued below the point at which the *pressure* and the *reduction limiting chambers* equalize, the pressure in the *pressure chamber* can no longer continue to reduce in accordance with the still falling brake pipe pressure. This results in a differential being established between the pressure in the *pressure chamber* (and *chambers D* and *E*) and the *brake pipe* pressure which, when the brake pipe pressure is reduced below 60 lbs. when carrying 110 lbs. brake pipe pressure, or below 35 lbs. with 70 lbs. brake pipe pressure, is sufficient to cause the release piston to travel to its extreme *(emergency)* position and produce quick action and an emergency application of the brakes as will be explained under the heading "Emergency Position."

RELEASING.

a. Preliminary Release Position.

Whether the parts are in *Service Lap*, or *Over Reduction Lap* position, after an application has been made, an

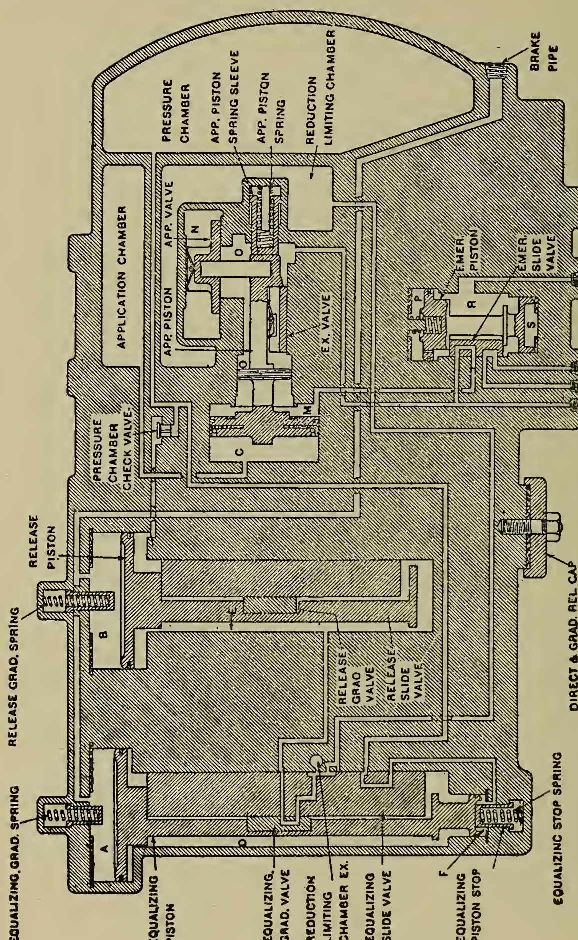


Fig. 130—No. 3-E Control Valve. Preliminary Release Position.

increase in *brake pipe* pressure above that in the *pressure chamber (chambers D* and *E)* will cause the equalizing piston and its valves to return to the release positions described below.

The equalizing piston moves before the release piston, the parts being designed to require a somewhat higher differential to move the release piston and its attached valves than is sufficient to move the equalizing piston.

In *Preliminary Release* position (Fig. 130), it will be noted that *chamber E* behind the release piston, is connected by way of the equalizing slide valve and graduating valve to the *reduction limiting chamber exhaust.* This connection is made but momentarily, in what may be considered the first stage of the movement of the parts to *Release* position. It plays a very important part, however, in the release operation of the valve, since by thus insuring a momentary but material drop in the pressure in *chamber E* below that in the *brake pipe* and in *chamber B,* the release piston is forced to return positively to its *Release* position shown in Fig. 131—*Secondary Release* position.

In *Preliminary Release* position, the *pressure chamber* is connected, by way of the equalizing slide valve to *chamber F.* The pressure thus acting in *chamber F,* in addition to the force of the equalizing stop spring, serves to insure that the equalizing piston and its valves hesitate in *Preliminary Release* position for a sufficient length of time to reduce the pressure in *chamber E* (as already explained).

It will be observed that the application piston is still in its *Lap* position, holding the pressure in the service brake cylinder. This continues until the release of air from the *application chamber* and *chamber C,* which does not take place until the parts move to the next stage in the release movement, called *Secondary Release* position, Fig. 131.

In the movement of the equalizing slide valve to *Preliminary Release* position, the *reduction chamber* is connected to the reduction chamber exhaust port and the *atmosphere* and so remains until the parts again move to *Over Reduction* position or beyond.

Although there are other connections made in the *Preliminary Release* position as shown in Fig. 130, they perform no particular function other than has already been described, and consequently do not need to be again referred to.

b. Secondary Release Position.

In the movement of the parts to *Release* position, the next stage, following the *Preliminary Release* position, is called the *Secondary Release* position and is shown in Fig. 131. It will be seen from the illustration that the venting of the air from *chamber E* through the equalizing slide valve and graduating valve to the *reduction limiting chamber exhaust* has resulted in the relatively higher brake pipe pressure moving the release piston and its valves to their *Release* positions, although for an instant the equalizing piston and its valves still remain as shown in Fig. 130—*Preliminary Release* position.

With the release piston and its valves in the position shown in Fig. 131, a connection is made from *chamber F* through the release slide valve to the *emergency piston exhaust.* At the same time the *pressure chamber* is connected by way of the equalizing slide valve to the same

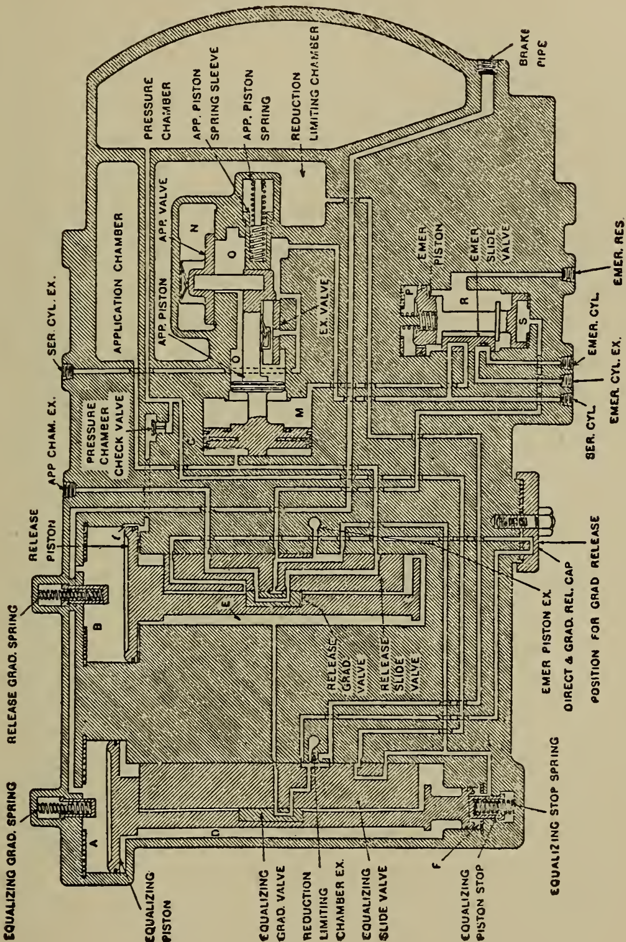


Fig. 131—No. 3-E Control Valve. Secondary Release Position.

port which connects *chamber F* to the *atmosphere.* This tends to maintain the pressure in *chamber F* temporarily so as to insure the connection from *chamber E* to the *atmspohere* being held open, as explained above, until the release piston and its valves are entirely back in their *Release* positions. In so moving, however, the release slide valve is gradually increasing the size of the opening from *chamber F* to the *atmosphere,* until a point is reached where the pressure in *chamber F* is lowered sufficiently to permit the differential pressure already acting on the equalizing piston to start this piston toward its *Release* position. The resulting movement of the equalizing slide valve restricts, and finally stops entirely, the flow of air from the *pressure chamber* to *chamber F,* the pressure in which is, therefore, rapidly exhausted to the *atmosphere* through the ports already mentioned, and the equalizing piston and its valves are then held positively in their *Release* position as shown in Fig. 132.

Comparing Fig. 130 and Fig. 131, it will be noted that the movement of the release piston, slide valve and graduating valve from the position shown in Fig. 130 to that shown in Fig. 131, opens communication from *chamber E* past the end of the release graduating valve, through the release slide valve and direct and graduated release cap, and through the equalizing slide valve to the reduction limiting chamber exhaust and *atmosphere.* This outlet from *chamber E* to the *atmosphere* is simply additional, it will be noted, to that already existing as explained in connection with Fig. 130, and, like it, is but momentary. In the succeeding position (Fig. 132) both these connections from *chamber E* to the *atmosphere* are cut off.

The movement of the release graduating and slide valves to their *Release* positions opens the *application*

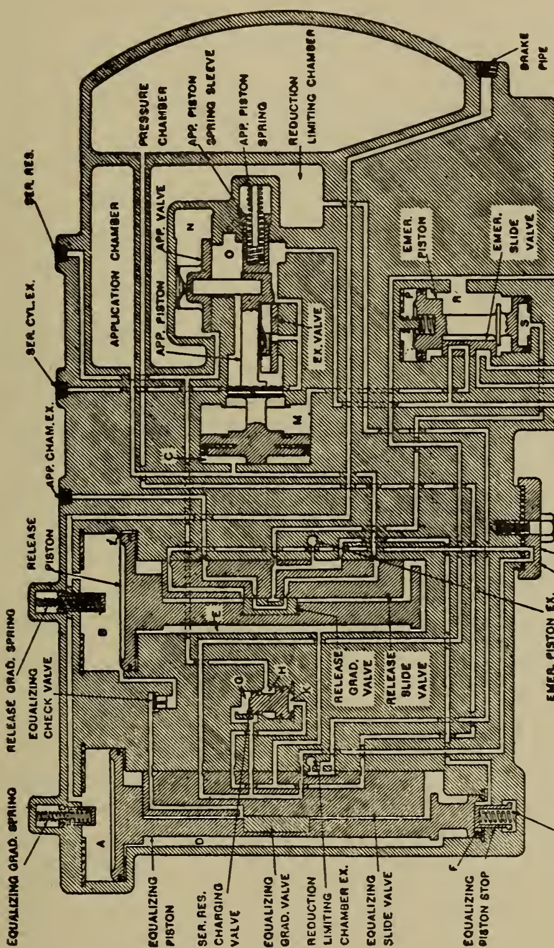


Fig. 132—No. 3-E Control Valve. Graduated Release and Release, Charging Pressure Chamber Only.

chamber and *chamber C* by way of the valves mentioned to the application chamber exhaust and *atmosphere.* The resulting reduction of pressure in *chamber C* below that exerted by the application piston spring and the air pressure in *chamber M* causes the application piston, with its attached valves, to move back to *Release* position (Fig. 131), opening the *service brake cylinder* through the exhaust valve to the service cylinder exhaust and *atmosphere.* The release of the brake is, therefore, commenced as soon as the release piston and its valves are returned to their *Release* positions.

While there are other connections shown in Fig 131 besides those just explained, they perform no particular function, so far as the momentary position of the parts in *Secondary Release* position (Fig. 131) is concerned, and will, therefore, not be referred to until all can be explained together under the heading "Graduated Release Position" (Fig. 132).

c. Graduated Release Position.

As already stated, the movement of the release slide valve to its *Release* position connects *chamber F* to the emergency piston exhaust and *atmosphere,* causing the equalizing piston and its valves to be moved to and held positively in their *Release* positions, as shown in Fig. 132.

It should be clearly understood that a very slight increase in brake pipe pressure (about 1½ to 2 lbs.) above that remaining in the pressure chamber, is sufficient to move the parts through the successive momentary positions of *Preliminary* and *Secondary Release* as just explained, until they reach their final positions shown in Fig. 132—*Graduated Release* position.

In this position (graduated release being assumed to be cut in), the *application chamber* and *chamber C are* open through the release slide valve and graduating valve to the application chamber exhaust and *atmosphere.* So far as this connection is concerned, the release would be complete, provided the parts did not move, but it will be noted that in this position also the *emergency reservoir* is connected by way of the equalizing slide valve, and the direct and graduated release cap (which is adjusted to give graduated release) through the release slide valve and past the end of the release graduating valve to *chamber E.* The pressure in the *emergency reservoir* is substantially that to which it was originally charged, namely, normal brake pipe pressure. The pressure in *chamber E,* it will be remembered, was reduced equally with the pressure chamber pressure when the brake application was made. Air from the emergency reservoir, at the higher pressure, will therefore flow into *chamber E* and, from *chamber E,* by way of the equalizing slide valve, to the *pressure chamber,* at the lower pressure, and tend to increase the pressure in *chamber E* and the *pressure chamber* at the same time that the brake pipe pressure in *chamber B* is being increased. If the pressure in *chamber E* rises faster than that in *chamber B,* the higher pressure which will soon be built up in *chamber E* will tend to move the release piston and graduating valve over toward *Graduated Release Lap* position (Fig 133) and either partially restrict or wholly stop the flow of air frem the *application chamber* to the atmosphere, and from the *emergency reservoir* to *chamber E.* If the brake pipe pressure is increased very slowly, the relatively rapid increase of pressure in *chamber E may* cause the release piston and graduating valve to gradu-

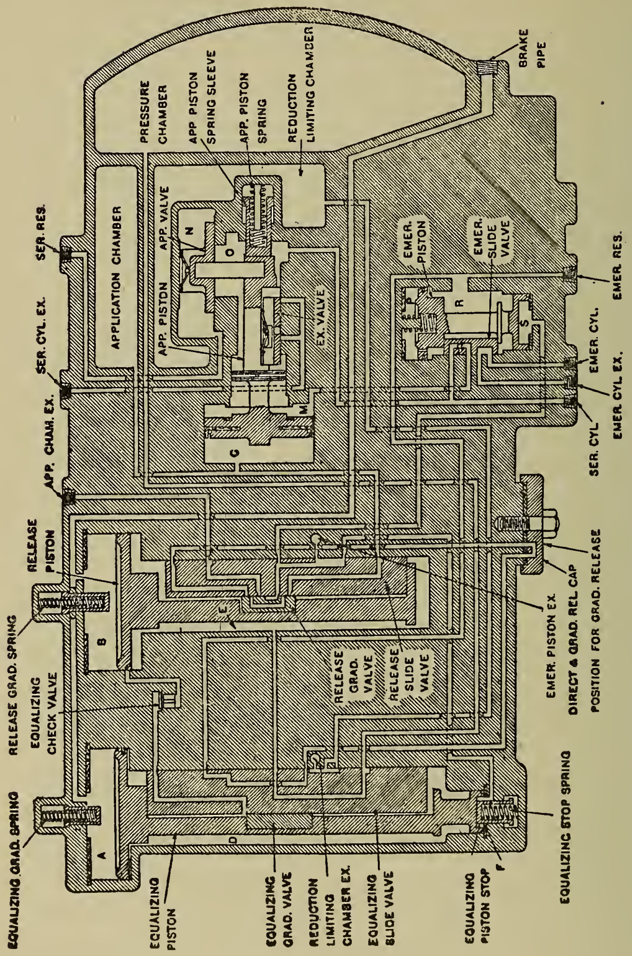


Fig. 133—No. 3-E Control Valve. Graduated Release Lap Position.

ate the release as explained in connection with Fig. 133. If the rate of rise of brake pipe pressure is not slow enough to permit this action, the parts will move toward the position shown in Fig. 133 sufficiently to so restrict the flow of air from the *emergency reservoir* to *chamber E,* as to adjust the rate of rise of pressure in *chamber E,* to correspond to that of the brake pipe and *chamber B,* in which case the release of air from the *application chamber* will be correspondingly prolonged.

The escape of air from the *application chamber* and *chamber C* to the *atmosphere* as already explained in connection with Fig. 131, results in the application piston spring and brake cylinder pressure acting in *chamber M,* moving the application piston with its valve back from their *Lap positions,* as shown in Fig. 130, to their *Release* position, as shown in Figs. 131 and 132, in which position, air from the *brake cylinder* is exhausted to the *atmosphere* by way of the exhaust valve, and service cylinder exhaust port. Whether the brake cylinder pressure is entirely, or only partially released depends upon whether the exhaust of air from the *application chamber* and *chamber C* is partial, or complete. This has already been referred to and will be further mentioned in connection with Fig. 133. It will be noted that in Figs. 130, 131 and 132, the *reduction limiting chamber* is connected to the reduction limiting chamber exhaust and *atmosphere* through the equalizing slide valve, and that in Figs. 131 and 132 *chamber S* is connected through the release slide valve to the emergency piston exhaust and *atmosphere,* so that the air in these chambers is completely exhausted to the atmosphere when either a graduated or direct release is made.

Referring to Fig. 132, it will be noted that *chamber E* is connected to *chamber K* and that air from the *emergency reservoir* has access to *chamber G.* These connections being opened by the movement of the equalizing slide valve to its *Release* position, whether or not the service reservoir charging valve will be opened and permit the recharging of the service reservoir to begin at once, will depend on the relative pressures in the pressure chamber, emergency and service reservoirs. With the ordinary manipulation of the brake, the service reservoir charging valve will remain closed, as shown in Fig. 132, preventing the air from the *emergency reservoir* reaching the *service reservoir* and the *pressure chamber* only will be recharged until its pressure has been increased to within about 5 lbs. of that in the *emergency reservoir.*

The other connections which are shown in Fig. 132 have been fully explained in what has preceded and require no further mention at this time, since they are not concerned in the particular function under discussion.

As already indicated, if the brake pipe is fully recharged without a graduation of the release being made, the parts will remain in the positions shown in Fig. 132 and the release will be complete and without graduations. The only change which takes place while such a release is being made is the movement of the service reservoir charging valve from the position shown in Fig. 132 to that shown in Fig. 123, which should properly be regarded as illustrating the final stage in the recharging of the equipment of which Fig. 132 illustrates the initial stage. That is to say, at first the *pressure chamber* alone is recharged, and this recharge is accomplished (as has been pointed out) from the *emergency reservoir* only, without any air being drawn for this purpose from the *brake pipe.* The air which is supplied through the brake valve to the *brake-pipe* is, therefore, given every possible advantage and opportunity to accomplish what is intended when the brake valve handle is moved to *Release* position, namely, to *release the brakes* by causing an increase of pressure sufficient to accomplish this, throughout the entire length of the *brake pipe.*

After the release has been thoroughly established in this manner, the recharging of the reservoirs to their original pressure takes place as explained in connection with Fig. 123. That is to say, when the pressure chamber has been recharged to within about 5 lbs. of the pressure remaining in the emergency reservoir, the service reservoir charging valve is lifted from its seat, opening the connection from the *emergency reservoir* to the *service reservoir,* and as the brake pipe pressure continues to be increased, the *service reservoir, emergency reservoir* and *pressure chamber* are finally recharged to full brake pipe pressure by the air coming from the *brake pipe,* as already explained in conection with Fig. 123.

d. Release Lap Position.

If, however, the brake pipe pressure is not fully restored, a graduation of release being made; that is, if the *brake pipe* is partially recharged and the brake valve handle then returned to *Lap* position, the continued flow of air from the *emergency reservoir* to *pressure chamber* and *chamber E,* as previously explained, will tend to increase the pressure in the *pressure chamber* and *chamber E* above that of *chamber B* which is now stationary, causing the release piston and graduating valve to move over until the shoulder on the end of the release piston stem comes in contact with the release slide valve as shown in Fig. 133. This closes the exhaust from the *application chamber* to the *atmosphere* and prevents further flow of air from the *emergency reservoir* to the *pressure chamber* and *chamber E.*

The flow of air from the *service brake cylinder* to the *atmosphere* (continuing as explained in connection with Fig. 132), will at once reduce the pressure in *chamber M* below that now retained in *chamber C* by the small amount which is sufficient to cause the application piston to move over to the position shown in Fig. 133, in which the exhaust valve is closed, thus preventing further release of air from the service brake cylinder. The other connections remain as already explained.

e. Release and Charging Pressure Chamber and Emergency and Service Reservoirs.

The gradual release of brake cylinder pressure may be continued as explained above (Fig. 133) until the pressures in the *emergency reservoir and pressure chamber* have become equal. On acount of the relatively large volume of the *emergency reservoir* compared with that of the *pressure chamber,* this equalization will not take place until the *pressure chamber* has been recharged to within about 5 lbs. of the brake pipe pressure carried. Beyond this point, whatever small amount of pressure may remain in the *service brake cylinder* is released entirely and the *emergency* and *service reservoirs,* as well as the *pressure chamber,* are recharged from the *brake pipe* as described in connection with Fig. 133.

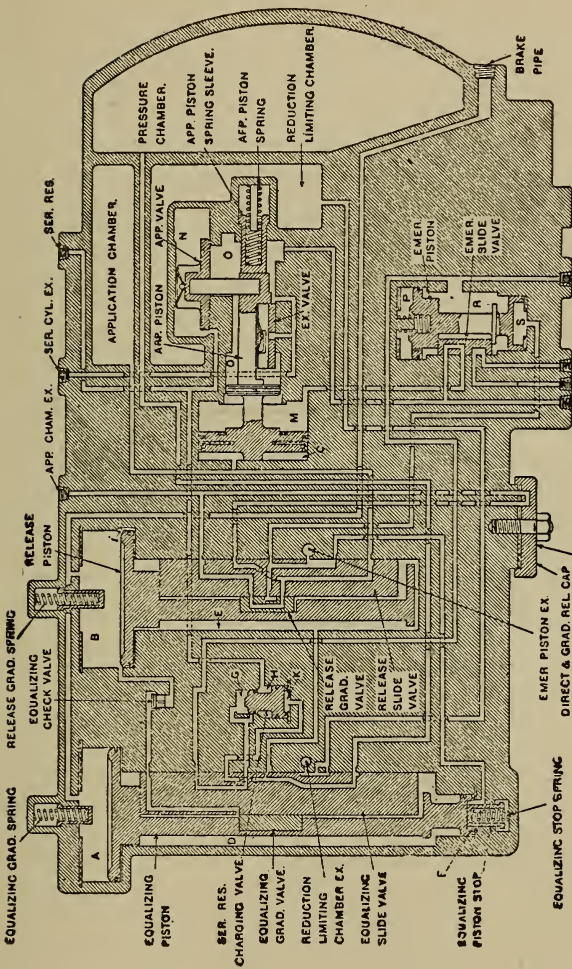


Fig. 134—No. 3-E Control Valve. Direct Release, Charging Pressure Chamber Only.

f. Direct Release and Charging Position.

Up to this point, the direct and graduated release cap has been assumed to be in the position for graduated release. Fig. 134 corresponds to Fig. 132, except that the direct and graduated release cap is adjusted for direct release. It will be noted that there is now no connection from the *emergency reservoir* to the *pressure chamber* or *chamber E*. Consequently the *pressure chamber* is being recharged only by air from the *brake pipe* going through feed groove *i* to *chamber E*, and thence by way of the equalizing slide valve, to the *pressure chamber*. The pressure in *chamber E* cannot, therefore, increase above that in *chamber B* and the release piston, graduating valve and slide valve remain in the position shown in Fig. 134.

With the direct and graduated release cap adjusted for direct release, it will be noted from Fig. 134 that the *application chamber* and *chamber C* are open through the release slide valve to a part connecting through the direct and graduated release cap to the application chamber exhaust and *atmosphere*. This affords an outlet from the *application chamber* to the *atmosphere* which cannot be closed as long as the release slide valve remains in the position shown, even though the release piston and graduating valve, should, from any cause, be moved back so that the release graduating valve would partially or entirely restrict the application chamber release port, which is also shown to be open through the release graduating valve in Fig. 134. Moreover, it will be noted that there are *two* outlets from the *application chamber* to the *atmosphere* when the valve is adjusted for *direct release* as compared with *one* when *graduated release* is cut in.

This, together with the fact that the direct release port is of greater capacity than the graduated release port, results in a more rapid rate of release being obtained with the direct than with the graduated release adjustment of the equipment, as is desirable. As the other connections shown in Fig. 134 are the same throughout as explained in connection with Fig. 132, it will be unnecessary to make further reference to same.

EMERGENCY POSITION.

a. *Quick Action Valve Venting.*

When the brake pipe pressure is reduced faster than at the predetermined rate for service applications, or if the brake pipe reduction should be continued below the point at which the *pressure* and *reduction limiting chambers* equalize (as explained above under the heading "Over Reduction Position") the differential pressure acting on the release and equalizing pistons becomes sufficient to move them to their extreme or *Emergency* positions as shown in Fig. 135.

In this position, air from the *emergency reservoir* flows directly to *chamber E* and from *chamber E* to the under side of the quick action closing valve. *Chamber T,* above the quick action closing valve, is connected to the emergency brake cylinder port, in which there is no pressure, even though a full service application of the brakes may have just preceded the emergency application.

The higher pressure on the under side of the quick action closing valve therefore raises this valve and air flows to *chamber W* above the quick action piston, forcing the latter down and opening the quick action valve

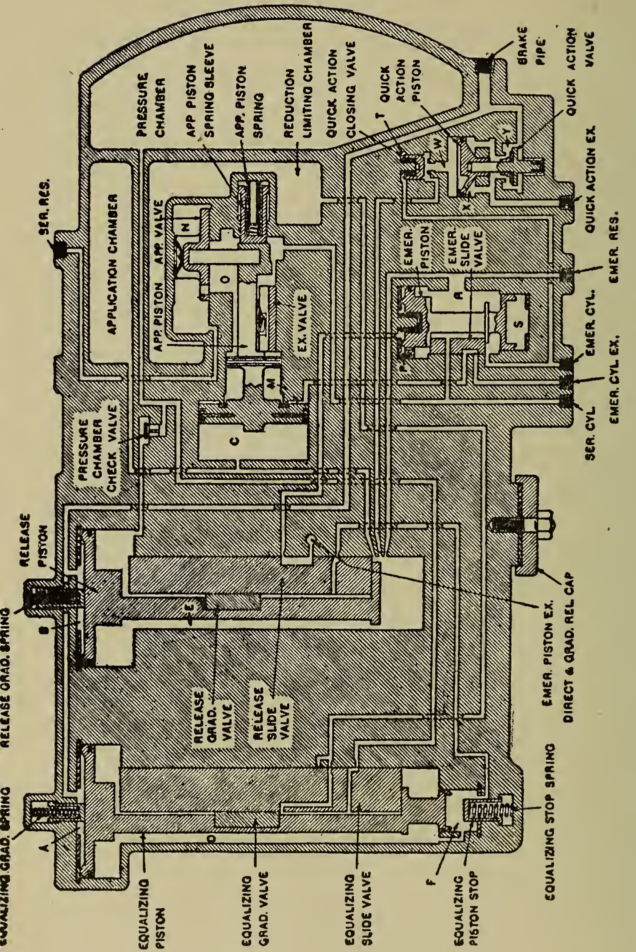


Fig. 135—No. 3-E Control Valve. Emergency Position, Quick Action Valve Venting.

against brake pipe pressure in *chamber Y.* As soon as the quick action valve is unseated in this manner, air from the *brake pipe* flows past the quick action valve to the quick action exhaust and *atmosphere,* causing a local venting of brake pipe air and transmitting the quick application serially throughout the train.

Air from the *emergency reservoir* flowing to *chamber E* also flows directly to the application chamber and *chamber C* which forces the application piston and its valve over into their extreme positions, opening the *service reservoir* through the application slide valve and *chamber O* to the *service brake cylinder,* thus permitting the pressures in the *service reservoir* and *service brake cylinder* to equalize.

At the same time *chamber P,* above the large emergency piston, is connected through the release slide valve to the emergency piston exhaust and *atmosphere,* permitting the emergency reservoir pressure in *chamber R* to force the emergency piston and its slide valve upward to their *Emergency* positions.

In this position of the emergency parts, the *emergency reservoir* is connected past the end of the emergency slide valve to the *emergency brake cylinder,* thus permitting the pressures in the *emergency reservoir* and *brake cylinder* to equalize. *Chamber R* is also connected through the emergency slide valve to the *service cylinder port* which permits equalization of the service and emergency reservoirs and brake cylinders.

It will be noted that in this position the emergency slide valve opens a port which connects *chamber M,* behind the application piston, through the emergency slide valve to *emergency cylinder exhaust.* This, in connection with the admission of air from the *emergency reservoir* to the *application chamber* and *chamber C,* as already explained, still further insures a quick and positive movement of the application piston and its valves to *Emergency* position.

In this position the *pressure chamber* is connected through the equalizing slide valve to *chamber D.* The *pressure chamber* is also connected past the pressure chamber check valve to *chamber E,* and *chamber D* is connected past the end of the equalizing graduating valve through the equalizing slide valve to the *reduction limiting chamber.* These connections perform no particular function except to insure pressure acting on all slide valves, graduating valves, etc., so as to hold them to their seats as well as to provide for the equalization of all chambers, reservoirs, etc., of the equipment when an emergency application is made.

b. Quick Action Valve Closed.

The emergency brake cylinder pressure and that in *chamber T,* above the quick action closing valve, continues to rise and the pressure in the *emergency reservoir* and in *chamber W* below the quick action closing valve falls, as explained above, until these pressures become substantially equal. This equalization of the pressures on the opposite sides of the quick action closing valve permits its spring to return the valve to its seat, cutting off further flow of air to *chamber W. Chamber W* is connected through the leakage hole in the quick action piston to *chamber X* so that as soon as the quick action closing valve is seated, the pressure in *chamber W* expands through this leakage hole to *chamber X* and the *atmosphere,* through the quick action exhaust opening.

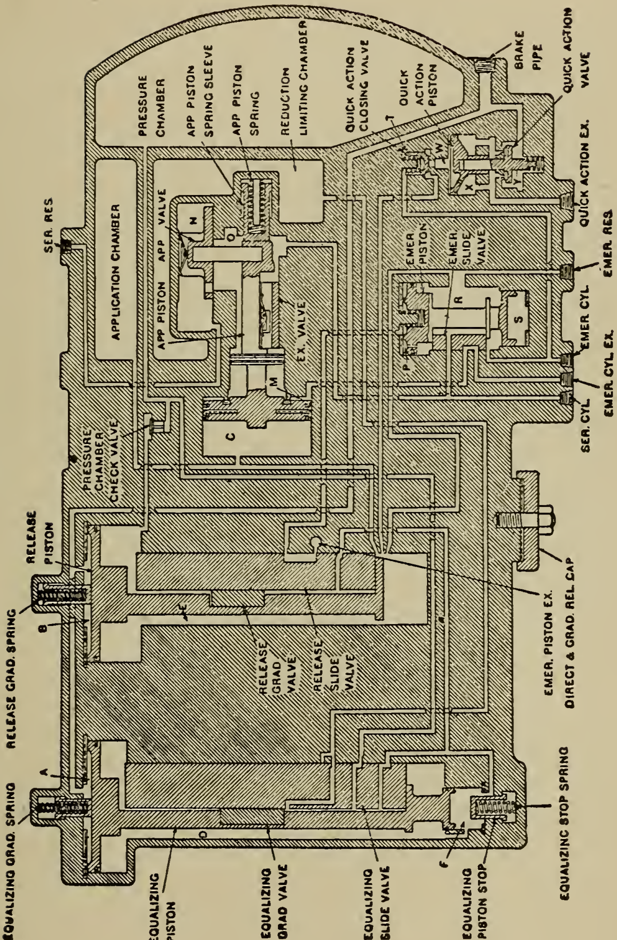


Fig. 136—No. 3-E Control Valve. Emergency Position, Quick Action Valve Closed.

The balancing of the pressures in *chambers X* and *W* thus permits the quick action valve spring to return the quick action valve to its seat, closing the outlet from the *brake pipe* to the *atmosphere,* as shown in Fig. 136. This insures against an escape of air from the *brake pipe* to the *atmosphere* when a release is made following the operation of the quick action parts.

Except for the closing of the quick action valve and return of the quick action parts to *Normal* position, as explained in the preceding paragraph, the positions of the other parts of the valve and connections between the various reservoirs and cylinders, etc., remain as already explained in connection with Fig. 135.

When releasing after an emergency application, as soon as the brake pipe pressure in *chambers A* and *B* is increased above that which remains in *chambers D* and *E,* the parts will move to their *Release* positions, exhausting the air from the brake cylinders and recharging the reservoirs and pressure chamber as explained under the heading "Release and Recharging." Figs. 130, 131 and 132.

BRAKE CYLINDERS.

Two brake cylinders per car are used. (See Figs. 111 and 112.) Only *one* brake cylinder operates during service applications, but *both* are brought into play when an emergency application is made. This gives the necessary increased braking power for emergency applications, not by an increased pressure in one brake cylinder (as in previous equipments), but by bringing the same brake cylinder pressure to act upon the pistons of two brake cylinders instead of one. This means that *double* the maximum service braking power is obtained in emergency applications.

It will be noted that Figs. 111 and 112 differ in the arrangement of the brake cylinders and related parts. Fig. 111, with brake cylinders pointing in opposite directions, permits a somewhat simpler arrangement of the hand brake rigging, while the arrangement shown in Fig. 112 brings the slack adjusters and their connections into a more convenient location for some installations. Which of the two arrangements is to be recommended depends largely on the construction of the car underframing and the location of the apparatus under the car.

Fig. 137 illustrates the section and exterior of the type of brake cylinder used with this equipment. The piston 3 has a solid push rod which is connected to the levers of the foundation brake gear through the slotted crosshead; 12 is a release spring which forces piston 3 to release position when the air pressure is exhausted from the opposite end of the cylinder; the packing leather, 9, is pressed against the cylinder wall by the packing expander, 10, and prevents the escape of air past the piston. A slotted crosshead, 6, is used on the service cylinder when the hand brake rigging is designed to work in harmony with the air brake system—an arrangement which we strongly recommend for all conditions where it is practicable. The slotted crosshead on the emergency cylinder permits movement of the emergency cylinder lever in service applications without a movement of the piston of the emergency cylinder.

RESERVOIRS.

The service reservoir is used to supply air only to the service brake cylinder. The emergency reservoir, in ad-

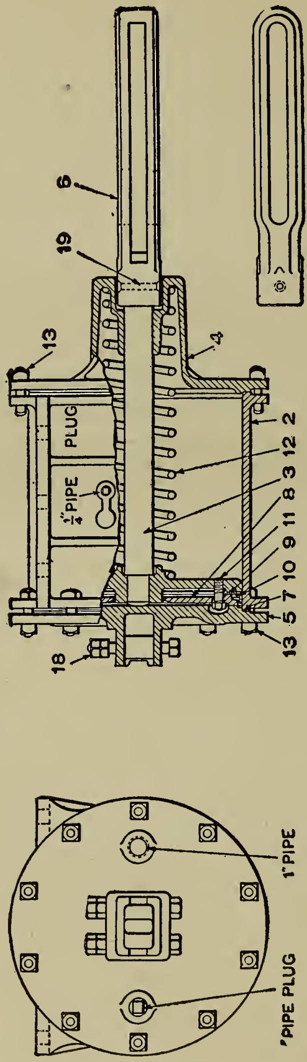


Fig. 137—Brake Cylinder.

dition to supplying air to the emergency brake cylinder in emergency applications, is also the source of air supply utilized in obtaining the graduated release feature and the prompt recharging of the equipment in service operation.

Enameled reservoirs are now strongly recommended on account of their durability and protection against cor-

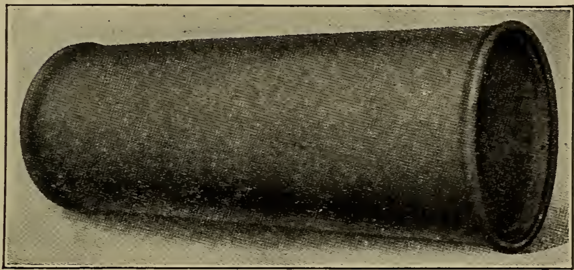


Fig. 138—Reservoir.

rosion, oxidation, etc., preserving a greater factor of safety than does the plain unenameled type. These reservoirs are enameled by a special process both inside and out.

THE AUTOMATIC SLACK ADJUSTER.

The automatic slack adjuster is illustrated in Figs. 139 and 140. The brake cylinder piston acts as a valve to control the admission and release of brake cylinder pressure to and from pipe *b*, Fig. 139, through port *a* in the cylinder, this port being so located that the piston uncoveres it when the predetermined piston travel is exceeded. Whenever the piston so uncovers port *a*, brake

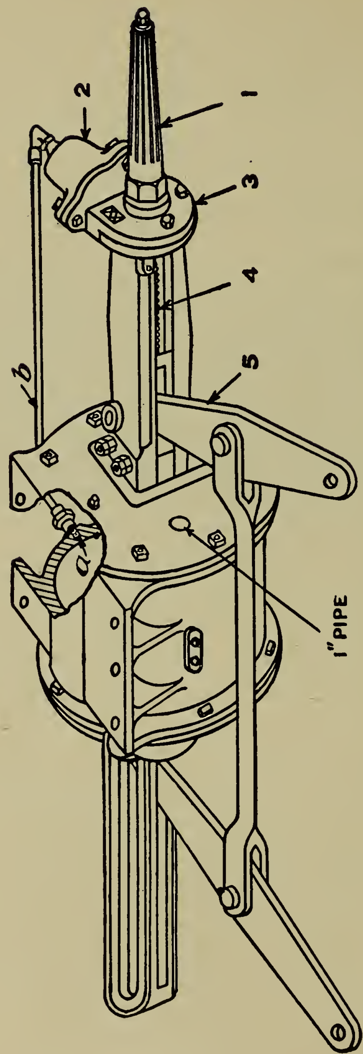


Fig. 139—Application of Slack Adjuster to Brake Cylinder.

cylinder air flows through pipe *b* into slack adjuster cylinder 2 where the small piston 19, Fig. 140, is forced outward, compressing spring 21. Attached to piston stem 23 is a pawl extending into casing 24, which engages ratchet wheel 27, mounted within casing 24 upon screw 4, Fig. 139. When the brake is released and the brake cylinder piston returns to its normal position, the air pressure in cylinder 2 escapes to the atmosphere through pipe *b*, port *a* and the non-pressure head of the brake cylinder, thus permitting spring 21 to force the small piston to its normal position. In so doing, the pawl turns the ratchet wheel upon screw 4 and thereby draws lever 5 slightly in the direction of the slack adjuster cylinder, thus shortening the brake cylinder piston travel and forcing the brake shoes nearer the wheels. As the pawl is drawn back to its normal position, a lug on the lever side strikes projection *a*, Fig. 140, on the cylinder, thus raising the outer end of the pawl, disengaging it from the ratchet wheel and permitting the screw to be turned by hand if desired.

To apply new shoes, turn casing 1 to the left, thus moving lever 5 toward the position shown in Fig. 139, until sufficient slack is introduced in the brake rigging. To bring the shoes closer to the wheels and shorten the piston travel, turn casing 1 to the right.

The screw mechanism is so proportioned that the brake shoe wear is compensated for at the rate of about $\frac{1}{32}$ of an inch for each operation of the adjuster, thereby removing the danger of *unduly* taking up false travel which would result in the shoes binding on the wheels.

The best results are obtained by the use of copper pipe from the brake cylinder to the adjuster cylinder, since this pipe is more flexible and does not corrode. It should always be firmly secured.

Every time the brake cylinder is cleaned and oiled, the slack adjuster should receive the same attention, and,

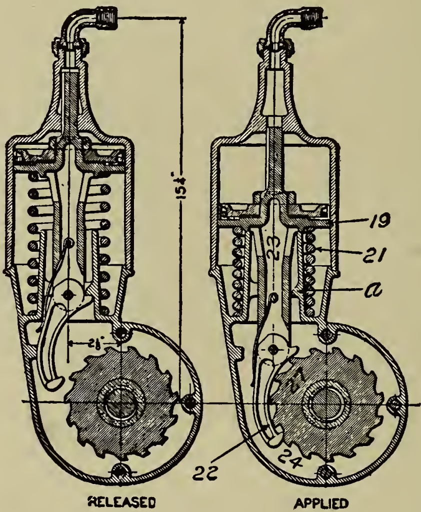


Fig. 140—Automatic Slack Adjuster Cylinder.

after each cleaning and oiling, a test of the brakes should also include one of the adjuster.

CENTRIFUGAL DIRT COLLECTOR.

The centrifugal dirt collector, as illustraed in Fig. 141, is so constructed that, due to the combined action of centrifugal force and gravity, all dirt and foreign material is *automatically* eliminated from the air flowing through the collector—as when the brakes are applied or released—*without reducing the area of the opening in any way*. The efficiency of this method of keeping dirt out of the brake system is remarkable, and the importance of this fact will be appreciated by those who are familiar with the troubles which result from the entrance

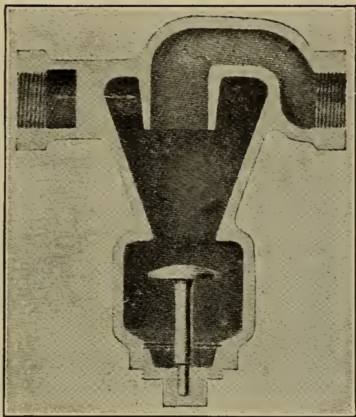


Fig. 141—Centrifugal Dirt Collector.

of dirt, pipe scale, etc., into the brake system and especially the triple valves. The design of the collector is such that the dirt and foreign matter eliminated falls into the bottom chamber and by means of a plug may be removed at intervals without breaking any pipe connections whatever.

CONDUCTOR'S VALVE.

The conductor's valve, Fig. 142, may be located at any convenient point in the car, preferably with a cord attached to its handle and running the length of the car; however, one valve may be placed at each end which will obviate the necessity of the cord. When this valve is opened, the air from the brake pipe flows directly through it to the atmosphere, setting the brakes in emergency. It should therefore be used only in case of actual danger and should then be opened as wide as possible and left open until the train stops.

PIPE FITTINGS.

The *cut-out cock,* Fig. 143, of which there is one 1-inch in the branch pipe, should be placed where it can be

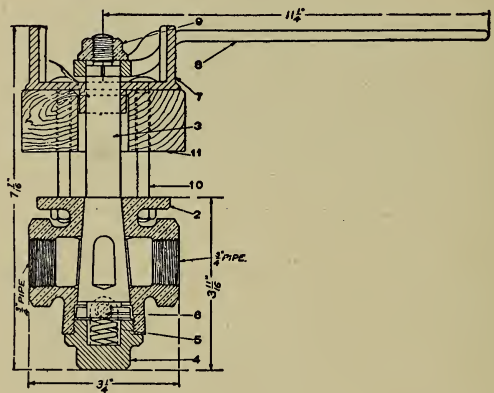


Fig. 142—C-3 Conductor's Valve.

easily reached but protected from accidental closing. The handle should be in such position that, as affected by vibration, it would tend to jar open instead of shut.

The *self-locking angle cock* has been developed to prevent any accidental movement of the handle from either open or closed position by flying missiles, loose brake rods, swinging check chains or other cause. In all details except the handle the self-locking type is the same as the old style angle cock; the upper illustration, Fig. 144, shows the self-locking handle while the lower represents the old form. In the case of angle cocks now in service it is necessary to supply only the improved handle to secure advantages which the self-locking angle cock provides.

Hose couplings, Fig. 145, make the brake pipe continuous throughout the train. When cars are being separated, as in switching, the hose should be uncoupled by hand, to prevent rupture or damage.

Dummy couplings, Fig. 146, are provided at each end of the car to which the hose couplings should be attached when not coupled up, to protect against injury to the hose couplings or dirt entering the pipes.

GENERAL HINTS.

The brake should be handled by the engineers in the same manner as with cars equipped with quick-action triples, the only difference being that an emergency application will be obtained should a service reduction of the brake pressure be continued below 60 lbs. when carrying 110 lbs. pressure or below 35 lbs. with 70 lbs. brake pipe pressure.

When it is found necessary to cut out the brake, close the cut-out cock in the crossover pipe and bleed both the service and emergency reservoirs.

Should it become necessary to bleed the brake when the engine is detached, or air connection is not made, first bleed the brake pipe and then bleed both the service and emergency reservoirs.

The two sets of cylinder levers are connected to the same truck pull rods as stated above. Therefore, when a service application of the brake is made, the push rod end of the emergency cylinder lever will move the same distance as the push rod end of the service cylinder lever, but the cross head being slotted, the piston of the emergency cylinder will not move. Consequently, the fact that

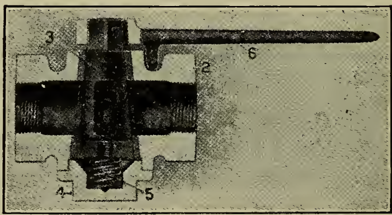


Fig. 143—Cut Out Cock.

the *emergency cylinder* cross head is in release position does *not* indicate that the air brakes are released. To determine this, look at the ends of either the service or emergency cylinder levers.

Whenever it is necessary to change the adjustment of the automatic slack adjuster, it is imperative that the cross heads of the two adjusters be left at the same distance from their respective brake cylinder heads, in order that the piston travel of the two cylinders in emergency application will be the same.

The various exhaust openings referred to in the following are plainly marked on the outline drawings, Figs. 116 and 116^{A}.

The Quick Action Exhaust is the one-inch opening in the bottom of the control valve reservoir. Should there be a continual blow at this opening, make an emergency application and then release; if the blow continues, remove the quick action portion and substitute a new or repaired portion, or repair the quick action valve seat which will be found defective. The quick action portion is at the left hand when facing the equalizing portion.

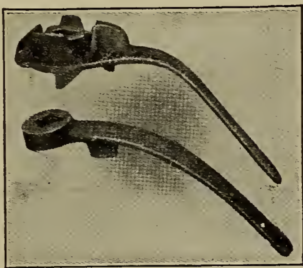


Fig. 144—New and Old Angle Cock Handle.

There are three control valve exhaust openings, two on the equalizing portion and one on the side of the control valve reservoir, all tapped for 3/8-inch pipe.

Should there be a blow at the Application Chamber Exhaust (3/8-inch exhaust opening on the side of the control valve reservoir) with the brakes applied or released, it indicates a defective equalizing portion and a new one, or one that has been repaired, should be substituted.

Should there be a blow at the Reduction Limiting Chamber Exhaust (3/8-inch exhaust on left side of equalizing portion) in release or service position it indicates a defective application portion and a new one, or one that has been repaired, should be substituted. This portion is located back of the equalizing portion, inside the reservoir. If the blow occurs only after 30 lbs. brake pipe reduction, it indicates a defective emergency reservoir check valve (the middle check valve in the equalizing portion) and a new one, or one that has been repaired,

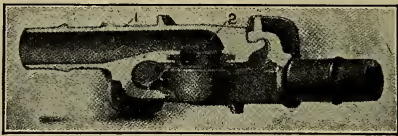


Fig. 145—Hose Coupling.

should be substituted. If the blow does not cease, it indicates a defective equalizing portion and a new one, or one that has been repaired, should be substituted.

Should there be a blow at the Emergency Piston Exhaust (⅜-inch exhaust on the right hand side of the equalizing portion) make a 15-lb. brake pipe reduction and lap the brake valve. If the blow ceases, it indicates

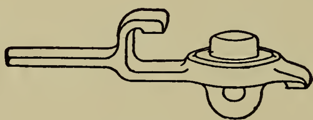


Fig. 146—Dummy Coupling.

that either the emergency portion or seal on the small end of the equalizing piston is defective and a new portion, as found to be needed, or one that has been repaired, should be substituted. If the blow does not cease, it indicates that the equalizing portion is defective and a new one, or one that has been repaired, should be substituted.

A hard blow at the Service Brake Cylinder Exhaust (tapped for ⅜-inch pipe and located on the left side of the control valve reservoir) with the brakes applied, indicates that the application portion is defective and a new one, or one that has been repaired, should be substituted. This portion is located back of the equalizing portion inside the reservoir. If this blow occurs when the brakes are released it indicates either a defective application or emergency portion and a new one, or a repaired portion, as found to be required on investigation, should be substituted.

A hard blow at the Emergency Cylinder Exhaust (tapped for ½-inch pipe and located on the bottom of the control valve reservoir) with the brakes either applied or released, indicates a defective emergency portion and a new one, or one that has been repaired, should be substituted.

If the trouble described in the five paragraphs immediately preceding is not overcome by the remedies therein suggested, remove the application portion and examine its gasket, as a defect in same way may be the cause of the difficulty.

When removing the application, emergency and quick action portions, their respective gaskets should remain on the reservoir. On removing the equalizing portion, its gasket should remain on the application portion, except when the application portion is shipped to and from points where triple valves are cared for.

When applying the different portions, the gaskets should be carefully examined, to see that no ports are restricted, and that the gasket is not defective between ports. See also that all nuts are drawn up evenly to prevent uneven seating of the parts.

On the front and at the center of the equalizing portion is located the direct and graduated release cap (held by a single stud) on which is a pointer. (See Fig. 114.) The position of this pointer indicates whether the valve is adjusted for direct release or graduated release. This cap should be adjusted for either direct or graduated release according to the instructions issued by the railroad.

LUBRICATION OF NO. 3-E CONTROL VALVE.

Equalizing Portion. All equalizing portions should be lubricated with dry graphite instead of oiling.

The following is the method of lubricating the equalizing portion:

After the bearing surfaces have been properly rubbed in by a free use of oil, this oil should be wiped off with a soft cloth or some soft material. All oil, gum, or grease should be thoroughly removed from the slide valves and seats. After this has been done, rub a high grade of very fine, dry (not flake) graphite, of the highest obtainable fineness and purity, on to the face of the slide valves, their seats, the face of the graduating valves, their seats, and the upper portion of the bushings where the slide valve springs bear, in order to make as much as possible adhere and fill in the pores of the brass and leave a very thin, light coating of graphite on the seats. When this is completed, the slide valves and their seats must be entirely free from oil or grease. Care must be taken when handling the slide valves, after lubricating, that the hands do not come in contact with the lubricated parts, as moisture will tend to remove the thin coating of graphite.

To apply the graphite, use a stick, suitable for the purpose, about 8 inches long, on one end of which a small pad of chamois skin has been glued. Dip the skin covered end in the dry graphite and rub the latter on the surfaces specified. A few light blows of the stick on the slide valve seats will leave the desired light coating of loose graphite. After the pistons and slide valves have been replaced in the equalizing portion, they should be moved to *Release* position, and a little good oil or lubricant applied to the circumference of the piston bushings, and the pistons moved back and forth several times to insure proper distribution of this lubricant on the walls of the cylinders.

When oiling, as just directed, or in the cases which follow, only a thin coating of oil is necessary and care should be taken not to leave any free oil on the parts.

Application Portion. The exhaust valve and seat and application valve and seat of the application portion should be cleaned, rubbed in and sparingly lubricated with graphite grease.

Before applying the piston to application portion, clean the application cylinder and piston. Lubricate the walls of the cylinder and piston ring, using Emery Brake Cylinder Lubricant.

Emergency Portion. After the bearing surfaces have been properly cleaned and rubbed in, and before applying the slide valve to the emergency portion, remove the top cover and take out the loose fitting cylinder bushing. Lubricate the large piston with a few drops of a good grade of triple valve oil and apply the same oil sparingly to the slide valve, then enter the slide valve into the portion. Lubricate the slip bushing for the small emergency piston, applying a few drops of triple valve oil to inner circumference. Apply the bushing to the portion and bolt on top cover. Move the slide valve to *Release* position and put a few drops of triple valve oil on the walls of the large cylinder bushing. Move the slide valve and piston back and forth several times to insure a proper distribution of the oil. Apply the large cover to the emergency portion.

Quick Action Portion. No parts of the quick action portion require lubrication but, if desired, the closing valve piston and cylinder bushing may be sparingly lubricated with triple valve oil. After lubricating, work the piston a few times, making sure that it moves freely.

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