Northern Pacific
Railway Company

Instructions
for
Operating and Maintaining Air Brake and Air Signal Apparatus.

No. 671

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Railway Company

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Operating and Maintaining Air Brake and Air Signal Apparatus.

Chicago
M. A. Donohue & Company
407-429 Dearborn St.

INDEX.

INTRODUCTION.

The information contained herein is for the instruction and guidance of employes of the Northern Pacific Railway Company whose duties require that they be familiar with the maintenance and operation of the air brake and signal equipment.

Each employe having anything to do with air brake maintenance or operation will be required to familiarize himself with all paragraphs pertaining to his duties.

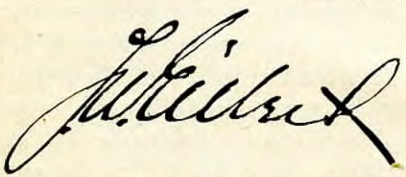
In addition to the information contained in this book employes will be given instruction by the General Air Brake Inspector, or some one appointed for the purpose, and will, at such times as may be required by the Railway Company, be called for an examination as to their knowledge of the maintenance and operation of air brake and air signal equipment. The ability to satisfactorily pass such examination will be considered merely as a recommendation, and the value of each man's services will be determined by what he does rather than what he apparently knows.

Any employe whose work indicates an apparent absence of the requisite brake knowledge may be required to pass an examination at any time following such indications. The results of examination will be embodied in the service records.

An employe who repeatedly fails to pass satisfactorily the required examination or to handle this class of equipment properly will be subject to dismissal from the service.

Employes who pass the examination satisfactorily will, from time to time, be called for further examination, in order that the highest degree of efficiency in service may at all times be maintained.

Mechanical Superintendent.



General Superintendent.

NOTE: The index denotes where the information and instruction relative to the various matters covered by this book may be found. Numbers following various chapters refer to Operating Department rules and regulations concerning brake and signal matters.

HOW TO STUDY.

Air brake study should be carried on in two ways, the theoretical, and the practical, keeping them as close together as possible.

First, learn the name of every complete part of the air brake apparatus on the engine, tender and car. Next, the connections by which the air passes from one part to another, but neglecting all ports and passageways inside of complete parts. In other words, learn how the air brake looks on the outside. Then, where every air connection is made to the pump, main reservoir, engineer's valve, triple valve, etc., including steam connections to the air pump and the governor. Until this is so well learned that it can be pictured out in the mind without reference to the engine, car or illustration, you are not ready to study the interior of any part.

The next step is to know what each complete part is for. This being well understood for all parts, you are ready to learn how they perform their duties.

By closely observing the pump when working, operating the engineer's valve, and watching the action of the brake pistons during this study, the subject matter will become clearer and better fixed in your memory.

OBJECT OF STUDY.

As the sole object of the study is to produce the best possible use and care of the brakes, it is necessary to use, as far as practicable, at the terminal and on the road, the knowledge gained. All enginemen know that a student fireman might study the theory of firing and observe the work done, until he had become as thoroughly acquainted with every detail as an experienced man, yet he could not duplicate the work of the latter until he had fired an engine for a time. How to do certain work and *doing* it, are entirely different propositions.

Not less true is it, that the man must learn to put into practice the knowledge gained by air brake study. If already an engineer, he may have to break well-established but wrong habits, which is harder than merely establishing new ones. Fail to practice what you learn, and it will soon be partially or wholly forgotten.

Remember that it is your business to ascertain, as far as tests and outside examinations will permit, the diseases the brakes under your charge are suffering from, and either to apply the proper remedies or make clear reports of the troubles.

It is true that the best work cannot be done with poor brakes and therefore the enginemen and trainmen in charge should be able to make intelligent reports of all defects so that they can be remedied.

Seek for the best knowledge which you can make use of in practice. While it is well enough for you

to know *why* the feed groove in the triple valve is made so small, yet you cannot use this knowledge on the road. Know that it *is small* and the effect of this on charging auxiliary reservoirs; then govern your work accordingly. A little useful knowledge put into practice is better than a great deal which is used merely to pass an examination, or impress others with the amount you know. Never lose sight of the fact that you should *obtain* and *use* the air brake knowledge which will aid in making accurate reports and doing good braking.

GENERAL INFORMATION.

Brakes are used to prevent movement of cars or engines when at rest and, when in motion, to control their speed on descending grades or to stop them whenever desired. These results are accomplished through the friction or holding power resulting from pressing the brake shoes against the wheel faces or treads.

An air brake is one with which compressed air, instead of hand power, is used to cause the brake shoe pressure.

The automatic air brake has the following ten important parts which, with their connections, are illustrated by Plate 1. Those parts requiring it will be illustrated and described in detail in following chapters.

First—A *Brake Cylinder* which applies the air pressure to the brake rigging, thus forcing the brake shoes against the wheels and causing the friction or holding power.

Second—An *Auxiliary Reservoir* where the air pressure is stored for filling the brake cylinder to apply the brake.

Third—A *Pressure Retaining Valve* that in its ordinary or cut out position permits of the brake cylinder pressure being freely discharged to the atmosphere, or when cut in, as in descending a mountain grade, retards the discharge of air from the brake cylinder down to 15 pounds and then retains this amount.

Fourth—A *Train Pipe* for conveying the air to fill or "charge" the auxiliary reservoirs and cause the release of the brakes if applied.

Fifth—The *Triple Valve*, having the train pipe, auxiliary reservoir, brake cylinder and pressure retaining valve connected by separate openings and which controls the flow of air between these parts so as to cause charging, applying and releasing of the brake.

Sixth—A steam-driven *Air Pump* for compressing the air.

Seventh—A *Main Reservoir* into which the pump discharges the compressed air. This reservoir catches most of the moisture, dirt and oil discharged with the air by the pump, and in this reservoir a reserve amount of air is stored for quickly charging auxiliary reservoirs and releasing brakes.

Eighth—An *Engineer's Brake Valve* having openings leading to the main reservoir, the train pipe, and the atmosphere. With it (*a*) the main reservoir pressure is allowed to flow into the train pipe, causing the triple valve to open ports that permit the auxiliary reservoir to charge, and any air in the brake cylinder to pass to the retaining valve, from which it escapes freely to the atmosphere when the retaining feature of the valve is cut out; (*b*) all connections are closed to retain both main reservoir and train pipe pressures so as not to cause the triple valve to either release or farther apply the brake; and (*c*) the main reservoir

pressure is retained while making a discharge from the train pipe to the atmosphere to cause the triple valve to apply the brake.

Ninth—An *Air Pump Governor* which sufficiently reduces the steam supply to the pump as to prevent a farther gain in air pressure when the desired amount is attained in the part (main reservoir or train pipe) to which it is connected.

Tenth—An *Air Gauge* having two hands so as to indicate at the same time the pressure in the main reservoir and that in the train pipe.

The automatic action of the air brake is mainly due to the triple valve, of which there are two types, plain and quick action. The first is used with driver, tender (except as noted below) and engine truck brakes, and the quick action triple valve with all modern car brakes and passenger tenders. As they have the same air connections and as the parts that operate in the ordinary or service braking are alike, the plain triple valve alone is shown in the general illustration Plate 1.

The triple valve is made to perform its duties by the variation of the train pipe and auxiliary reservoir pressures. If the train pipe pressure is the higher of the two, made so by filling it from the main reservoir or reducing ("bleeding") the auxiliary reservoir pressure, certain parts of the triple valve will move to position for releasing the brake and charging the auxiliary reservoir. But if the auxiliary reservoir pressure is the higher of the two, made so only by reducing the train pipe pressure, the charging opening between the train pipe and auxiliary reservoir will be cut off and air will be admitted to the brake cylinder; thus applying the brakes.

The automatic feature results from the fact that a reduction in the train pipe pressure, such as would follow the bursting of a hose or the train parting, will cause the brakes to apply.

The plain triple valve was employed with the first freight car brakes. It was entirely satisfactory for all service braking, but in an emergency with a long train it required too great a distance to make a stop and caused very serious shocks. This was due to the long time required by the engineer's brake valve, which made the only opening from the train pipe to the atmosphere, to reduce the train pipe pressure enough (20 pounds) to cause a full application, and to the additional fact that the reduction and, in consequence, the application of the brakes was sudden and heavy at the head end, but lessened toward the rear, so that immediately following the brake valve being placed in emergency position the head brakes were fully and suddenly applied while, if the train was long, the rear ones had not started to set.

This showed the need in emergencies for some means of getting a quicker reduction in train pipe pressure, one that would set the brakes faster than the train slack could run in or out. It was accomplished by *adding* some parts to those of the plain triple valve, the improved device being designated as the quick-action triple valve. With it, if the train pipe pressure is reduced *gradually*, the added or quick-

action parts do not act, but if it is reduced *suddenly* they at once, while the service action is taking place, aid the engineer's brake valve or other part that caused the sudden reduction, by making a discharge of air from the train pipe at each triple valve. This sudden and almost simultaneous application of the brakes throughout the whole train, aided by special features which will be described later, result in the quicker and shorter stop desired in emergencies.

As the method of operating just described, commonly spoken of as quick-action or emergency, should never be used for ordinary braking, there is provided in all of the modern Westinghouse brake valves a "service stop" position which when in order will never cause quick action.

The foregoing constitute the foundation principles of the air brake and should be studied until well remembered.

THE NINE AND ONE-HALF INCH AIR PUMP.

(Westinghouse.)

CONSTRUCTION AND OPERATION.

The lower part of the 9½-inch pump is where the air is compressed and the upper part is the steam engine which drives the lower part or air compressor. These are shown by Plates 2 and 3.

AIR CYLINDER.

The compressor consists of an air cylinder 63 in which operates the air piston 66. This piston has two, well-fitted, cast iron packing rings 67 and is moved up and down the full length of the cylinder by the steam piston 59, having similar packing rings, to which it is connected by piston rod 65. This rod 65 has a stuffing box where it passes out of the air cylinder and another where it enters the steam cylinder. These are in the center piece 62, which forms the upper head for the air cylinder and the lower head for the steam cylinder, thus connecting the two.

The illustration of the air cylinder in Plate 2, is not exactly as it is constructed, it being slightly altered so as to show some of the passageways that would not be made clear in an accurate drawing; but the parts and method of operation are correct.

The pump is double acting and has four air valves. They are all alike and are numbered 86. Those on the left are respectively the upper and lower receiving valves, and those on the right the upper and lower

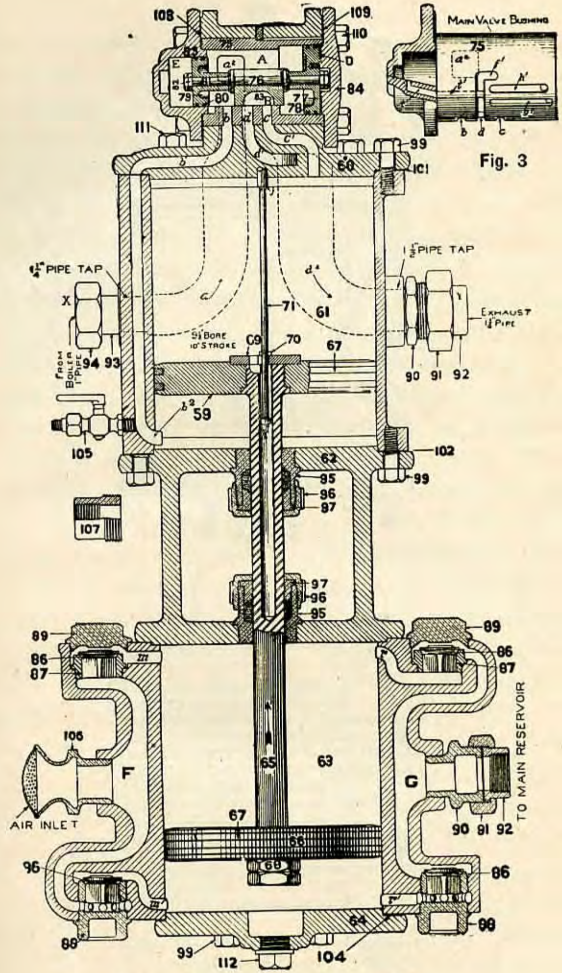


Plate 2—Nine and One-Half Inch Pump.
Front View.

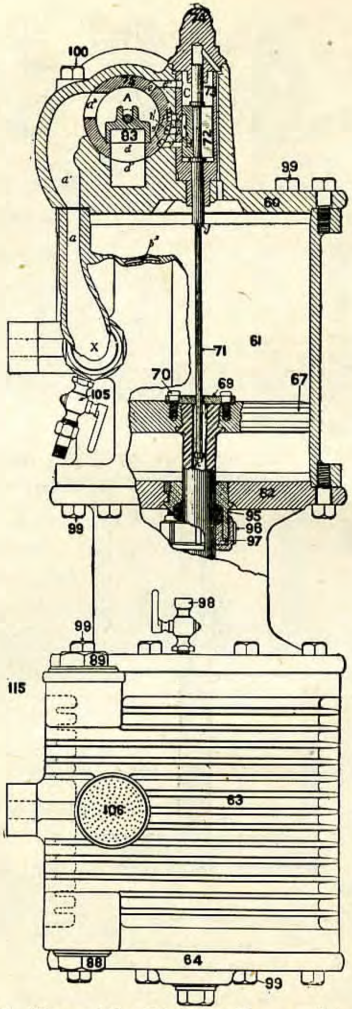


Plate 3—Nine and One-Half Inch Pump.—Side View.

discharge valves. From the air inlet, passageways lead to the *bottom* of the two receiving valves, and from the main reservoir connection similar ones lead to the *top* of the discharge valves. The cylinder is connected with the *top* of the receiving valves and the *bottom* of the discharge valves.

The piston is shown making its up stroke. This causes a partial vacuum or suction below it. As the lower discharge valve prevents air from passing back from the main reservoir, the lower receiving valve is raised and air is drawn in through the air inlet.

While this is taking place, the air above piston 86 is being compressed as the upper receiving valve will not allow it to pass back to the atmosphere. When the pressure above the piston slightly exceeds that in the main reservoir, which is on top of the upper discharge valve, the valve is lifted and the air above the piston is discharged into the main reservoir.

On the down stroke this is repeated in the reverse order, air being drawn into the upper end of the cylinder, while that below the piston is being compressed and discharged into the main reservoir.

STEAM CYLINDER.

Steam from the boiler, after passing through the pump governor, connected to union nut 94, enters the pump at X, flows up through passageway a, a^1 and at a^2 enters the main valve bush 75 and fills the cavity A. This cavity has a small piston 79 on the left and a larger piston 77 on the right, joined by the rod 81-76. Between the collars of this rod is the main valve 83, a slide valve of the D type, which admits and exhausts the steam from the cylinder.

In the position shown, live steam can flow down through b, b^1 to b^2 where it enters below the main steam piston 59 and drives it up.

At the same time, the exhaust cavity B in slide valve 83, is connecting port C, C^1, entering the top of the cylinder, with exhaust passageway d, d^1 and d^2, to which the exhaust pipe is coupled at Y, thus discharging the steam from above main piston 59.

On the completion of the up stroke, slide valve 83 is moved to the left so as to (*a*) connect the lower end of the cylinder with the exhaust cavity and to (*b*) admit live steam to the upper end, thus causing the down stroke.

The reversal of the pump stroke is accomplished as follows:

The left end of cylinder E, in which the small piston 79 operates, is always open to the exhaust; hence, the steam in cavity A always tends to drive this small piston to the left. The larger piston 77 has the space D on its right, being one end of the cylinder in which this piston operates, connected with the exhaust when the main piston is making its up stroke, as shown, but live steam pressure is on this side of the piston when the main piston is making its down stroke.

With the outsides of pistons 77 and 79 connected with the exhaust, the larger one draws piston 79 and slide valve 83 to the right, as shown. But when live steam is admitted to D on the right of piston 77, the

latter is balanced, and the small piston 79, the left side of which is always connected with the exhaust, can then draw piston 77 and slide valve 83 to the left and thus cause the down stroke of the main piston.

Steam is admitted to and exhausted from space D at the right of piston 77, by the vertically operating reversing valve 72, Plate 3. The space C about it is constantly supplied with steam from cavity A through port e, e^1. The reversing valve 72 is operated by the reversing-valve rod 71, which extends into the hollow piston rod 65. The reversing-valve rod has a button head k on its lower end and a shoulder j near the upper end of the cylinder. As the main steam piston completes each stroke the reversing-valve plate 69, secured to the main piston, comes in contact with one or the other of the points j and k on the reversing-valve rod, thus moving the reversing valve 72.

The reversing valve seats at the left and has an exhaust cavity H. Leading from its seat are three ports, f, h and g, which join their continuations f^1, h^1 and g^1 in the main valve bush 75, Plate 2, Fig. 3.

Exhaust port f^1 does not enter the main valve bush, but is a groove in the shape of an inverted L, running to the left and then down around the bush into the main exhaust port d, shown in all three illustrations.

Ports h^1 and g^1 are grooves running to the right in the main valve bush, but end with holes that enter cylinder D at the right of piston 77, Plate, 2. The lower is the admission port g^1 and enters practically at the end of the bush so as to insure against piston

77 closing it. Port h^1 is the exhaust and enters a short distance from the end of the main valve bush so that piston 77 will pass it and get the cushion needed to prevent it from striking hard on the cylinder head 84.

In the position shown, cylinder D is connected with the exhaust port at *d* by port h^1, *h*, Plate 3, exhaust cavity H in the reversing valve and port *f*, f^1. Admission port *g*, g^1 is closed by the lower end of the valve. This results in the position of main valve shown in Plate 2 and causes the up stroke of the main piston.

When the completion of the up stroke has raised the reversing valve 72, Plate 3, the lower part of the latter will cover exhaust port *h*, h^1 and open admission port *g*, g^1. This will admit live steam to D on the right of piston 77, Plate 2, balance the pressure on the opposite side, thus allowing small piston 79 to move the main valve 83 to the left, and cause the down stroke of the main piston.

The Left Main-Valve Cylinder Head 85, Plate 2, is also shown by Fig. 3. In the latter may be seen port *t*, running from the left end of cylinder E in which the small piston 79 operates, to the end of the main valve bush and continuing in the wall of the latter until it ends in exhaust groove f^1, leading to main exaust port *d*. This is the connection previously referred to.

A Balancing Port, Plate 3, runs diagonally to the right in reversing valve cap nut 74, and meets a groove down the outside of the reversing valve bush 73, where

it enters the upper end of the cylinder through a small port in the head. The object is to assure the same pressure above as below the reversing rod, whether there is live or exhaust steam in the upper end of the cylinder, thus balancing it so far as steam pressure is concerned.

MAINTENANCE.

The *Air Cylinder Heating* is a feature of air compression which can not be prevented. As an example of the *Normal Heating*, resulting from extreme duty, a 9½-inch pump 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 pump 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.

Keep a good, well lubricated swab on the piston rod as it will aid the rod packing and assist in lubricating the air cylinder. Be careful not to cross the gland nut threads.

The drain cocks should always be open while the pump is shut off, and it is important that the throttle does not leak.

Before starting a pump, see that the drain cocks are open, as they should be. Then run it very slow until all water is worked out and a pressure of 25 or 30 pounds is obtained to cushion the air piston. With the water out of the steam cylinder, close the drain cocks, feed this cylinder 10 or 15 drops of oil rapidly and then reduce the feed to the proper amount. The latter depends upon the pump speed, air pressure, condition of the steam cylinder and whether one or two pumps are being supplied. Have any pump steam pipe leaks promptly repaired, even though slight, as they waste a great deal of oil.

With two pumps per engine, the separate throttles should be kept wide open and the speed regulated

by the main pump throttle. The purpose is to equally divide the work.

Lubricate the air cylinder with valve oil only, using the automatic cup. Where this does not supply enough or the pump has no such cup, introduce a small amount of oil by means of the hand oil cup. The air cylinder needs regular lubrication as much as does the steam cylinder. A little at a time and more frequently instead of one heavy oiling for the trip is what is needed. An oiling just before heavy pump labor, as before starting down a steep grade, is very important.

Do not use more oil than necessary as it is wasteful and will quickly gum up the packing rings, ports and valves, a condition likely to come about gradually even with proper oiling. For the same reasons the cylinder should never be lubricated through the suction.

Where either the steam or air cylinder requires an unusual amount of oil to keep it lubricated it indicates defects which should promptly be repaired.

The standard *Air Valve Lift* is three thirty-seconds (3-32) of an inch for all of the valves. As the lift increases with use, repairs should be made before it is sufficient to cause damage to valves and seats by pounding.

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.

If a *Pump Refuses to Work* when its throttle is open, shut off the steam for about fifteen seconds, then admit it quickly. This failing to start the pump, tap lightly on the top head. If again unsuccessful open the drain cocks so as to determine if the governor is at fault. If not, shut the pump throttle, remove the plug from the lower air cylinder head and, by feeling, ascertain if the nuts have worked off from the piston rod. If not, remove the reversing valve chamber cap 74, raise the rod carefully until its end touches the reversing-valve plate 69, then pull to determine whether the plate is loose.

If either of the faults just mentioned are found to exist, an attempt to make temporary repairs may be warranted, but otherwise it would not be as a rule. The existing circumstances must govern this to a considerable extent, bearing in mind that safety and getting trains in on time are the requisities.

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.

A pump with a *Blowing Steam Cylinder* is liable to stop if dry and very closely throttled.

While steam cylinder blows are to be avoided as far as possible, so as to prevent waste of fuel and insure proper operation, yet so long as the pump runs reliably and at ample speed, the good condition of the air cylinder is of the greater importance. Any

faults in the latter should be promptly repaired, even though comparatively slight if the pump is in hard service.

If the *Air Cylinder Heats Abnormally* (see Normal Heating) it will be due to one or more of the following defects: Leakage past the air piston packing rings, from the main reservoir back into the air cylinder, at the air cylinder stuffing box, at either air cylinder head or at the receiving valves; air cylinder insufficiently lubricated; or obstructed air passageways, due either to accumulated gum or to insufficient air valve lift.

To *Test the Air Cylinder*, obtain 90 pounds main reservoir pressure, open the air cylinder oil cup 98, regulate the speed to 30 exhausts per minute and then, by holding a finger just above the cup while the piston is making its *down* stroke, note whether any air discharges and, if so, for about how much of the stroke. Leakage for one-fourth or more of the stroke demands prompt repairs.

The fault is either leakage past the piston packing rings, or leakage back from the main reservoir or both. That from the main reservoir will show at the open oil cup with the pump stopped.

A sticking upper receiving air valve or air stuffing-box leakage will interfere with the foregoing test and must first be remedied.

A good air cylinder will have no blow at the oil cup on the down stroke. This does not imply entire freedom from packing ring or discharge valve leakage as any such will cause no blow at the oil cup until it is so great as to fill *above atmosphere pressure* the space created as the air piston descends. Therefore, the air discharged at the oil cup on the down stroke is but a *portion only* of the leakage existing.

The speed and main reservoir pressure given for the test are of the utmost importance in rendering it reliable. It should be noted, too, whether the receiving valves leak, determining this by listening at the suction opening when the pump is working against full pressure.

It is evident that a pump can compress no 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 suction* when the pump is working slowly while being controlled by the governor, and whenever 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.

An *unequal stroke* is usually due to air valve or air stuffing-box leakage, improper air valve lift or obstructed air ports.

Any steam leakage that can reach the pump suction should be promptly repaired as such increases the danger of water entering the train pipe.

When *Air Valves Stick* it may be caused by back leakage from main reservoir; leakage past main piston packing rings; an accumulation of gum on valves; too

broad bearing of valves on seats; a too acute angle of valve seats; or applying valves with no lift.

Sticking valves that can be loosened by tapping lightly about them can generally be kept working until the terminal is reached. A few drops of engine oil in such cases (this being the only time such practice is permissible) will aid in keeping the valves working, but on arrival at terminal the cause for valves sticking should be ascertained and remedied.

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

THE EIGHT-INCH AIR PUMP.

(Westinghouse.)

CONSTRUCTION AND OPERATION.

Plate 4 shows the construction of the eight-inch air pump. A steam cylinder 3 and an air cylinder 5 are joined together by a center piece 4 which forms the lower head of the steam cylinder and the upper head of the air cylinder. Suitable stuffing boxes 56 provide for packing piston rod 10, the lower end of which is attached to air piston 11 and the upper end to the steam piston 10. Each of the pistons is provided with packing rings 12 and 13.

Suitably arranged valves in the walls of steam cylinder 3 and its upper head 2 admit steam alternately above and below the steam piston 10 forcing it upward and downward and giving a similar movement to the air piston.

AIR CYLINDER.

The operations of the air cylinder parts are exactly the same as with the 9½-inch pump. Except in sizes, the only difference in construction is that each receiving valve is immediately below the discharge valve for that end.

On the up stroke air is drawn in from below lower receiving valve 33, passes it and enters the cylinder. Lower discharge valve 32 prevents a back flow from the main reservoir, connected as indicated.

At the same time, the air above piston 11 is com-

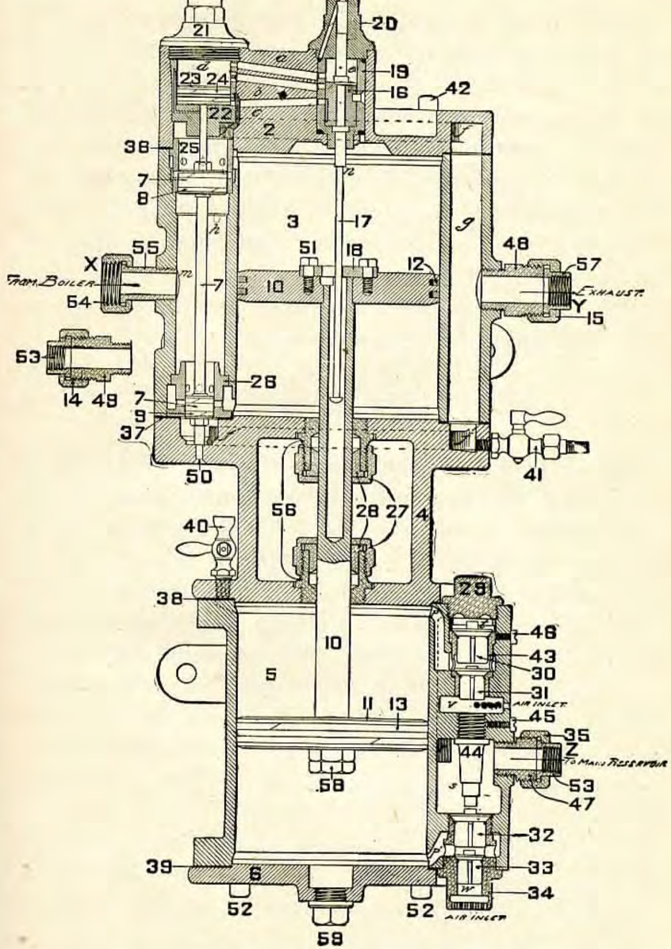


Plate 4—Eight-inch Pump.

pressed, being prevented by upper receiving valve 31 from flowing back through the upper air inlet. When the pressure above piston 11 slightly exceeds that in the main reservoir it will lift upper discharge valve 30, enter the opening indicated by the dark spot at the left above the valve, flow down this passageway toward the back of the pump to where it joins the common discharge, shown by the dark spot to the left of discharge valve stop 44.

The down stroke merely reverses the order of operation, the pump being double acting.

STEAM CYLINDER.

Steam from the boiler passes through the governor, connected to union nut 54, and enters between the two pistons of main valve 7. The bush in which each piston works, has two series of holes or ports. The pistons are so spaced by the valve stem that when the main valve is down, as shown, the lower or small piston has closed its lower series of ports and opened the upper, thus admitting steam below the main piston 10. The upper main valve piston has its lower or admission ports closed and, by the upper series, has connected the upper end of the steam cylinder with the exhaust.

The letter *f* just below the number 22 on the reversing cylinder and the two, parallel, dotted lines leading from it across the head to another letter *f*, indicate the exhaust passageway around the back of the pump head. A similar passageway is indicated

from below the small main valve piston to the common exhaust cavity at the right of the cylinder. This cavity has a drain cock 41 at its lowest point. There are no cylinder cocks.

When the main valve is up it closes the lower admission and opens the lower exhaust port, while opening the upper admission and closing the upper exhaust port, thus causing the down stroke of the main piston 10.

Where there is pressure only between the two pistons of main valve 7, the greater area of the upper one causes the valve to raise and force reversing piston 23, the stem of which rests on the main valve, to the upper end of its cylinder, causing the down stroke of the pump. But with steam above the reversing piston the main valve is forced down, thus causing the up stroke of the pump.

Steam is admitted to and exhausted from *d* above the reversing piston 23 by reversing valve 16. This valve is operated by reversing valve rod 17, in the same way as with the 9½-inch pump. The port supplying the reversing valve with steam can not be shown in the illustration, but it leads from *h*, between the two pistons of main valve 7, direct into reversing valve bush 19.

With the reversing valve down, as shown, steam from *e* is admitted through *a* to *d* above reversing piston 23; but with the reversing valve up, the admission port *a* is closed and the exhaust cavity in the face of the valve connects *b* and *c*, the two exhaust ports, discharging the steam down the side of reversing cylinder 22 into the upper exhaust passageway *f*.

This pump has a balancing port exactly the same as shown in the 9½-inch pump, but Plate 4 does not show the groove down the outside of reversing valve bush 19, and the diagonal hole in reversing valve cap 20 is on the ieft.

MAINTENANCE.

The *Standard Air Valve Lift* is one-eighth (⅛) of an inch for the receiving valves and three-thirty-seconds (3-32) of an inch for the discharge valves.

Other than the foregoing, that which has been said about heating, running, lubricating, testing, defects and maintenance in general for the 9½-inch pump applies equally to the eight-inch pump.

PUMP GOVERNOR.

(Westinghouse.)

Plate 5 shows the single pump governor. When used in connection with a brake valve having a feed valve attachment it controls the main reservoir pressure, but with older forms of brake valves it controls the train pipe pressure.

Steam enters at X, passes under steam valve 26 and out to the pump, connected at Y.

The upper end of the stem of the steam valve 26 is connected to piston 28, having a packing ring 29. This piston is operated by air pressure above it and spring 31 below it. Air pressure admitted above piston 28, drives it down until steam valve 26 so restricts the flow of steam and, in consequence, the pump speed as to prevent a farther increase in pressure. With no air admitted above piston 28, its spring 31 holds the steam valve wide open, as shown.

The air pressure governed is connected at W and enters chamber *a*. When diaphragm valve 47 is raised the air passes down port *b* to the top of piston 28, driving the latter downward, as explained.

Vent port *c* causes a small steady leakage so long as air is passing diaphragm valve 47, and when the latter closes it quickly discharges the pressure from above piston 28 so it can raise.

A diaphragm 46, composed of two thin sheets of brass to give it strength and elasticity, has the dia-

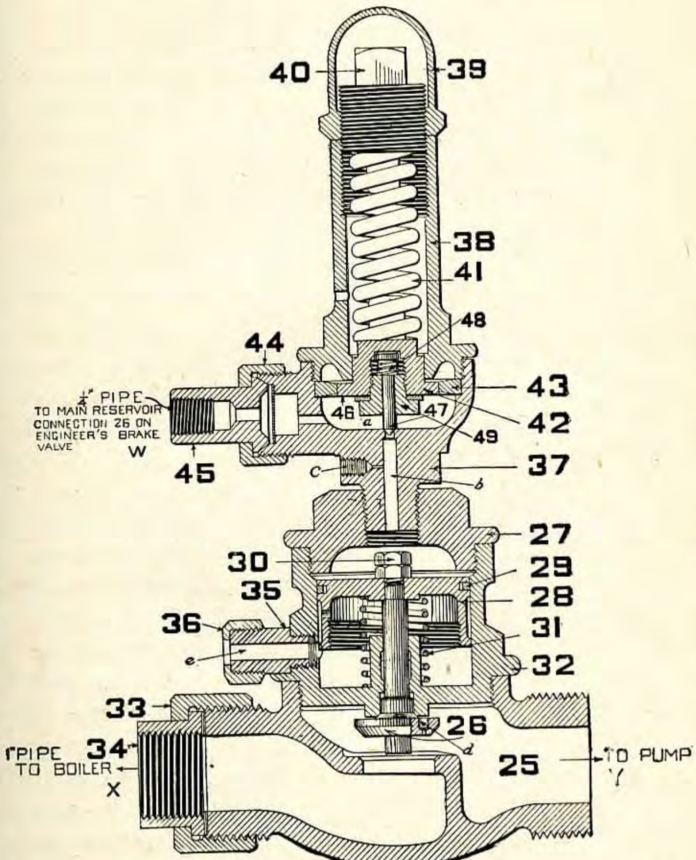


Plate 5—Pump Governor.

phragm valve 47 secured to it by the diaphragm base 42 and nut 49.

A small spring 48 under the head of the diaphragm valve 47 and a loose fit through its nut 49 allow it to seat accurately, yet prevent lost motion vertically.

The diaphragm is clamped to the narrow shoulder of the diaphragm body 37 by the pressure exerted by spring box 38 on diaphragm ring 43, thus making an air tight joint.

The upward pressure of the air in chamber *a* beneath the diaphragm 46 is resisted by the regulating spring 41, the tension of which is adjusted by regulating nut 40, inside of check nut 39. When the air pressure exceeds the resistance of regulating spring 41 the diaphragm and its attached parts raise and a sufficient increase will cause the diaphragm base 42 to strike on the spring box 38.

The small hole in spring box 38 is to guard against any accumulation of air pressure from slight leakage into the spring box. Vent port *c* is threaded in its larger diameter so one can be plugged with the duplex governor. Waste connection *e* is to prevent the accumulation of steam or air which may leak in beneath the piston. The hole in the side of the piston is to prevent the latter from closing the waste opening when down. Steam valve 26 seats above so as to prevent steam leakage past its stem when wide open, the fit of the stem in the guide being depended on at other times. A small port *d* in the steam valve aids the vent port *c* in preventing all steam from being temporarily cut off as in cold weather this

would be followed by condensation which would wash out the lubrication and throw water from the exhaust.

Though the pump governor is intended to regulate the air pressure to which it is connected, and the pump speed should be sufficient to assure this if practicable, it is not to regulate the pump speed. This should be regulated by the throttle and should never be faster than the circumstances require.

DEFECTS IN THE PUMP GOVERNOR.

To operate properly the pump governor should be very sensitive. It should regulate the air pressure when the predetermined amount has been obtained, and when this pressure has been reduced not over two pounds, the governor should allow the pump to work freely again. A *sluggish pump governor* when connected to the train pipe is very liable to cause stuck brakes. It may control the pump at the desired pressure, but if it opens so sluggishly as to require a reduction of, say, 5 or more pounds of air before it will allow the pump to work freely again, train pipe leakage may cause brakes to creep on. If such a governor is connected to the main reservoir pressure it may prevent the full amount of excess pressure from being had at times when most needed.

If the *governor does not allow the pump to operate properly* and cannot be made to do so by adjusting the regulating spring 41, the trouble may be due to any of the following causes: leaky diaphragm valve; vent port *c* stopped up; waste pipe connecting at *e* frozen or stopped up; or the governor piston 28 stuck in its cylinder.

Rust or scale will prevent the diaphragm valve from seating properly, in which event the air under the diaphragm will leak past the defective valve and onto piston 28. If the air leaks past the valve faster than it can escape through vent port *c*, piston 28 will be forced down far enough to partially or wholly close steam valve 26, causing the pump to run slowly or stop. A scratched or cut diaphragm valve or seat will cause the same trouble.

If the vent port *c* is stopped up the air above piston 28 cannot escape through that source and it will have to leak past packing ring 29. If the latter happens to be a snug fit the air will leak by it slowly, resulting in a very sluggish acting governor.

If the waste pipe is frozen or stopped up, air leaking by piston 28 or steam by stem of steam valve 26 will gather in the space below piston 28 and prevent the governor from regulating the pressure. Gum on the diaphragm valve may cause the same trouble.

When from some unknown cause the air pump refuses to operate and can not be started by opening and closing its throttle or by tapping lightly on the head, ascertain by the use of the drain cocks with the 9½-inch pump or, with the 8-inch, by breaking the joint between the governor and pump, whether the governor is at fault. If so, tap lightly on the steam pipe near the governor, but *not on the latter.* This failing to remedy the trouble, clean the diaphragm valve and seat, avoiding scratching either. Be care-

ful not to screw regulating nut 40 down too far, as it is possible to seriously damage the diaphragm, its valve and the seat.

All that has been said concerning the modern governor will apply to the old style governor as well, but the diaphragm in the latter is more susceptible of derangement because it is not so well supported. The tendency for it to become distorted causes it to be less reliable.

Before adjusting the governor it should first be known that the air gauge is correct. If necessary, the air pressure can be cut out from the governor by placing a blind gasket in the small pipe leading to it, or by plugging up the opening at W. In such a case, however, the air pressure must be regulated by the pump throttle. Any defects in the pump governor should be promptly and intelligently reported on arrival at terminal.

DUPLEX PUMP GOVERNOR.

(Westinghouse.)

The duplex pump governor, Plate 6, is used in three different ways.

First, in connection with the regular automatic brake equipment and modern brake valve so as to permit of *carrying* (running position of automatic brake valve) a low excess pressure in order to reduce the pump labor, and yet assure obtaining a *high excess pressure* during brake application, so as to quicken the following release and recharge.

Second, it forms a part of the additional apparatus known as Schedule U or High Pressure Control, by means of which the mere turning of a cock handle will increase the regulations of the train pipe and main reservoir pressure from those now used to such higher amounts as are warranted by fully loaded freight trains in special service.

Third, with additional parts to those used in Schedule U, to make a similar change in pressure regulation for the High Speed Brake in passenger service.

The duplex governor differs from the single type only in having added to the latter a siamese fitting and another top or diaphragm portion. The siamese fitting is a tee which screws into cylinder cap and carries the two top or diaphragm portions. If either of the latter acts it admits pressure above the piston.

As this arrangement connects the two vent ports, one must be plugged to avoid wasting air.

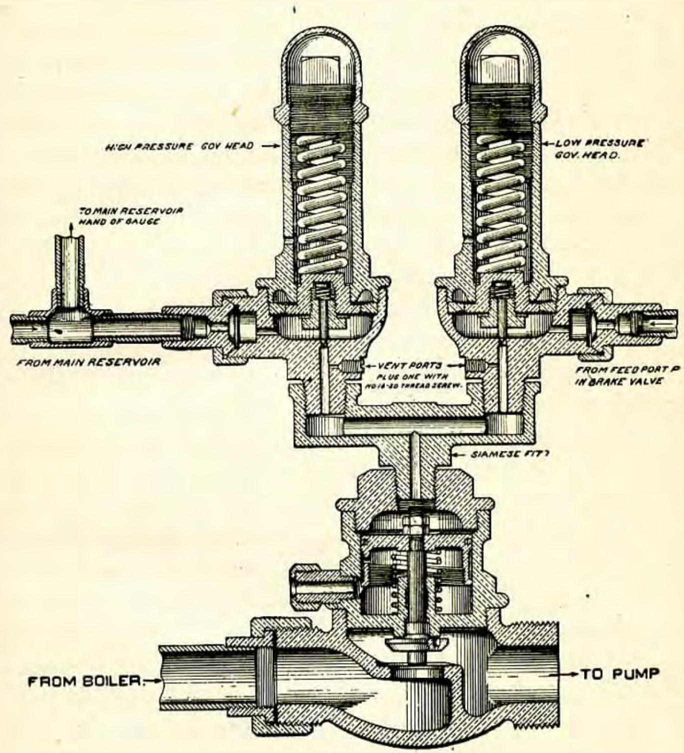


Plate 6—Duplex Pump Governor.

The high pressure head is connected direct with main reservoir pressure and should never be adjusted higher than 125 pounds where used with the regular automatic equipment.

With the latter the low pressure head is so connected with the brake valve as to be in communication with main reservoir pressure when the brake valve handle is in running position and, being set at 85 pounds, it will limit the main reservoir pressure to that amount in this position. Moving the handle to lap or either application position will cut out the low pressure head and, if time is sufficient, will allow the pump to increase the main reservoir pressure to the adjustment of the high pressure head.

The connection of the low pressure head will be shown and the reason for the operation as stated will be explained under "G-6 Engineer's Brake Valve."

Where an engine is fitted with two pumps, one has the duplex governor and the other only the steam valve portion, being those parts below the siamese fitting. The cylinder cap of this governor is connected by a small pipe with the siamese fitting, especially tapped for the purpose. Therefore, when either top of the duplex governor admits pressure to its steam valve portion, the corresponding part of the other pump will receive the same pressure and the two pumps will be controlled at once, thus equally dividing the work of maintaining the pressure.

The defects of the duplex governor being the same as with the single type, will not require farther explanation.

BRAKE CYLINDER, AUXILIARY RESERVOIR AND TRIPLE VALVE COMBINED.

Plate 7 illustrates the brake cylinder, auxiliary reservoir and quick action triple valve in half section, and shows the compact arrangement usually employed on freight cars.

BRAKE CYLINDER.

The work of the compressed air ends with the brake cylinder, and the one here illustrated will convey a good understanding of this important part of the air brake system. The cylinder proper is indicated by 2.

The piston 3 is the part against which the air pressure, entering the cylinder through tube *b*, operates and is shown in release position. The piston proper is indicated by the 3 on the left. The 3 on the right refers to the hollow rod riveted to the piston, guiding it true in the cylinder and receiving the push rod connected with the cylinder lever, neither of which are shown.

The piston is made air tight by packing leather 7, clamped to the piston by follower 6 and held in contact with the cylinder wall by expander 8. In order that the packing leather may make an air-tight joint on the cylinder wall, the latter must be lubricated and reasonably free from grit and gum.

The leakage groove *a*, indicated by dotted lines, is a shallow groove cut in the wall of the cylinder. It requires about 3 inches travel to move the piston

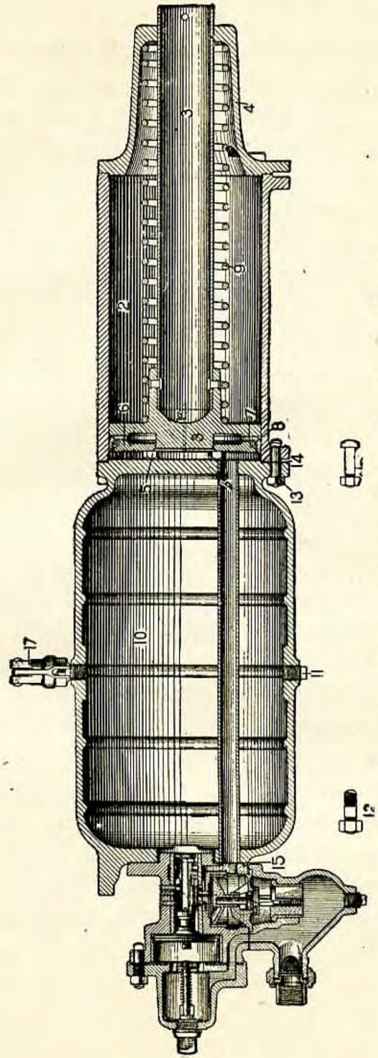


Plate 7—Brake Cylinder Auxiliary Reservoir and Triple Valve.

beyond this groove, and up to this amount it allows leakage past the packing leather to the atmosphere. This leakage will prevent the brake from applying unless the air pressure enters fast enough and for a sufficient time to move the piston beyond the groove.

It largely prevents brakes from "creeping on" by reason of unsupplied train pipe leakage, both when coupled to the engine and when detached, as in switching, etc.

Release spring 9 is to return the piston 3 to release position when the air pressure is released.

Non-pressure cylinder head 4 has an extension or spring pocket which prevents the release spring from closing solid in case of long piston travel.

AUXILIARY RESERVOIR.

Auxiliary reservoir 10 is where the pressure is stored for applying the brake. It is made of a size proportionate to the brake cylinder it supplies. Its end on the right forms the pressure head for the brake cylinder. Running through it is tube *b* which connects the brake cylinder with the triple valve, but having no connection with the auxiliary reservoir.

The release valve 17 or "bleeder" is for discharging air from the auxiliary reservoir and is employed to release the brake when the engine is detached or, with it coupled, when for any reason the engineer can not release it. The release valve is usually located as shown, but can be connected below by exchanging it and plug 11.

QUICK ACTION TRIPLE VALVE.

The quick action triple valve is shown connected to the end of the auxiliary reservoir at the left. Note that a threaded portion of the triple valve projects into the large opening in the end of the auxiliary reservoir and that below this threaded portion the tube *b* comes opposite another triple valve passageway.

The triple valve is secured to the auxiliary reservoir by studs 12, the triple valve gasket 15 aiding in making the joint.

BRAKE CYLINDER DEFECTS.

The two most common and serious brake cylinder defects are wrong piston travel and cylinder leakage. The first is covered under "PISTON TRAVEL."

Brake Cylinder Leakage is usually past the packing leather, due to gum, grit and lack of lubrication, or through it, caused by wear or by a cut or a hole made when the packing leather was out of the cylinder. Sometimes it is in the gasket joint at the pressure cylinder head or, with driver and most tender brakes, the pipe connecting the triple valve and cylinder. As cylinder leakage is a very serious defect it should be promptly located, reported and remedied.

For brake cylinder tests see "Driver and Tender Brakes" under "ENGINEMEN," "Test of Brakes" under "TRAINMEN" and "Repair Track and Shop Brake Test" under "INSPECTORS."

PISTON TRAVEL.

By the term piston travel is meant the distance the brake cylinder piston moves away from the pressure cylinder head when the brake is applied. This distance is measured on the piston rod. With the ordinary or push type of cylinder this is obtained by making on the piston rod, when the brake is off, a mark even with the end of the cylinder head through which it projects. Then apply the brake and the distance from the mark on the rod back to the end of the cylinder head is the amount the piston has moved or the piston travel.

The shorter the piston travel the smaller the cylinder space to be filled and consequently the auxiliary reservoir pressure will equalize higher in the brake cylinder. The longer the piston travel the greater this space and consequently the brake cylinder pressure will be lower. Therefore the brakes with the shorter piston travel will be more effective, but, following a full application of *all*, will be a trifle harder to release.

The piston travel will always be longer when a car is running than when standing, the difference depending on the amount of lost motion in center bearings, journal brasses, boxes in pedestals and the deflection in the brake beams, levers and connections.

The standard piston travel on freight car brakes with a full service application is 6 inches. When

found less than 4 inches or over 8 inches it should be adjusted to between 5 inches and 6 inches.

The piston travel is adjusted by means of the dead levers. On cars fitted with outside hung brakes, the piston travel is shortened by moving the dead levers toward the centers of the trucks. On most cars fitted with inside hung brakes the dead levers must be moved in the reverse direction to obtain the same result. For regulation of piston travel, etc., on brakes fitted with automatic slack adjuster see "AUTOMATIC SLACK ADJUSTER."

AUTOMATIC SLACK ADJUSTER.

(American.)

The importance of correct piston travel on all brakes was explained in the previous chapter, and it was stated that the piston travel when running is always greater than when standing. This latter varies with different cars and ranges from one inch to two and one-half inches.

The automatic slack adjuster, Plates 8, 9 and 10, is a device for maintaining a uniform running piston travel of 8 inches, any longer travel being shortened one-thirty-second of an inch (1-32-inch) each time the brake releases.

On passenger cars the slack adjuster is secured to the front or pressure brake cylinder head, as shown by Plate 8 in which the upper part of the adjuster is removed. That end of cylinder lever 5, otherwise attached direct to the cylinder head, is connected with a crosshead in the slack adjuster. The movement of this cross-head any given distance from the cylinder head will reduce the piston travel the same amount, while a movement toward the head will increase the piston travel correspondingly. The cross-head is secured to a threaded rod 4 which has a ratchet-nut where its opposite end extends through the adjuster body. This nut has a hollow extension 1 for protecting the screw 4 and can be turned by an ordinary wrench when it is necessary to quickly let out or take up slack.

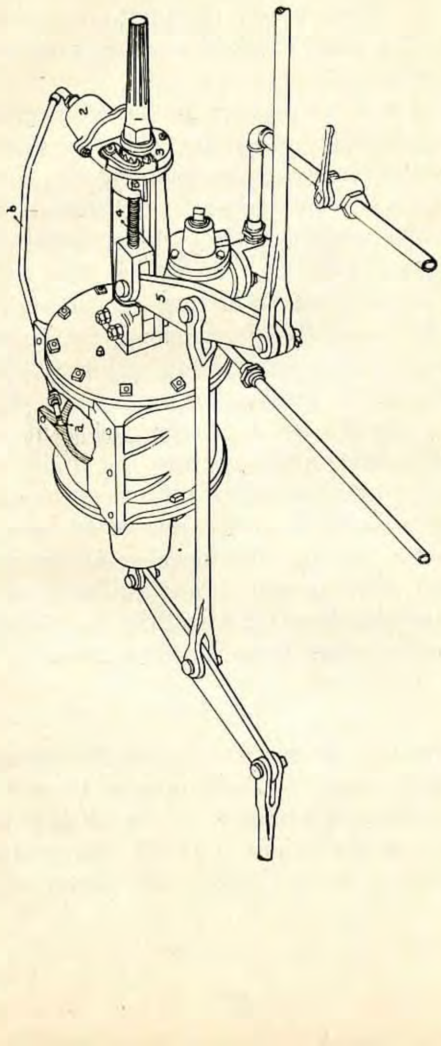


Plate 8—Automatic Slack Adjuster Attached to Brake Cylinder.

The piston travel, when over that for which the adjuster is set, is automatically shortened by a small cylinder 11, Plates 9 and 10, having connected with its piston 16 a pawl 22 which engages with and turns the ratchet-nut 27.

When there is no pressure in the adjuster cylinder 11 the pawl is not in contact with the ratchet-nut, as shown by Plate 9, thus enabling the nut to be turned either way by a wrench, as before mentioned.

The slack adjuster cylinder is similar in construction to the air brake cylinder. The piston 16 is made tight by a packing leather 19 and, when the air pressure has moved it and then been exhausted, is returned to its normal position by piston spring 21. The adjuster cylinder 11 gets air pressure from the brake cylinder, Plate 8, the connection being made by a small pipe *b* that is tapped into the brake cylinder at *a*. This port is located a distance from the front or pressure cylinder head approximately equal to the desired piston travel. The opening at the inside of the cylinder must be smooth and not over one-eighth of an inch in diameter, or it will cut the piston packing leather and cause brake cylinder leakage.

OPERATION.

Whenever the piston travel allows the piston packing leather to pass the small port *a*, Plate 8, brake cylinder pressure is admitted to the adjuster cylinder 11, Plate 9, moves its piston 16 the full stroke of the cylinder, Plate 10, compresses the piston spring 21

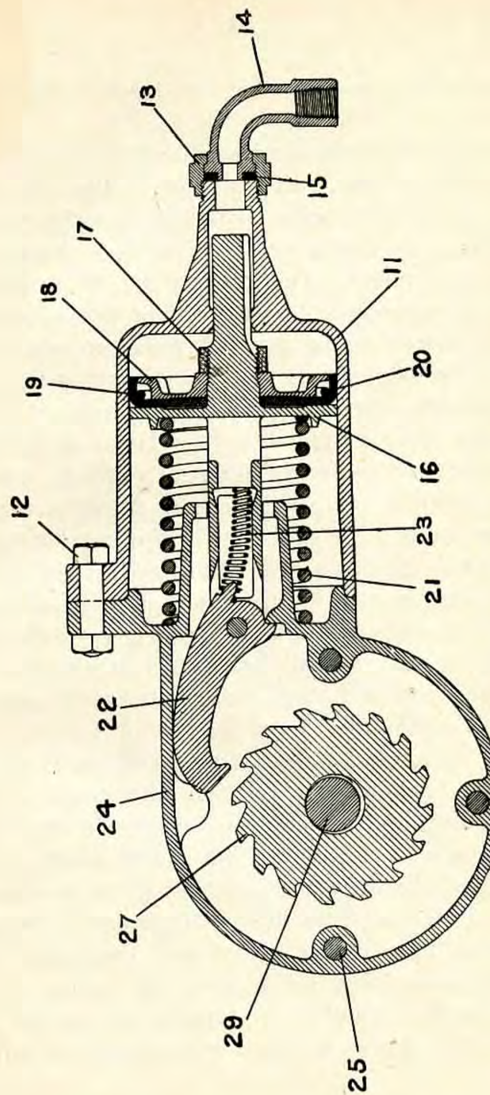


Plate 9—Automatic Slack Adjuster, Release Position, Slack Taken up.

and moves the pawl 22 over two teeth of the ratchet-nut 27.

When the air brake is released and the brake cylinder piston moves back past the port *a*, Plate 8, the air in the adjuster cylinder exhausts into the non-pressure end of the brake cylinder, which is always open to the atmosphere. This permits the piston spring 21 in the adjuster cylinder to force back the piston 16 and, by means of the pawl 22, make one-eighth of a turn of the ratchet-nut 27. This shortens the piston travel one-thirtieth of an inch (1-30-inch).

As the take-up movement is being completed a projection just below the pivot of pawl 22, comes in contact with a lug on the casing 24, thus throwing the pawl out of contact with the ratchet-nut 27. Pawl spring 23 is to keep the pawl in contact with the ratchet-nut at other times and is absolutely necessary when, as is possible, the adjuster cylinder is on the left of the ratchet-nut as this brings the pawl below the nut. Of these two positions the one illustrated is preferable.

Four turns of the ratchet-nut will make one inch difference in piston travel. As this means that it will require 30 applications to shorten the piston travel one inch, it follows that where much slack is let out on the adjuster to permit of replacing shoes it is desirable to immediately afterwards fully apply the brake, measure the travel and then take up by the ratchet-nut, any amount *over* 6½ inches.

The brake cylinder is tapped 8⅜ inches from the front or pressure head, but where the adjuster

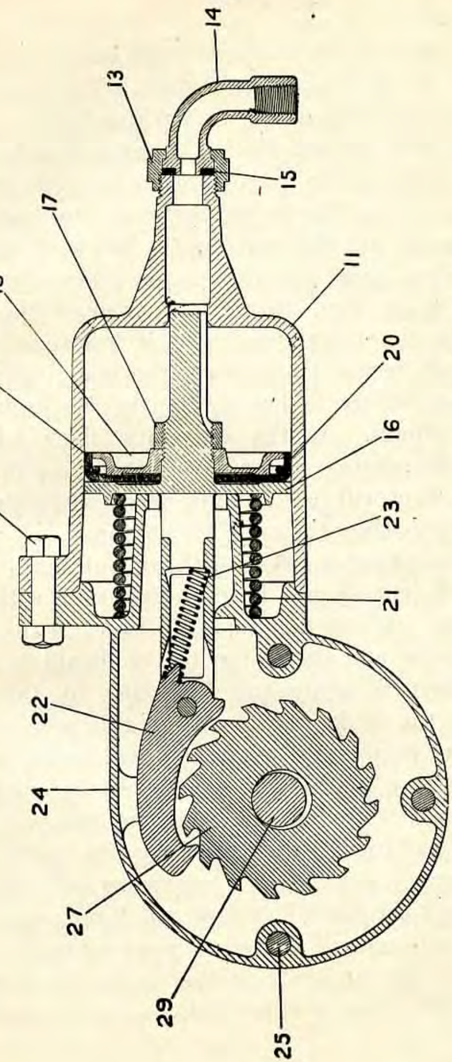


Plate 10—Automatic Slack Adjuster, Ready To Take Up Slack.

has regulated the piston travel, this amount will not be shown by a brake application. There are two reasons for this: first the piston packing leather, which opens the port leading to the adjuster cylinder, does not come back to the cylinder head in brake release. Therefore, though the space between the pressure cylinder head and the port to the adjuster cylinder is 8¾ inches long, yet the piston does not have to travel quite that distance to uncover the port. Second, the running piston travel is from one to two and one-half inches longer than the standing travel. This is due mainly to lost motion in the brake rigging and trucks. As the automatic slack adjuster regulates the *running* piston travel, it follows that the standing travel will be less than what exists with the brake applied when the train is running.

When equipping a brake with an automatic slack adjuster the car should be entirely fitted with new brake shoes. All slack should be let out on the automatic adjuster and the piston travel should be regulated between 6 inches and 6½ inches by the dead levers and the brake rods. Where this is done and the adjuster is in good order there will be no farther need of altering the rods or dead levers except larger or smaller wheels are put in. Following such a change, or where the proper adjustment was not made when the adjuster was applied, or in case some one has afterward altered the dead levers or rod connections, the method described will enable a proper correction.

Before letting out slack on the automatic slack adjuster always make a slight take-up movement, the

same direction as in screwing on a nut. Ordinarily the pawl 22 is free from the ratchet-nut 27 when the brake is off, Plate 9, but in some instances where there is excessive brake beam spring resistance or the adjuster is not in good order the take-up movement may not be completed, thus leaving the pawl 22 engaged with the ratchet-nut 27. *An effort to let out slack under such a condition would break the ratchet-nut teeth or the piston rod jaw.* The take-up movement will release the pawl and prevent such damage.

A pawl yet in contact with the ratchet-nut will be indicated, in this test, by the sound it should make on releasing when the take-up movement is completed. Where this occurs the cause of the failure to finish the take-up movement should be located and remedied. Excessive resistance when an attempt is made to let out slack also indicates the same fault. Breaking the adjuster parts under such a condition is inexcusable and must be avoided.

The adjuster illustrated, Schedule E, has a stop-screw against which the cross-head on screw 4, Plate 8, will strike in case all slack is taken up on the automatic slack adjuster. Such a condition will leave the pawl in contact with the ratchet-nut and prevent letting out slack. By removing the stop-screw the adjuster can finish its take-up movement and release the pawl. Do not fail to replace the stop-screw.

The Schedule J adjuster, for 14-inch and 16-inch passenger cylinders, has this stop-screw in the end of the hollow ratchet-nut extension, now standard for all adjusters.

The old style or Schedule C adjuster, which is quite similar to the one illustrated, but has no extension on the ratchet-nut, has no stop-screw. Where it is locked on account of all slack being taken up, the casing will have to be removed, the pawl pried out of contact and slack then let out.

The cause of all slack being taken up on the adjuster is failure to make the original adjustment as instructed or same being changed afterward by replacing wheels or some one letting out slack elsewhere than on the automatic slack adjuster. Its capacity is ample to wear out a full set of shoes without locking.

Cars starting on long runs must have at least four and one-half inches take-up movement left on the adjuster and not over 7-inch piston travel so as to insure correct piston travel being maintained and to prevent the adjuster from locking.

The three casing bolts 25, Plates 9 and 10, must be kept tight so as to exclude dirt. There should be a brass washer between the ratchet-nut and the end of the adjuster body. The adjuster screw 4, Plate 8, must be kept free from paint, oil, grease or any substance that will catch grit or cause gum.

Clean and lubricate the adjuster cylinder at the same time this work is done on the brake cylinder and at any other time required, using the same lubricant as is employed in the brake cylinder. Usually the cylinder is removed from the piston for cleaning, but quick repairs can be made by replacing the cylinder and casing complete by another in good order when the extra one is on hand. This is the best practice in

very cold weather, cleaning, lubricating and testing the removed cylinder inside of a building.

After cleaning and lubricating, work the cylinder back and forth on the piston a few times, draw it about two inches from the casing, cover its pipe connection with the palm of the hand and then endeavor to push the cylinder back to place, exerting a steady pressure for about one-half of a minute.

This will compress the air between the piston and the pipe connection. If any leakage exists past or through the piston packing leather the cylinder can gradually be shoved closer to the casing. Any such leakage should be remedied.

To test the action of the adjuster, let out slack on it until the brake piston can pass the adjuster port. Then have a brake application made and *listen* for the *two* clicks which should be made as the pawl passes the two teeth it should travel over at each operation. Also listen for leakage in adjuster cylinder or from its pipe. Next, have the brake released and note whether the ratchet-nut makes about one-eighth of a revolution, as it should.

In case of any failure of the adjuster to act as just described, repeat the test and if the results are the same, the cause should at once be located and remedied. But one click indicates a missing tooth or failure to move the required distance, assuming the ratchet-nut has not been turned by hand.

A possible cause of wrong action is the piston or its connected parts binding, owing to dirt or the adjuster cylinder being so tightened as to throw the piston out of line.

PRESSURE RETAINING VALVE.

Plate 11 shows the pressure retaining valve in use on freight cars and some passenger cars. On vestibuled cars the valve differs slightly in construction and the operating handle only is inside, but its general construction and action are the same. It is connected to the exhaust port of the triple valve by suitable piping from the latter to X, and is placed within convenient reach of the trainmen. Its purpose is to cause a slow discharge of brake cylinder pressure down to 15 pounds to the square inch and to retain this amount in the cylinder during the time the triple valve is in release, recharging the auxiliary reservoir preparatory to the brake being again applied. Its use is necessary down steep grades to reduce the amount of air required and to prevent the speed from increasing too rapidly while the engineer is recharging.

With the valve cut in, handle 5 is turned up to the position shown (horizontal). The air from the brake cylinder, when the triple valve is in release position, enters the pressure retaining valve at X and passes up through ports *b*, *b*, connected by the broad, shallow groove *a* in cock key 6, raises the weighted valve 4 and escapes slowly through the small port *d* until the triple valve is again brought to application position or the brake cylinder pressure is reduced to 15 pounds.

For brakes with cylinders 10 inches or less in diameter port *d* is one-sixteenth (1-16) of an inch in

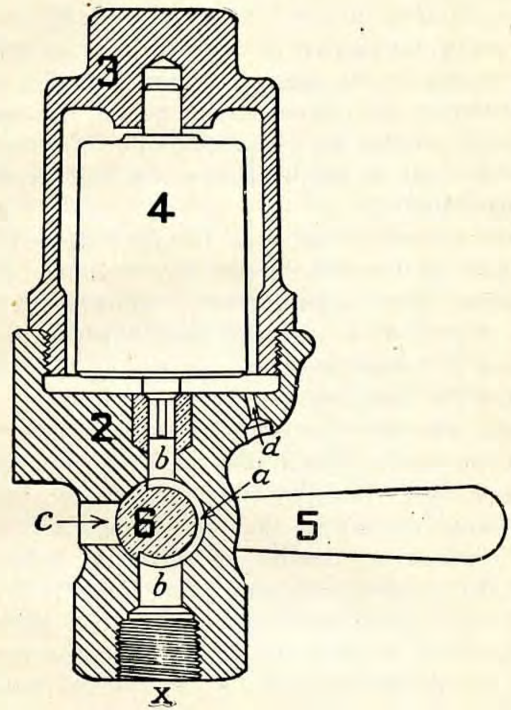


Plate 11—Pressure Retaining Valve Cut In.

diameter. For larger cylinders it is one-eighth ($\frac{1}{8}$) of an inch. The former requires a three-eights ($\frac{3}{8}$) inch pipe from the triple valve to X and the latter a one-half ($\frac{1}{2}$) inch pipe.

The diameter of port *d* is purposely made small so as to retard the passage of air from the brake cylinder. This results in the pressure accumulating in case 3 faster than it can escape through port *d;* this pressure acting in concert with weighted valve 4 causes the latter to seat at frequent intervals and produce a puffing sound.

With the valve cut out, handle 5 turned down (vertical), groove *a* in the cock key 6 connects X with the large, direct exhaust port *c*, allowing all brake cylinder pressure to discharge rapidly when the triple valve is in release position.

From the foregoing description it will be seen that with the pressure retaining valve cut in, handle turned up (horizontal), a given train pipe reduction will result in a higher brake cylinder pressure *after* the first application and release than will be obtained by the first application. Because of this it is desirable to have the pressure retaining valves cut in (handles horizontal) before starting down a steep grade and to apply and recharge the brakes as soon as possible after passing the summit. In addition to other advantages, this gives an increased reserve of brake power.

The value of the pressure retaining valve will be better understood when it is stated that 15 pounds means nearly one-third of the total brake power

possible to obtain on a car with a full service application from standard pressure, together with a *slow* reduction down to 15 pounds. (See also "Reason for Pressure Retaining Valve" under "PLAIN TRIPLE VALVE").

DEFECTS.

If a pressure retaining valve is *not holding properly* it may be due to the following causes: dirt or gum on the seat of weighted valve 4 preventing it from seating properly; leak in union of retaining valve pipe near triple valve or other retaining valve pipe joints; leak in cock key 6; split in the pressure retaining valve pipe; and a leaky brake cylinder, all of which reduce the efficiency of the pressure retaining valve.

Before the valve is tested it should be known that the brake cylinder packing is entirely free from leakage. When testing it should be cut in, (horizontal) and a full service application should be made (see instructions to "Inspectors") so as to develop a high pressure in the cylinder. The triple valve should then be released and the parts mentioned should be inspected quickly before the cylinder pressure becomes low. It should also be known that port *d* in the pressure retaining valve is free; for, if stopped up, the brake cylinder pressure will not reduce and the wheels will be skidded or so overheated as to crack.

The valve should always be in a vertical position to allow its weighted valve to seat properly and should have nothing above it to interfere with removal of cap 3.

INCREASING PRESSURE RETAINING VALVE VALUE.

While the weighted valve does not finally seat until the brake cylinder pressure has reduced to about 15 pounds, and though leakage from the pressure retaining valve or its pipe will continue reducing the cylinder pressure while the triple valve is in release, yet by proper handling of the brake valve the value of the pressure retaining valve can be raised materially above 15 pounds and the detrimental effect of leakage mentioned can be considerably reduced.

These desirable results are accomplished by a rapid recharge of the auxiliary reservoirs and an early reapplication of the triple valves. The retaining position exhaust port being small permits of a slow reduction of cylinder pressure, so much so that when the auxiliary reservoir pressure has not previously been greatly reduced it can be restored before that in the brake cylinder has become low enough for the weighted valve to close. An immediate reapplication closes the triple valve exhaust port and stops further reduction by either the pressure retaining valve or leakage from its pipe.

When in making the thermal or wheel temperature brake test after pressure retaining valves have been in use, if some wheels are found which, while warm, are yet far below the average of the train, one of the most probable causes is leakage from pressure retaining valve pipes or valves on these cars. In fact if these brakes are found to hold when applied, the

fault will almost invariably be either as stated or choked up feed grooves in the triple valves.

Leaky pressure retaining valve pipes can often be located without air pressure, as one that can be vibrated and shows motion at some joint will invariably leak. Such a pipe should be secured even though no joint has worked loose as vibration will soon cause leakage.

PLAIN TRIPLE VALVE.

(Westinghouse.)

The plain triple valve was at first used with all automatic brakes, but is now standard only for driver and engine truck brakes and tender brakes of freight and switching locomotives. As all of its parts and functions will be found in the quick action triple valve, the latter having merely additional ones, a thorough understanding of the plain triple valve will be of great assistance in studying the quick action triple valve.

The plain triple valve is illustrated by Plate 12. Fig. 1 shows the shell of the valve with all working parts removed. The train pipe, auxiliary reservoir and brake cylinder are connected as indicated The exhaust port, where the retaining valve would be connected if used, is indicated by *k*. These connections give the triple valve control of the air in its passage from the train pipe (supplied by the pump and main reservoir) to the auxiliary reservoir (charging), auxiliary reservoir to the brake cylinder (applying) and brake cylinder to the atmosphere (releasing).

The train pipe pressure enters at W, passes down *a*, *a* into the cylinder cap 21, where all dirt and water are deposited; from here it has free access through ports *c*, *c* to the cylinder *d* where the piston 23 operates. This piston has a packing ring 30 for the purpose of, as near as possible, closing off all connection with its two sides except when the piston is at the upper end

of its cylinder. Here a short feed groove *m*, cut in the wall of the cylinder, makes a very small opening around the piston, and the groove *n* on the upper side of the latter prevents a joint being made where the piston strikes on the end of the cylinder.

The space above the piston is connected by Y direct with the auxiliary reservoir pressure. Slide valve 24 is located here, opening and closing port *f* to the brake cylinder, connected at X, and port *h*, leading to the atmosphere through *k*.

Graduating valve 25, shown with piston 23, is connected to it by a pin fixed in the stem of the piston and entering loosely through a hole in the head of the graduating valve. Port *l* is a hole across the slide valve to give auxiliary reservoir pressure a free opening to the seat for the graduating valve. This seat is shown just above the port *l*. The graduating valve 25 operates in the slide valve 24 and in service braking, controls the flow of air from port *l* through *p* to the face of the slide valve. The graduating valve *aids* the slide valve in gradually admitting air to the cylinder in service applications, but performs no duty in emergency applications.

The slide valve, located on the piston stem, is drawn down to apply brakes, by the collar *u* on the upper end, and is pushed up to release brakes, by the graduating valve. The piston can move up and down a short distance without either the collar or the graduating valve moving the slide valve. Slide valve spring 32 aids in holding the slide valve onto its seat.

Graduating stem 26 and graduating spring 27 are located in the cylinder cap 21 and aid in securing correct service applications.

CHARGING AND RELEASE POSITION.

Fig. 2 shows the valve with all operating parts in place and in charging and release position. The piston 23 stands over feed groove *m*, allowing train pipe pressure, below the piston, to pass around it. As groove *n* prevents a joint where the piston rests against the end of the cylinder and as the auxiliary reservoir is connected at Y, all pressure on the slide valve side of the piston is auxiliary reservoir pressure. That on the opposite side of the piston is train pipe pressure.

The air continues to flow gradually around piston 23 until the pressures on its two sides are equal. The time required to charge an auxiliary reservoir to 70 pounds depends to a considerable extent on how high the train pipe pressure is maintained and on the amount of gum which has accumulated in the feed groove, there usually being some. As a general rule for an empty auxiliary reservoir allow at least two minutes where the train pipe pressure is raised to and maintained at 70 pounds. With the auxiliary reservoir partially charged or with a higher train pipe pressure the time will be proportionally shorter. Two or more brakes can be charged as quickly as one so long as the needed train pipe pressure can be steadily maintained.

All communication between the auxiliary reservoir and the brake cylinder is now cut off by slide valve 24, and the exhaust port *g* in the latter has port *f*, *f*, leading to the brake cylinder, connected with port *h*, leading to the exhaust opening at *k*, thus allowing the brake cylinder pressure to escape. The brake is charging and releasing at the same time, giving this position of parts its name.

EMERGENCY APPLICATION POSITION.

While this triple valve has no "quick action application" position, as the term is used with the quick action triple valve, it has an emergency application position in which the full braking power possible to get in service application position, is obtained much quicker and in a more simple manner. Because of the latter it will be explained now.

To apply the brake the slide valve 24, Fig. 2, must be moved so as to cut off the present communication with the exhaust *h*, *k* and allow the auxiliary reservoir pressure to flow through ports *f*, *f* into the brake cylinder. One duty of piston 23 is to move the slide valve. To move the latter in the desired direction (down with the plain triple valve) the pressure on the slide valve side (auxiliary reservoir) must be made greater than that on the opposite side (train pipe). This can be accomplished only by reducing the train pipe pressure. In an emergency this is effected by suddenly opening the train pipe wide, as can be done with the engineer's brake valve, the conductor's valve or the rear angle cock and as also follows from a burst hose or breaking in two. The effect on the plain triple valve is shown by Fig. 3.

All train pipe pressure having been discharged caused the piston 23 to move suddenly the full length of its cylinder, striking on leather gasket 29. The knob on the train pipe side of the piston has moved graduating stem 26 and farther compressed graduating spring 27.

The collar *u* on the end of the triple valve piston stem has drawn slide valve 24 beyond port *f*, making a direct and large opening from the auxiliary reservoir to the brake cylinder, thus rapidly and fully applying the brake.

To release the brake will require that the piston 23 move the slide valve 24 back to the position shown in Fig. 2. To bring this about the train pipe pressure must be made greater than the pressure remaining in the auxiliary reservoir. There are two ways of accomplishing this. The usual way is to increase the train pipe pressure by that from the main reservoir.

As the parts stand in Fig. 3 the upper end of the graduating valve 25 is away from its seat, but the other end of port *p*, *p* has no connection. When the train pipe pressure is increased above that in the auxiliary reservoir the piston 23 will raise the graduating valve 25 to its seat in slide valve 24, when all will then move together to the charging and release position shown by Fig. 2, thus releasing and recharging the brake.

SERVICE APPLICATION POSITION.

In ordinary or service braking the pressure is admitted to the brake cylinder more gradually and only in such quantities at a time as the needed braking power requires. In this work the graduating valve 25 assists the slide valve.

Starting again with release and charging position, Fig. 2, and assuming 70 pounds train pipe and auxiliary reservoir pressure, a 5 pound "service" or gradual reduction is made. This will move the parts to the service application position shown in Fig. 4. In this movement the graduating valve 25 is first unseated, allowing auxiliary reservoir pressure to pass through port *p*, *p* to the face of the slide valve; the collar *u* on the end of the piston stem then draws the slide valve down until the port *p*, *p* is over port *f* leading to the brake cylinder. To better insure against the slide valve being carried too far, the short stem on the train pipe side of the piston is now in contact with graduating stem 26, to move which will require overcoming the resistance of graduating spring 27.

With the parts as shown, air will flow through ports *l*, *p*, *p* and *f*, *f* to the brake cylinder until the auxiliary reservoir pressure has been reduced a little below 65 pounds, the amount remaining in the train pipe, when the slightly higher pressure in the latter will *start* the piston toward release. But as this requires overcoming only the weight of the piston and the very slight friction of its packing ring 30, the additional resistance of the slide valve, forced against its seat by both its spring 32 and auxiliary reservoir pressure, will arrest the movement of the piston when it has seated the graduating valve 25. The latter will stop the flow into the brake cylinder, thus leaving the brake lightly applied and the parts on lap position, as shown by Fig. 5.

Another reduction of, say, five pounds will cause the piston to reopen the graduating valve and again close it after the auxiliary reservoir pressure has once more been reduced a trifle below that in the train pipe, thus farther increasing the brake cylinder pressure.

This can be continued until the auxiliary reservoir and brake cylinder pressures are equal, at which time the brake is fully applied. Up to full application, reducing the train pipe pressure any number of pounds below that in the auxiliary reservoir will cause an equal number of pounds to be discharged *out of* the auxiliary reservoir. How much it will give *in the brake cylinder* is dependent on piston travel and cylinder leakage.

The triple valve is caused to apply the brake by reducing the train pipe pressure *below that in the auxiliary reservoir.* Hence, when brakes are being charged, any train pipe reduction that does not bring this pressure below that which the auxiliary reservoirs have had time to acquire will *not* cause an application.

The triple valve is caused to release the brake by making the train-pipe pressure *higher than that in the auxiliary reservoir.* This is accomplished by *increasing* the train pipe pressure, as before explained, or by *decreasing* the auxiliary reservoir pressure. The release valve or "bleeder" on the auxiliary reservoir permits of the latter operation, necessary when it is desired to release a brake cut off from the

engine or, if connected, in case the engineer can not release it.

When "bleeding" a brake, close the release valve as soon as the exhaust indicates the triple valve parts have moved to charging and release position: otherwise, the train pipe pressure will also be discharged thus wasting air and, if the train pipe is not being supplied, causing application of connected brakes.

FULL APPLICATION.

Each size of brake cylinder is supplied by an auxiliary reservoir having such a volume that from a pressure of 70 pounds and with a piston travel of about 8 inches either an emergency application or a full service application with the plain triple valve will give a cylinder pressure of 50 pounds to the square inch. The same cylinder pressure is obtained by a full service application with a quick action triple valve, but the Westinghouse valve gives more pressure in a quick action application for reasons that will be explained in another chapter.

From a 70 pound train pipe and auxiliary reservoir pressure and with a 7 or 8 inch piston travel and no cylinder leakage a train pipe reduction of 20 pounds will fully apply the brake. Lower pressure at the start or shorter piston travel will require less reduction to fully apply, while higher pressures and longer piston travel will require more than a 20 pound reduction to fully apply.

The higher the auxiliary reservoir pressure and shorter the piston travel the greater will be the resultant brake cylinder pressure under application.

Ordinarily a train pipe reduction of 20 to 25 pounds will fully apply all brakes. However, this will not be true where the brakes are held applied for some time, as those having brake cylinder leakage will have lost at least part of the 50 pounds the full service application should have given, but that amount will be left in the auxiliary reservoirs if the train pipe is not below 50 pounds. Consequently, a further reduction will again increase the cylinder pressure in the brakes which have such leakage, but *can not* again raise it to 50 pounds. Because of this it is bad practice to reduce *more* than 20 or 25 pounds except in emergencies, and the frequent use of so great a reduction is not good practice, owing to it leaving no braking power in reserve and by reason of the amount of air used.

A cut-out cock is provided in the branch pipe leading from the main train pipe to the triple valve for cutting out the brake whenever a defective condition warrants. When a brake is cut out the release valve or "bleeder" on the auxiliary reservoir should be left open.

REASONS FOR PRESSURE RETAINING VALVE.

It should be noted that the auxiliary reservoir can not be recharged without the slide valve opening the exhaust port; also, that the much greater size of the latter over that of the feed

groove will result ordinarily in the brake releasing much quicker than its auxiliary reservoir can recharge.

Without other aid on a descending grade this would cause a runaway when the triple valves were released, owing to inability to get recharged before the speed increased too much. The purpose of the retaining valve, previously explained, will now be seen as, when cut in, the slow reduction of brake cylinder pressure which it permits and the final retention of 15 pounds will give more time for recharging and will require less air being sent into the cylinder on reapplication.

USE OF PROPER TRIPLE VALVE.

The varying sizes of brake cylinders and accompanying auxiliary reservoirs require similar differences in triple valves. It is therefore important that those who have to do with the application of these parts should see that the recommendations of the makers, as shown in their catalogues, are carried out.

OLD STYLE PLAIN TRIPLE VALVES.

Two old style plain triple valves are yet in use and can be distinguished from the one illustrated through having a four-way cock in the body of the valve. The cock handle has three positions: horizontal for automatic; vertical for straight air, a position not now used; and midway between these or at an angle of 45 degrees for cut out.

The general construction and the operation of these valves are similar to the modern valve, but before cutting out the one used on driver and tender brakes the brake must be released. The plain triple valve used on some old freight cars will also bleed the brake when the four-way cock is brought to the cut out position. It has no release valve.

DEFECTS.

A *Sticking Brake* can be caused by a poorly fitting piston packing ring 30 and a slow rise in train pipe pressure after brake application. The same valve will usually release if the train pipe pressure is raised quickly. Hence, the need of proper manipulation by the engineer, especially with long trains.

The same triple valve near the head end of a long train will release with the others, but may reapply when the brake valve handle is brought to running position. If so, again, but this time momentarily, moving the brake valve handle to release will usually cause it to remain off.

The leaky piston packing ring makes no sound to indicate the defect. To test for it, reduce ten pounds and then feed up the train pipe pressure slowly and steadily. The slowest and least rise that will cause release usually indicates the best fitting packing ring.

A constant *Blow At The Exhaust Port* indicates a leak past the slide valve. With the old style valve it can also be due to a defective four-way cock. In either case report that triple valve blows at exhaust port.

A Bent Piston Stem or even a broken one will be caused by loosening the cylinder cap bolts 31 when there is any pressure in the auxiliary reservoir. Do not slack these bolts until *all* pressure is gone.

Where a *Triple Valve Releases* when it should remain applied, it may be caused by an increase in train pipe pressure due to a defective brake valve.

The other causes are leakage from the auxiliary reservoir, due to the slide valve, graduating valve, pipe between triple valve and auxiliary reservoir or the release valve. A very dirty or dry triple valve may also cause release. Any except the graduating valve leak can either be heard or be located by a torch. To test for graduating valve leakage, remove the piston, wipe clean the face of the slide valve and, holding the graduating valve against its seat, suck on the end of the graduating port and drop the tongue against it to see if it is held there a second or so. If not the valve is leaky.

Long piston travel and brake cylinder leakage aid in causing the defect just considered.

THE WESTINGHOUSE QUICK ACTION TRIPLE VALVE.

Why the plain triple valve was found unsatisfactory for long trains and how this was overcome by the quick action triple valve is covered under "General Information." This should be reviewed before further study of the quick action triple valve. For its connections on freight brakes see "Brake Cylinder, Auxiliary Reservoir and Triple Valve."

Under each car, in the main train pipe, is a drain cup or strainer, forming a tee, from which a branch pipe extends to the triple valve, to which it is connected at A, Plate 13. A cut-out cock is placed in this branch pipe for the purpose of rendering the brake inoperative upon any car, when occasion requires, but leaving the main train pipe open to supply air to the other cars of the train and to operate the brakes thereon.

The quick action triple valve has two distinct sets of parts and two methods of operation, service and quick action, the service being identical in operation and differing little in construction from the plain triple valve. The service parts alone are used in all ordinary braking. The service action is caused by a gradual reduction of train pipe pressure, no matter how great the amount. One object of the service stop position of the D-8 and all later Westinghouse brake valves, is to mechanically guard against so rapid a reduction as to cause the other method of operation, or quick action, as it is called.

The quick action parts of this valve are brought into operation by a sudden and heavy (10 pounds or more) reduction of train pipe pressure, no matter what causes it. The triple valve that first experiences such a reduction will suddenly make a discharge of air from the train pipe into the brake cylinder. As this causes a similar train pipe reduction at the next valve, the latter will act the same way. By reason of this fact, if one triple valve is made to work quick action all others in the train will follow where the conditions are as they should be.

By means of the large number of openings made from the train pipe, that at the brake valve and one on each car, the train pipe pressure is reduced and the brakes are applied rapidly, thus lessening the shock from the slack of the train running in or out and enabling a quick stop.

In service braking the only pressure entering the brake cylinder is that from the auxiliary reservoir, which with 70 pounds and with a full application will give about 50 pounds in the cylinder. In quick action the discharge of train pipe pressure into the cylinder aids the pressure entering from the auxiliary reservoir and thus gives a higher cylinder pressure, being about 60 pounds or a gain of 20 per cent. This is another most important aid in shortening the distance required for making a stop, with this type of valve.

Another feature worthy of note is that less air is

required for recharging than would be needed after an emergency application if the triple valve did not aid in filling the brake cylinder.

Fig. 1 shows the shell of the valve with all operative parts removed. The movement of the main piston and its parts is horizontal, instead of vertical as with the plain triple valve.

The graduating stem 21 and graduating spring 22 are shown just below the cylinder cap 19 and graduating-stem nut 20.

The slide valve 3 is shown in section at the upper right hand corner of the illustration, its spring 6 being in place. Just below is a view of the face of the slide valve. At the left is the crooked exhaust cavity. The small, round hole next to this is the lower end of the graduating port *z*, *z*, and the small, oblong hole is the emergency port S, both of which are shown in sectional view just above. The slot above the two small ports is to let auxiliary reservoir pressure down onto the emergency piston 8. It cannot be shown in the other illustrations. This slotted port and emergency port S operate only in quick action, being over blank portions of the slide valve seats at all other times. These are the additions to the plain triple valve slide valve.

Main piston 4 with its packing ring 5 and the graduating valve 7 are of the same construction as in the plain valve. The main piston 4 operates in cylinder *h*, having a feed groove *i*. The stem of the piston extends into the slide valve bush *m* where the slide valve 3 and its graduating valve 7 operate.

In the bottom of the slide valve bush is exhaust port *p*, leading part way around the bush and then out through the body to where the retaining valve is connected; also, port *r*, *r*, leading down to the opening C from which a direct connection is made to the brake cylinder. The end at the right of slide valve bush *m* opens directly into the auxiliary reservoir, this and brake cylinder connection C being plainly shown in the illustration of "Brake Cylinder, Auxiliary Reservoir and Triple Valve." Another port in the slide valve seat is indicated by two vertical, dotted lines. It leads down to the emergency piston cylinder, just above X, where the emergency piston 8 is located.

The emergency piston 8 receives the upper stem of the emergency valve 10 and drives the emergency valve downward, unseating it, when the slide valve 3 admits air above the piston.

The emergency valve 10 has a rubber seat 11 and makes a joint at the port through the emergency valve seat 9, its upper stem and the lower end of emergency piston 8 being guided by the emergency valve seat 9. The emergency valve 10 is to open or close the large port between chambers Y and X. When open, air from the train pipe can flow rapidly into the brake cylinder. The lower stem of emergency valve 10 extends into the cavity in the check valve 15. Check valve spring 12 holds the emergency valve and check valve to their seats except when they are opened by air pressure.

The check valve 15 seats on its bush 31 and prevents pressure from flowing from the brake cylinder into

the train pipe at times when the train pipe pressure is reduced below that in the brake cylinder.

The train pipe connection being made at A, the passage from this point through *e*, *e*, *f*, *g*, *h*, *i* and *m* into the auxiliary reservoir in charging; from *m* through *r*, *r* and C to the brake cylinder in both service and emergency applications; and from A through *a*, Y, X and C to the brake cylinder in emergency applications can all be plainly traced.

It should be understood that in all service applications the brake is applied by pressure entering the brake cylinder from the auxiliary reservoir only, the manner and results being the same as with the plain triple valve. But in the emergency applications when the quick action feature of the valve operates, air from the auxiliary reservoir and from the train pipe both enter the brake cylinder, thus quickly reducing the train pipe pressure and giving the higher braking power.

Figures 2, 3, 4 and 5 show the quick action triple valve in charging and release, service, lap and emergency positions, respectively.

CHARGING AND RELEASE POSITION. FIG. 2.

Air from the main reservoir on the engine being discharged into the train pipe by operation of the engineer's brake valve, enters the triple valve at A and passes through ports *e*, *e* and *g*, *g* to main piston chamber *h*, forcing piston 4 to the position shown, charging and release, which it occupies when brakes are released. This permits air to pass the piston through feed groove *i*, groove *k* on the piston where it bears against the slide valve bush and into chamber *m*. occupied by slide valve 3, from which it has a free opening to the auxiliary reservoir. The latter charges slowly owing to the size of the feed groove, but to the same pressure as that in the train pipe. That portion of the stem of piston 4 between the shoulders *u* and *c* is half round and passes between the two flanges of slide valve 3. The length of the latter being slightly less than the distance between these shoulders, permits a limited movement of the piston without moving the slide valve. The graduating valve 7 is attached to and moves with the stem of piston 4. It extends into a recess in the slide valve 3, opening and closing communication between ports *W* and *Z, z* which lead to the brake cylinder when connected with port *r, r*. In the position shown in Fig. 2, being release and charging, the air contained in the brake cylinder can escape through ports C and *r, r*, cavity *n* in the slide valve and port *p* in the slide valve seat, thence to the atmosphere through retaining valve pipe and valve.

When the air first enters the triple valve at A it will momentarily raise check valve 15 and fill the chamber Y above it. This pressure will merely aid spring 12 in holding emergency valve 10 to its seat. This is the only movement of the emergency parts except in sudden or emergency applications.

SERVICE APPLICATION AND LAP POSITIONS. FIGURES 3 AND 4.

To apply the brake moderately, a reduction of 5 to 10 pounds, depending on the circumstances, is made in the train pipe pressure. The then higher pressure in the auxiliary reservoir, with which chamber *m* is in constant communication, forces main piston 4 to the left as shown, cuts off feed groove *i* and moves graduating valve 7 from its seat in port W until the shoulder *u* on the piston stem engaging slide valve 3. These parts then move together until the knob *j* on piston 4 meets graduating stem 21, graduating spring 22 resisting further movement.

In this position port *Z, z*, in the slide valve is opposite port *r* in the slide valve seat, and air from the auxiliary reservoir passes through ports *W, Z, z, r, r* and C into the brake cylinder, forcing its piston outward and applying the brake.

The pressure in the auxiliary reservoir thus continues to reduce by discharging into the brake cylinder until *slightly* less than that remaining in the train pipe. This forces piston 4 to the right and graduating valve 7 to its seat, thereby closing port *Z, z* and preventing farther brake application. The slide valve remaining stationary retains the pressure in the brake cylinder. The triple valve is now in the lap position, all ports closed, as will be noted in Fig. 4, in which the collar *u* on the end of the piston stem is some distance from slide valve 3. Air cannot pass through feed groove *i* on account of the piston 4 being beyond it.

Further reductions of pressure in the train pipe, as may be desired to apply the brakes with greater force, cause piston 4 to repeat part of the operation just described. Graduating valve 7 is again moved from its seat and admits additional pressure from the auxiliary reservoir to the brake cylinder until, if continued, they are entirely equalized, or at about 50 pounds, from an initial pressure of 70 pounds in the train pipe and auxiliary reservoir.

This total effect is caused by a reduction of about 20 pounds in the train pipe pressure. Therefore a further reduction is ordinarily a waste of air, and the force with which the brakes will be applied is proportionate to the reduction of pressure made in the train pipe within this limit. After the first reduction when the slide valve 3 is moved far enough to bring Z, *z* opposite port *r*, the slide valve does not move again by the repeated reductions unless the train pipe pressure is reduced below that at which the auxiliary reservoir and brake cylinder equalize.

The brake is released by again admitting pressure from the main reservoir to the train pipe, which forces piston 4 to the right as shown in Fig. 2, permitting the brake cylinder pressure to escape to the atmosphere through ports C and *r*, exhaust cavity *n* and exhaust port *p*.

EMERGENCY POSITION.

To cause the triple valve to apply quick action a sudden and very heavy reduction in train pipe pressure is made, as follows a break in two, placing the

brake valve handle in full emergency position or opening wide the conductor's valve or the rear angle cock. The effect on the quick action triple valve is shown by Fig. 5.

The sudden and heavy reduction in train pipe pressure caused the main piston 4 to move rapidly throughout the entire length of its cylinder *h*, farther compressing graduating spring 22. This brought the slot, (Fig. 1) in slide valve 3 over the port *t*, shown by dotted lines, leading down onto emergency piston 8. The auxiliary reservoir pressure thus admitted above this piston forced it downward and unseated emergency valve 10, heretofore held shut by spring 12 and the train pipe pressure. This, by the opening past emergency valve 10 into the brake cylinder, allows the air presssure in chamber Y above the check valve 15 to escape into the brake cylinder. As all this takes place before the train pipe pressure has more than well started to reduce, its remaining pressure forces open check valve 15 and flows rapidly from A, *a* through the large ports past the check and emergency valves and into the brake cylinder, thus making the sudden train pipe reduction which causes the next valve to act the same way.

The instant the train pipe and brake cylinder pressures are about equal the check valve 15 is forced to its seat by spring 12, thus preventing any brake cylinder pressure from flowing back to the train pipe. Without this and with the train pipe left open, the brake would release or leak off immediately after it applied.

At the same time as the port was opened over the emergency piston 8 another port S, Fig. 5, in the slide valve was brought over port *r* in the seat, thus taking the position occupied in service application by the graduating port Z, *z*, but which now does nothing. This admits air from the auxiliary reservoir into the cylinder at the same time as that from the train pipe is rushing in. But as the opening past check valve 15 and emergency valve 10 is so very much larger than the smallest part of port *S* in the slide valve, it can be said that almost no air has had time to pass from the auxiliary reservoir into the brake cylinder until the train pipe air has got in and the check valve 15 has closed. Therefore the auxiliary reservoir air flowing in onto the air obtained from the train pipe gives about 20 per cent higher cylinder pressure than would have been obtained from a full service application.

As soon as the brake cylinder and auxiliary reservoir pressures are equalized the spring 12 forces the emergency valve 10 and its piston 8 back to their normal positions as shown in Figs. 2, 3 and 4.

The emergency piston illustrated has a packing ring 30 and also a small port near X. These are used only with the passenger triple valves, the freight valves having a piston without the port or the ring.

As has been made apparent, a sudden reduction of train pipe pressure is required to cause quick action. Where there are together more than three cars on which quick action cannot be obtained, such as piped cars, those fitted with plain triple valves or cars with

quick action valves, but cut out, the quick action operation may stop owing to the inability of the brake valve or the preceding triple valve to make a sufficiently rapid reduction to throw into quick action the one beyond the cars without this feature. For this reason it is very important that such a condition be prevented whenever possible. It is particularly important that the car coupled to the locomotive tender have an operative quick action brake.

While with such a condition it would be impossible to get quick action beyond this obstruction to its operation, yet the full service action will follow if the train pipe is left open. It is because of this and other conditions having a similar effect, that in an emergency the train pipe should be opened wide and kept so until the stop is made or the danger is past.

On account of important differences of construction, principally in the size of the ports, triple valves designed for service with passenger and freight car brakes respectively must be used only in the service for which they are intended, as the improper use of these devices will set up conditions which will prevent harmonious action of the brakes. There are two passenger and two freight quick action triple valves, and with one exception, they can be distinguished from one another by the bore of the slide valve bush. With the freight valve, known as Plate F-36, it is $1\frac{1}{4}$ inches; with the passenger valve for 10-inch cylinders, known as Plate F-27, it is $1\frac{3}{8}$ inches; and with the passenger valve for 12-inch, 14-inch and 16-inch cylinders, known as Plate F-29, it is $1\frac{3}{4}$ inches.

The exception is the Plate H-49, being the freight triple valves for 10-inch cylinders. The bore of its slide valve bush is 1⅜ inches, the same as the Plate F-27, but they are readily distinguished from each other as the latter has *two* bolt holes through the flange at its auxiliary reservoir end while the Plate H-49 has *three* bolt holes at this point, in this being like the Plate F-29 valve.

Where a service application exceeds the reduction necessary to fully apply any one or more brakes the main piston and connected parts move to the position shown in Fig. 5, but the emergency and check valves remain seated. The only effect is to maintain the connection between the auxiliary reservoir and the brake cylinder by means of port *S* in the slide valve so long as the train pipe pressure remains lower than that in the auxiliary reservoir.

DEFECTS.

Among the most serious defects and those which are likely to cause trouble on the road are the following: leaky slide valve 3; leaky graduating valve 7; leaky triple piston packing ring 5; leaky emergency valve 10, due to a defective rubber seat 11, a bent stem or a damaged bearing on emergency valve seat 9; leaky check valve case gasket 14; leaky gasket between triple valve and auxiliary reservoir on freight apparatus, and between triple valve and brake cylinder head on passenger apparatus; broken graduating pin; and a broken graduating spring 22.

The air which causes a *constant blow at the exhaust port* of the triple valve, such air escaping at the retaining valve, comes, with exceptions too rare to be noted, from either the train pipe or auxiliary reservoir. To determine from which, cut out the brake, bleed all air from the auxiliary reservoir and then quickly cut in again. If the blow *at once* commences with the same force as before the brake was cut out and bled, the leak is from the train pipe pressure and will be past either the emergency valve 10 or the check valve case gasket 14.

If, after cutting out, emptying the auxiliary reservoir and again cutting in, the blow soon commences very gradually and steadily gets stronger as the auxiliary reservoir charges, this shows that the leakage is from the auxiliary reservoir pressure. Such is caused by a defect in the triple valve gasket where it separates the auxiliary reservoir from the brake cylinder, being the narrow portion immediately to the left of the number 30; by a leak past the slide valve 3; or, with the freight brake, by a leak in the tube *b* leading from the triple valve through the auxiliary reservoir to the brake cylinder, (see Plate 7), this defect being very rare.

With all else in good order the triple valve leak of train pipe pressure, when a moderate brake application has been made, will act like any train pipe leak by causing all brakes to apply heavier, but the one with the defect will apply the heaviest, as it will be receiving air from both the auxiliary reservoir and the train pipe. This becomes more serious as the length of train pipe becomes greater, owing to the larger volume to equalize into the brake cylinder. As this contributes to wheel sliding, the brake should be cut out, even though the blow at the exhaust is not strong.

A *leaky main piston packing ring* 5 makes no blow, but is a very serious defect, as it contributes to brake sticking and wheel sliding. To force the main piston and its parts to release position the train pipe pressure must be made higher than that remaining in the auxiliary reservoir. Where the train pipe pressure raises very slow, whether the fault of the engineer or due to conditions beyond his control, the leaky ring will permit the auxiliary reservoir to charge so fast that a sufficient difference in pressure to cause release will not be obtained. With a brake stuck from this cause, if there is also leakage from any of the parts previously mentioned, that by the slide valve 3 being the only possible exception, or if the graduating valve and the main piston packing ring both leak, the brake will steadily apply harder, unless there is a heavier leak from the brake cylinder, and the cylinder pressure may eventually raise to the full train pipe pressure.

While proper handling by the engineer will generally prevent a leaky packing ring 5 from causing the brake to stick, yet if this trouble occurs frequently on the same car, the brake should be cut out. Such a valve is more difficult to release the farther it is from the engine.

Any leakage from auxiliary reservoir pressure tends to release an applied brake, but a leaky packing ring opposes such tendency.

A broken graduating pin will cause a triple valve to go into quick action during a service application, and when one triple valve goes into quick action the others will follow. As was previously explained, when a light train pipe reduction is made to moderately apply the brakes, the first movement of the main piston causes graduating valve 7 to open port Z, z in the slide valve 3, after which the slide valve is moved to bring ports Z, *z*, and *r* together to allow the air in the auxiliary reservoir to pass to the brake cylinder. In the event of the graduating pin being broken the graduating valve 7 will not be unseated and air from the auxiliary reservoir cannot pass to the brake cylinder. This will leave the auxiliary reservoir pressure higher than the train pipe pressure, but the difference will not be great enough with a light reduction to cause the main piston to compress graduating spring 22. But a farther reduction will cause the much higher pressure in the auxiliary reservoir to move the main piston to the extreme left, thus causing quick action as previously explained.

A sticky main piston caused by an accumulation of dirt and gum, a dry slide valve or one with a very strong slide valve spring, made so by bending the spring upward, may act in a manner similar to the broken graduating pin; that is these parts may not move at the first reduction, but when they do the triple valve may apply quick action.

With a broken graduating pin it will generally require a train pipe reduction of over 5 pounds to force the main piston to quick action position, but the amount of train line reduction required to cause similar action with a sticky triple valve is uncertain. A sticky valve which causes quick action from a service application or one having a broken graduating pin, now very rare, can best be located as follows:

With train pipe and auxiliary reservoirs thoroughly charged, make a service reduction of 5 pounds; then examine the train to see if there is a brake which is not set. If so, and it is cut in, cut it out, and make a full service application. If quick action does not then take place, in all probability the one cut out has the defective triple valve.

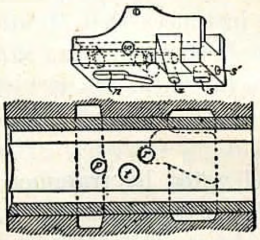
A broken graduating spring 22 is liable to cause trouble only on a short train, unless there are present some main pistons that do not move freely. The reasons are as follows: With the graduating port in the slide valve in full connection with the one leading to the brake cylinder the auxiliary reservoir pressure can reduce as fast or a little faster than the preliminary exhaust port in the brake valve can reduce the pressure in chamber D over the piston 18. As with the shortest train the train pipe pressure can reduce no faster than that above the piston 18 and can reduce less rapidly with trains of over about eight cars, it follows that when the main pistons have brought their graduating ports over the ones leading to the cylinders the pressures in the auxiliary reservoirs will reduce just as rapidly as that in the train pipe can with a service reduction. Therefore, there will be no tendency for the main pistons to move on to the quick action position.

But if a main piston and slide valve are hard to move and do not start with the beginning of the train pipe reduction, or if with a short train the train pipe reduction commences a little fast, by reason of the small train pipe volume and the brake valve piston opening a little abruptly, the hard moving main piston in the former instance or any main piston in the latter, may start so suddenly that if no resistance is met when the graduating position is reached it is liable to pass it rapidly. In such a case quick action is sure to follow.

It is in these instances that the graduating spring has a duty to perform, it offering sufficient resistance to stop the main piston in the service position unless its movement has been made very rapid, an unusual condition.

A little time devoted by trainmen to the study of the operation of the triple valve will, in many cases, enable them to locate defects and report them intelligently; and a defect intelligently reported encourages prompt attention.

When a brake is cut out for any purpose the release valve or "bleeder" should be blocked open on a freight brake and left open on a passenger brake; for, if this is not done the brake may cause further trouble if the cut-out cock leaks. (See "INSPECTORS" for additional information relating to repairs.)



View of slide valve and its seat.

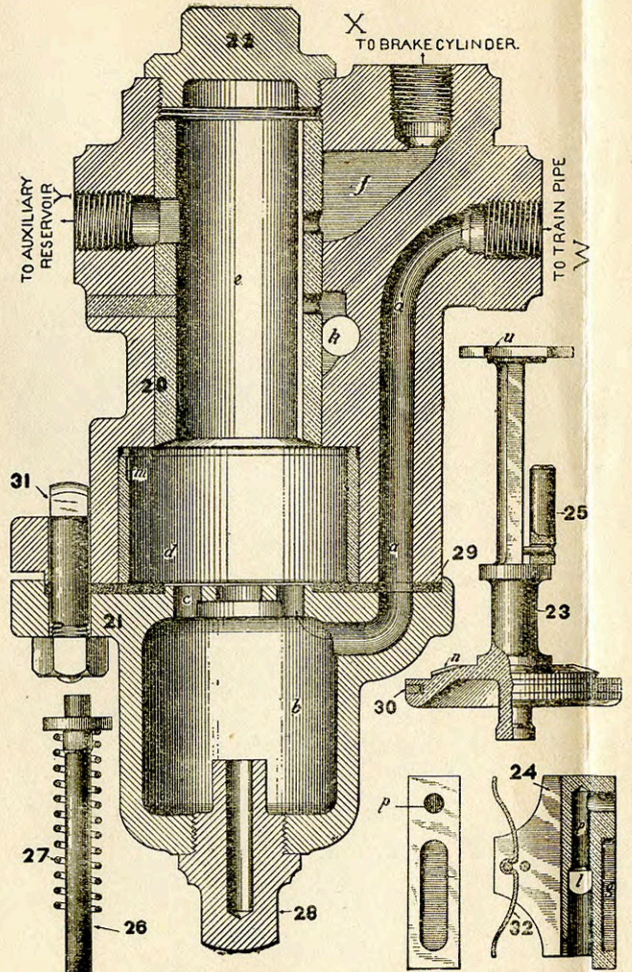


Fig. 1.
Plain Triple Valve. Operative Parts Removed.

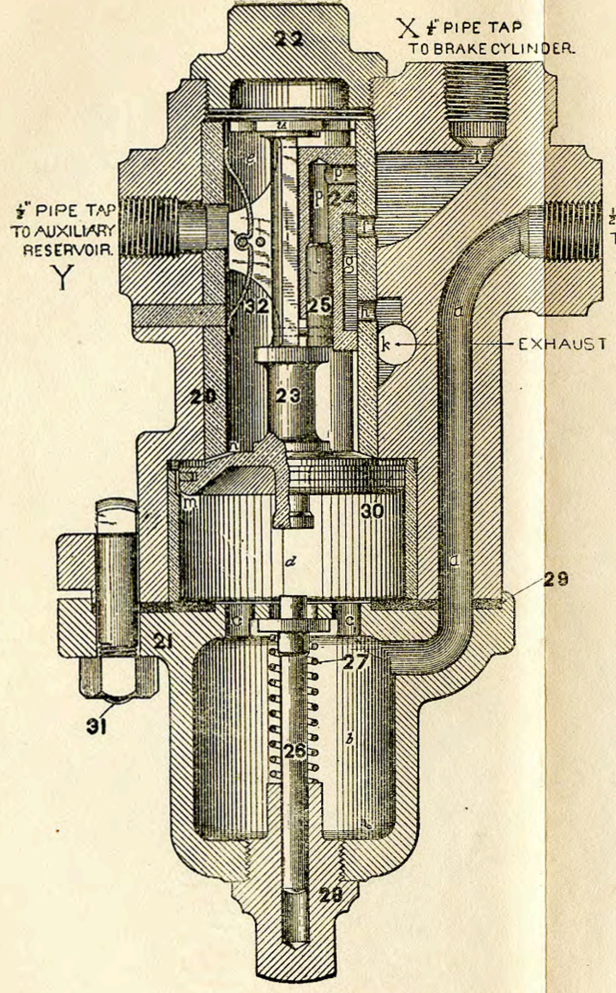


Fig. 2.
Charging And Release Position.

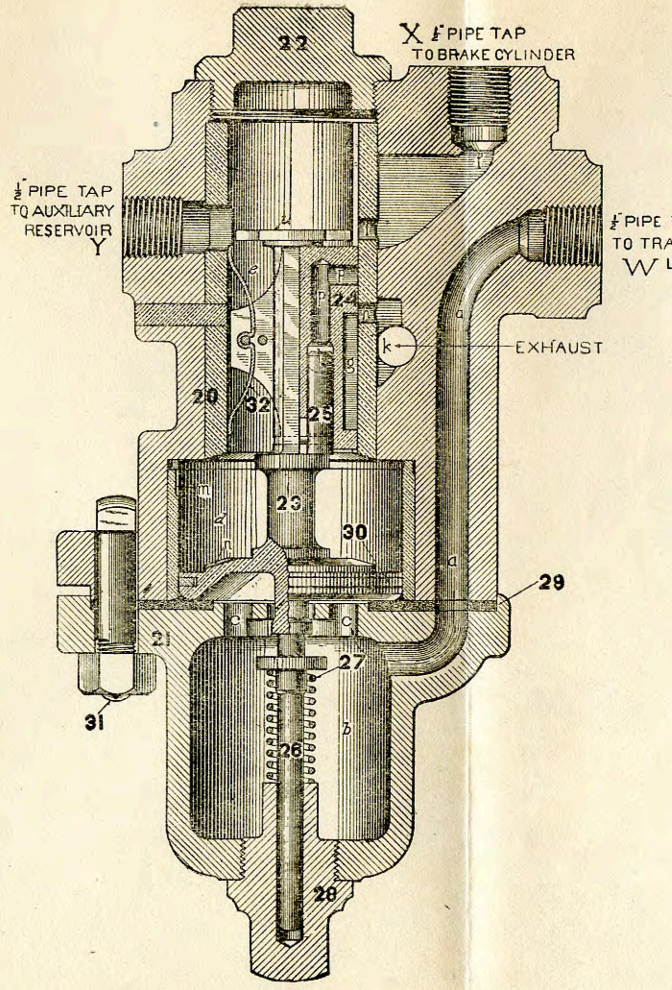


Fig. 3.
Emergency Application Position.

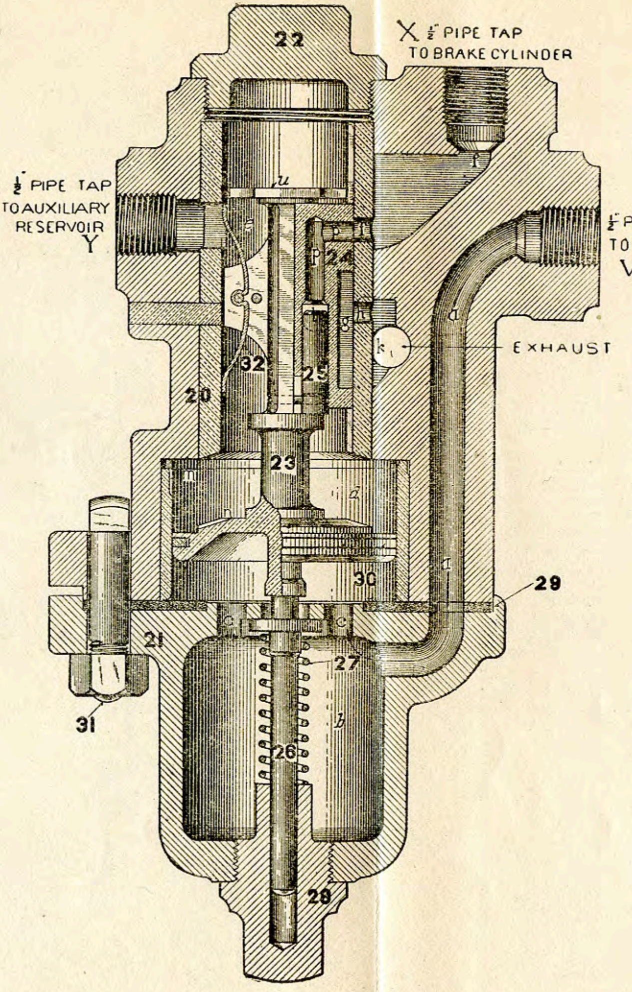


Fig. 4.
Service Application Position.

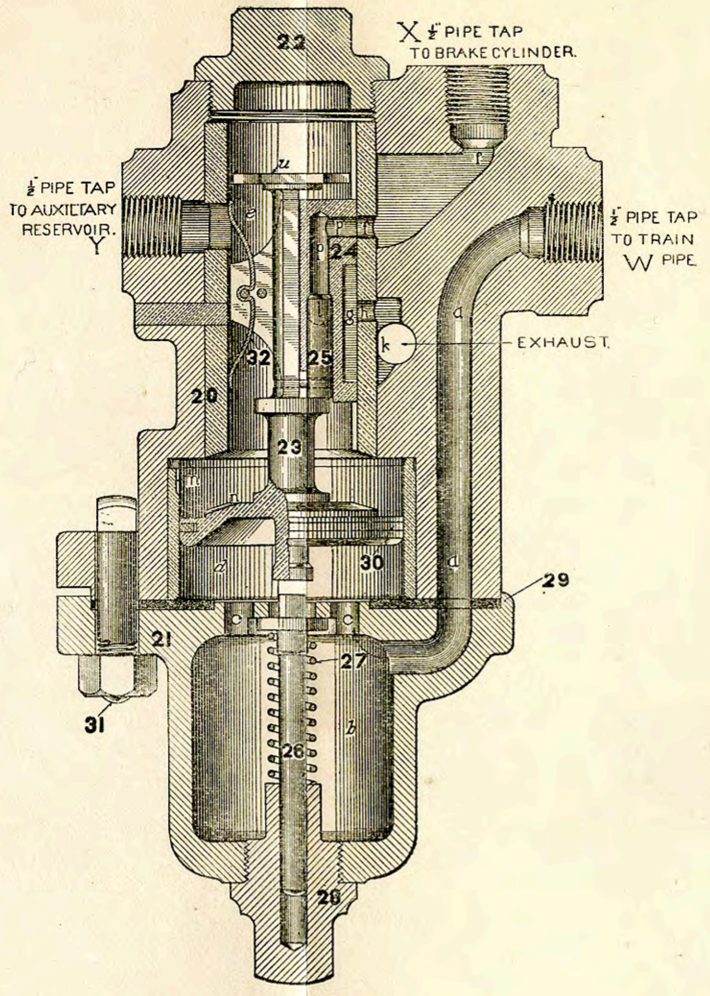


Fig. 5.
Lap Position

PLATE 12—PLAIN TRIPLE VALVE.

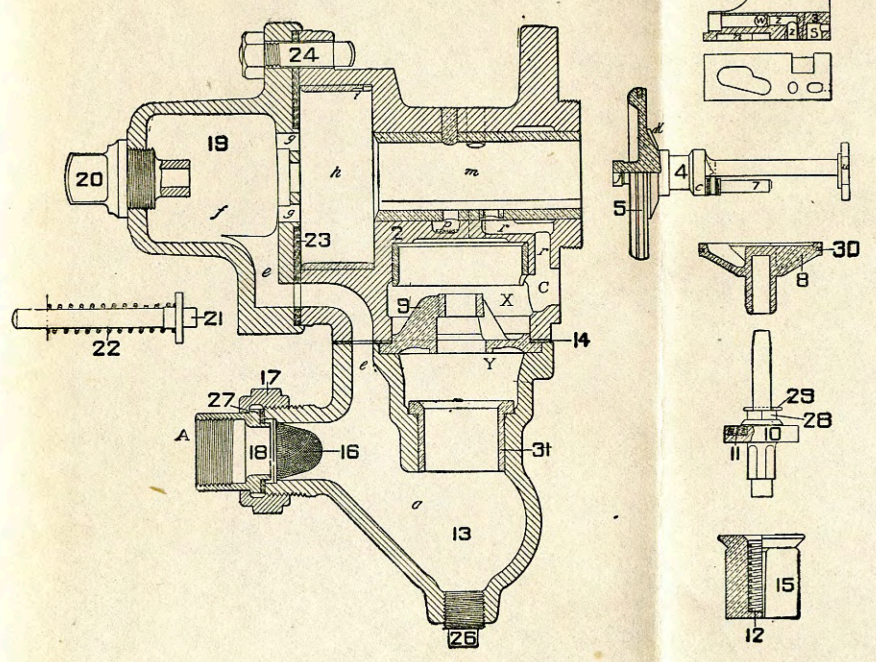


Fig. 1
Westinghouse Quick Action Triple Valve.
Operating Parts Removed.

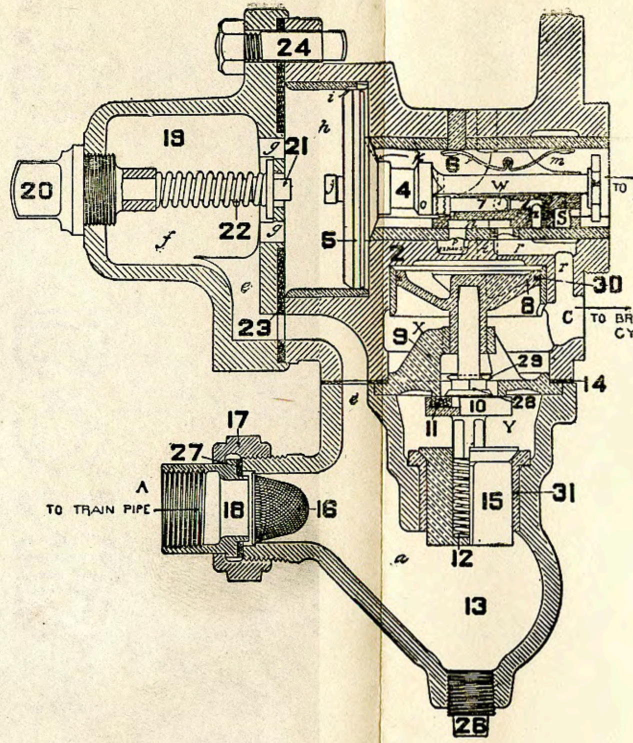


Fig. 2.
Charging and Release Position

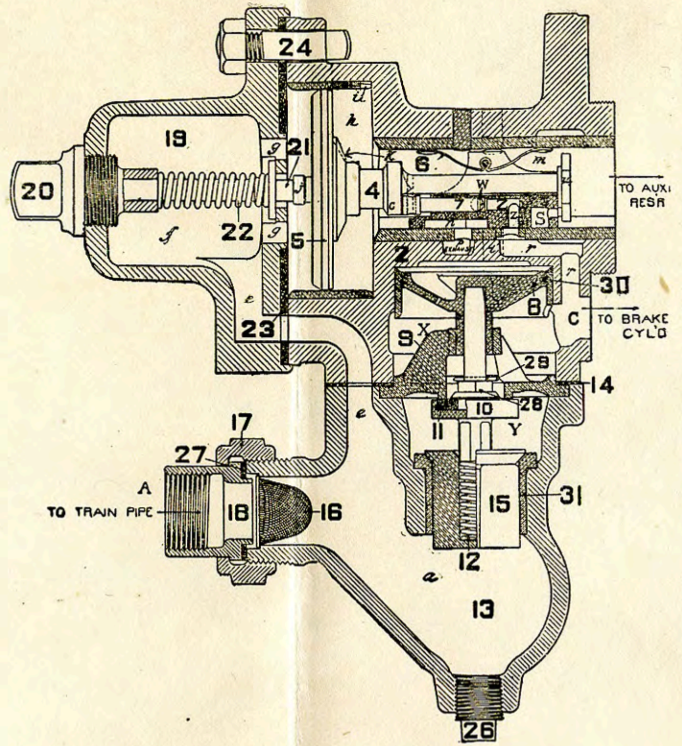


Fig. 3.
Service Application Position.

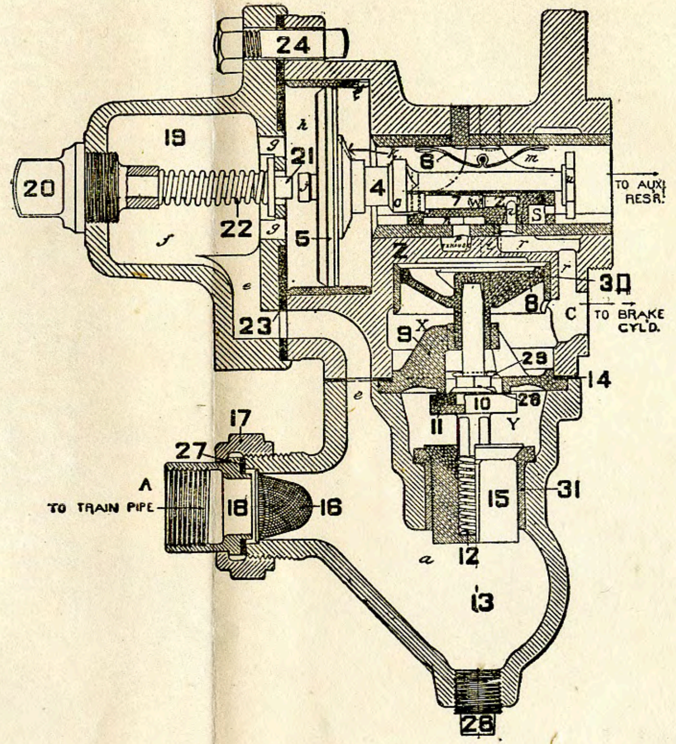


Fig. 4.
Lap Position.

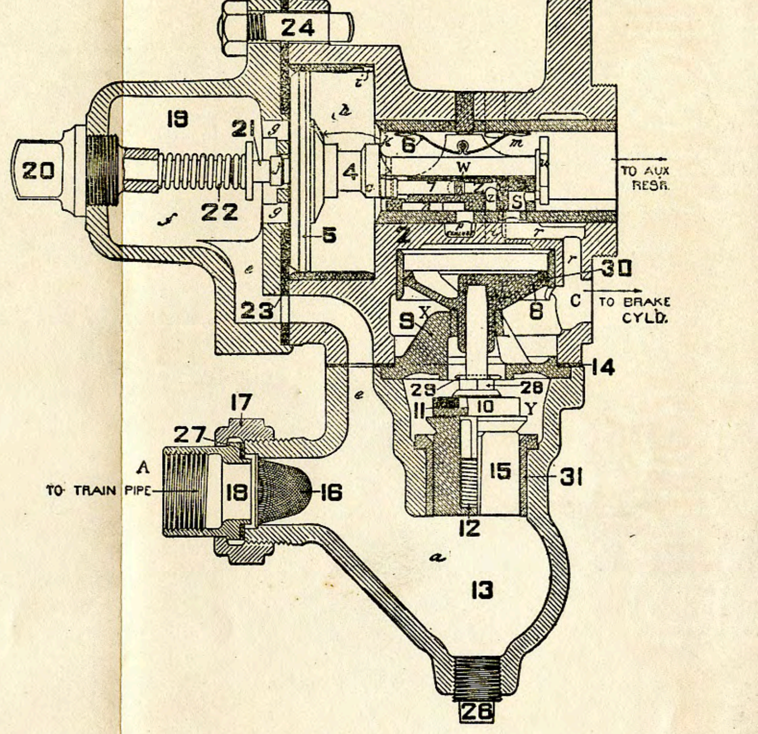


Fig. 5.
Emergency Position.

PLATE 13—THE WESTINGHOUSE QUICK ACTION TRIPLE VALVE.

THE NEW YORK QUICK ACTION TRIPLE VALVE.

The New York and Westinghouse Quick Action Triple Valves are interchangeable in their connections, as well as in method of operation and service application, but are somewhat different in construction and action in emergency application.

As has been previously explained, it is necessary to make a sudden reduction of the train pipe pressure at each triple valve in order to get quick action to carry through a train.

The quick action parts of this triple valve are brought into operation by any sudden, heavy reduction of train pipe pressure and immediately open ports which allow discharge of train pipe pressure to the atmosphere thus carrying the quick action to the next triple valve. In this manner the rapid "serial" action of the brakes throughout the train is assured when necessary, and the slack is prevented from running in or out so as to cause shock.

Also, in quick action, special valves are opened making a large and direct connection between the auxiliary reservoir and the brake cylinder and allowing the pressures to equalize almost instantly. There is no increase in brake cylinder pressure in emergency but the almost simultaneous application of the brakes and almost instantaneous equalization of pressure result in the quicker and shorter stop necessary in emergency applications of the brake.

For convenience in describing this triple valve, Figs. 1, 2, 3 and 4, of Plate 16, are shown with all valves and ports on one plane. Plates 14 and 15 show longitudinal and cross-section views with these parts in their proper position with relation to one another.

CHARGING AND RELEASE POSITION.

Fig. 1, Plate 16 and Plates 14 and 15 show the valve in charging and release position. Air entering from train pipe through strainer 28 flows into chamber A, forcing main piston 128 and vent valve piston 129 to the right, uncovering feed groove B and allowing pressure to pass into the auxiliary reservoir, *thus charging the auxiliary reservoir.*

When main piston 128 was forced to the right, graduating valve 48 closed, and slide valve 38 uncovered the exhaust port in its seat, allowing pressure from the brake cylinder to pass out of the exhaust, *thus releasing the brake.* The knob on the end of vent valve piston 129 has come in contact with piston stop 142 leaving a space G between the main piston and the vent valve piston. This space G charges through small feed port F to train pipe pressure. Vent valve 71-131, is held to its seat by vent valve spring 132, and quick action valve 138-139 is held to its seat by spring 140, and passageway K is charged to auxiliary reservoir pressure.

SERVICE APPLICATION AND LAP POSITION.

In a service application, a reduction in the train pipe pressure in chamber "A" allows the pressure in chamber "G" to pass through the small port "F" faster than it can flow back through feed groove "B" thus unbalancing the pressure on the two sides of main piston 128. The higher pressure on the auxiliary reservoir side then forces the piston to the left against gasket 133 into the application position shown in Fig. 2.

In moving to the application position, main piston 128 first closes feed port "B", cutting off communication between the train pipe and the auxiliary reservoir, then moves the slide valve 38, and the graduating valve 48, the first to position covering exhaust port and closing communication between the brake cylinder and the atmosphere, the latter, to a position uncovering the graduating port leading from the auxiliary reservoir to the brake cylinder.

As soon as the graduating port is uncovered, the auxiliary reservoir pressure commences to reduce by expanding into the brake cylinder until, in the case of a light application, it falls a trifle below the pressure remaining in chambers "A" and "G"; or in the case of a full application, until the auxiliary reservoir pressure equalizes with the brake cylinder.

With a light or partial application, when the auxiliary reservoir pressure drops a trifle below that remaining in chamber "G" and the train pipe, piston 128, which is free to move a limited distance without disturbing slide valve 38 and graduating valve 48, will move back to the lap position Fig. 3, or the position in which the graduating valve covers the graduating port. In this position all ports in the triple valve are closed and the brakes are held applied.

If it is desired to increase the force in the brake cylinder, another reduction in the train pipe pressure will be necessary, when the piston 128 and graduating valve 48 will again be moved to application position, uncovering the graduating port and allowing the auxiliary reservoir pressure to expand into the brake cylinder until it falls again a trifle below the pressure in the train pipe, when main piston will move to lap position as before. Thus in light or service applications of the brake, the graduating valve responds to each reduction in the train pipe pressure, and allows an equal reduction of the pressure from the auxiliary reservoir into the brake cylinder until, if continued, they equalize.

With seventy pounds train pipe and auxiliary reservoir pressure, the brake cylinder and auxiliary reservoir pressures should equalize at about fifty pounds, and consequently a train pipe reduction of a little more than twenty pounds will give full equalization and any further reduction will only be a waste of air from train pipe which must be supplied before brakes can be released properly.

By referring to Fig. 1, it will be seen that to release the brake, it is necessary either to increase the train pipe pressure above that in the auxiliary reservoir by means of the brake valve on the engine or to reduce

the auxiliary reservoir pressure below that in the train pipe by opening the auxiliary reservoir release valve or "bleeder." This will cause main piston 128 to move to the right, uncovering feed port "B" and moving graduating valve 48 to lap position and slide valve 38 to release position, all as explained under "Charging and Release."

EMERGENCY POSITION.

If an emergency application is desired, a quick reduction in the train pipe pressure must be made, and when this is done the pressure in Chamber "G" cannot reduce through port "F," on account of its small size, as fast as the train pipe pressure is being reduced. Consequently the main piston cushions on the air in chamber "G," and both the vent valve piston 129 and main piston 128 move together, the stem of the vent valve piston 129 coming against the lever arm 71 of the vent valve and opening vent valve 131, as shown in Fig. 4, this being the emergency position.

When the vent valve is forced from its seat, the train pipe air rushes into passage "H," and against the quick action valve piston 137, moving the latter to the right until its stem forces the quick action valve 139 away from its seat, and at the same time escapes through ports "J" and "M" directly into the atmosphere.

While quick action valve 139 is off its seat, the large passage is opened up from the auxiliary reservoir through "K" and "L" to the brake cylinder, and through this the auxiliary reservoir pressure rushes to the brake cylinder. Before the auxiliary reservoir pressure coming through the passage "L" can enter the brake cylinder, however, it must force the check valve 117 away from its seat. This check valve prevents the flow of air back from the brake cylinder after it has once entered it.

While the quick action is taking place, the small service port controlled by the graduating valve is also open, so that the auxiliary reservoir pressure may feed through it at the same time that it is going to the brake cylinder through the large port "L."

As soon as the sudden reduction in train pipe pressure, necessary to carry quick action to the next triple valve in the train, has been made, spring 132 forces vent valve 71-131 to its seat and vent valve piston 129 to the right. Pressure being relieved on the left of quick action piston 137 by exhaust through port "J" to the atmosphere, emergency valve 139 is forced back to its seat by spring 140, check valve 117 is closed by spring 118 and all triple valve parts are then in the position shown in Fig. 2 the same as in service application.

Release from this position is exactly the same as was described for release from service application, it being only necessary to move main piston 128 with slide valve 38 and graduating valve 48 back to the position shown in Fig. 1.

Plates 14 and 15, showing the valves and ports in their true position, give an accurate idea of the large size and direct connections of the passage for the air from the auxiliary reservoir to the brake cylinder in emergency application, and will explain why under these conditions full brake cylinder pressure is developed almost instantaneously and the shorter and quicker stop desired for emergency is obtained.

DEFECTS.

The defects which are found with this triple valve, some of which may cause trouble on the road by interfering with proper action of the brake, are among the following: Leaky vent valve 131; leaky quick action valve 139; sticky vent valve piston 129; port "F" in vent valve 129 partially gummed up; leaky triple valve piston packing ring 3; leaky check valve 117; leaky slide valve 38; leaky graduating valve 48; leaky gasket between triple valve and auxiliary reservoir on freight apparatus and between triple valve and brake cylinder head on passenger apparatus; leaky pipe between triple valve and brake cylinder on freight apparatus.

A leak by the vent valve No. 131 will allow the train pipe pressure to pass into chamber "H" and out to the atmosphere at port "M." This will be a train pipe leak and if it is not any greater than that usually found in the train pipe or hose the brake should not be cut out. After an emergency application of the brake, this valve sometimes sticks open and it will be impossible to release the brakes as the pressure will flow to the atmosphere by the stuck valve faster than the pump can supply it. The valve will usually go to its seat by closing the cut out cock in the crossover pipe and then opening it suddenly.

A leak by the quick action valve No. 139 will allow the auxiliary reservoir pressure from passage K to flow into passage L and by the quick action piston No. 137 to the atmosphere by port J. If the brake is in release position and the valve leaks badly the air will also force the check valve No. 117 off its seat and flow into the brake cylinder and out to the atmosphere at the triple valve exhaust port. A leak by this valve will cause the brake to release by reducing the auxiliary reservoir pressure. Sometimes after an emergency application dirt from the train pipe will cause the quick action valve piston to stick in application position, holding the quick action valve No. 139 off its seat.

If the vent valve piston No. 129 becomes dirty so that it will stick in the main piston No. 128 the brakes are liable to apply in emergency when a service application is desired. Port F becoming gummed up so that the air could not escape fast enough would be apt to cause the same trouble but this seldom occurs.

A leak by check valve No. 117 will cause the brake to leak off and will cause a blow at port J when brake is applied either in service or emergency. The result is exactly the same as a leaky packing leather in

the brake cylinder but the latter will leak out through the non-pressure head of the brake cylinder.

If a brake fails to release it is due to a leaky main piston packing ring 3, a sticky main piston 128, or after an emergency application, vent valve 131 stuck open.

A leaky slide valve 38 or graduating valve 48 will cause the triple valve to release prematurely.

The same care and attention in cleaning, oiling, maintaining standards and testing, as required for the Westinghouse triple valve, should also be given to the New York triple valve.

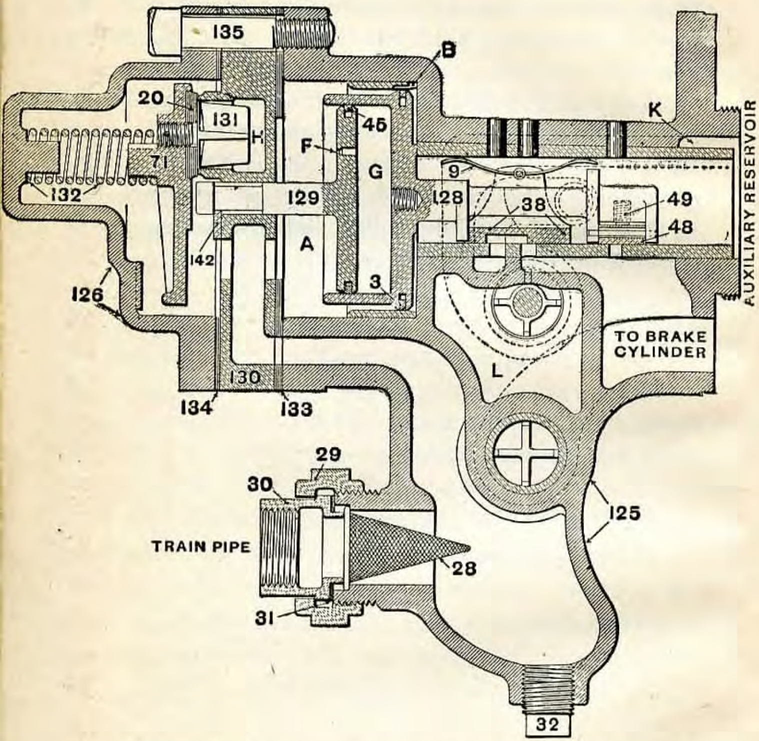


Plate 14—New York Quick Action Triple Valve, Side View.

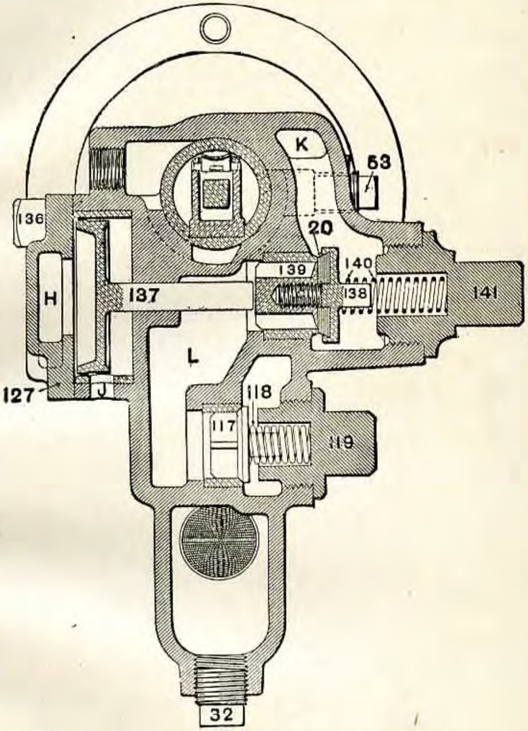


Plate 15—New York Quick Action Triple Valve, End View.

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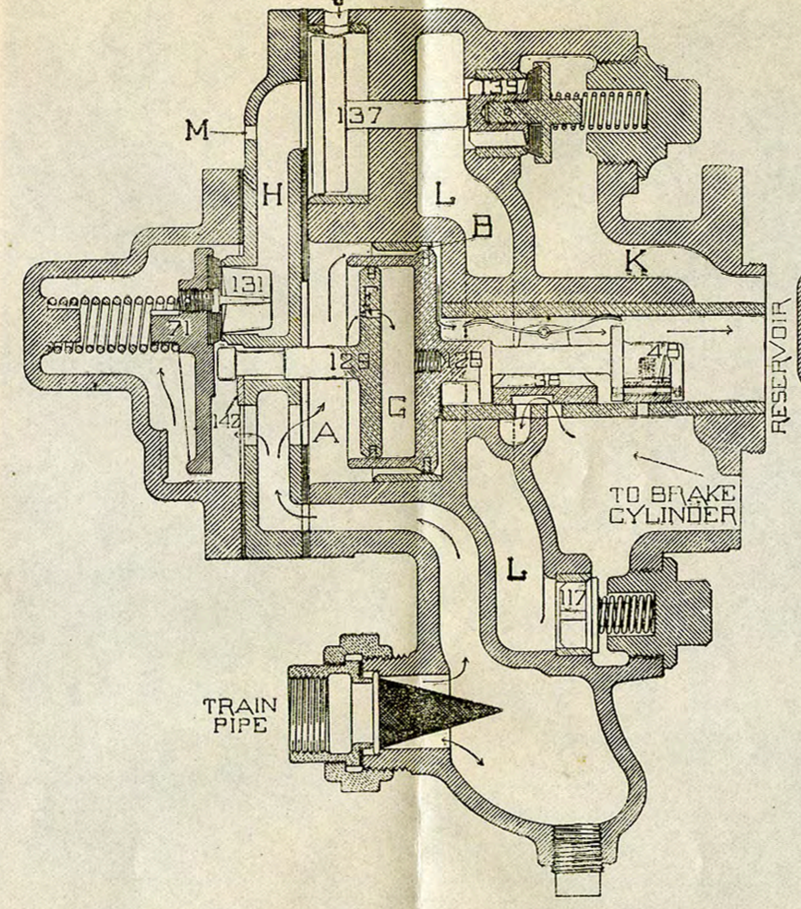


Fig. 1.
Charging and Release Position.

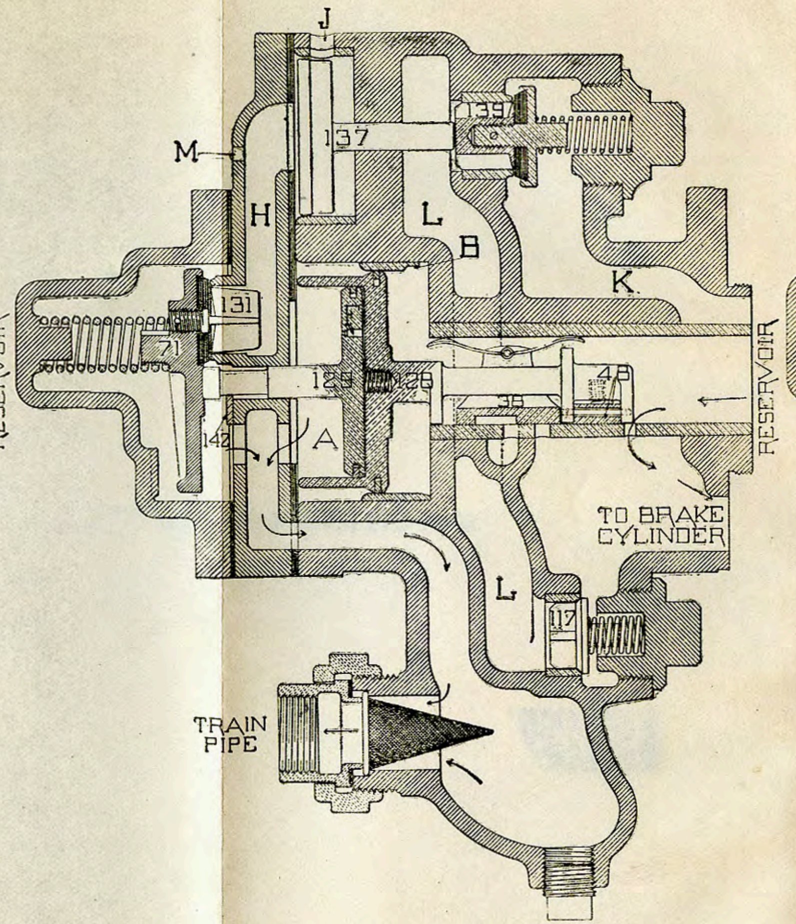


Fig. 2.
Service Application Position.

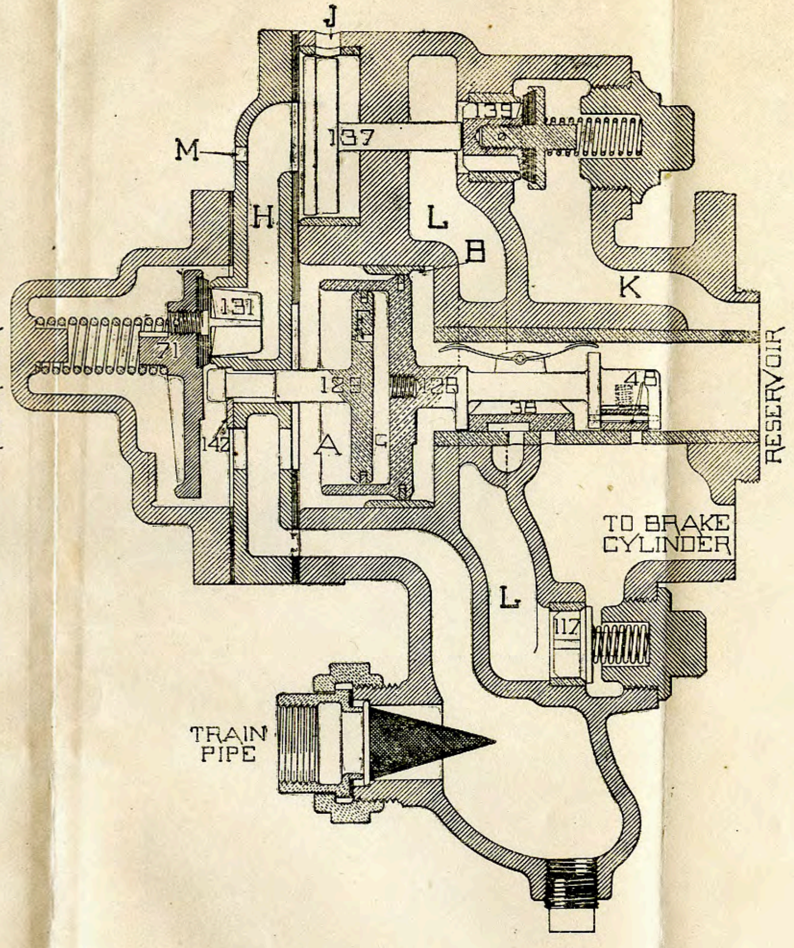


Fig. 3.
Lap Position.

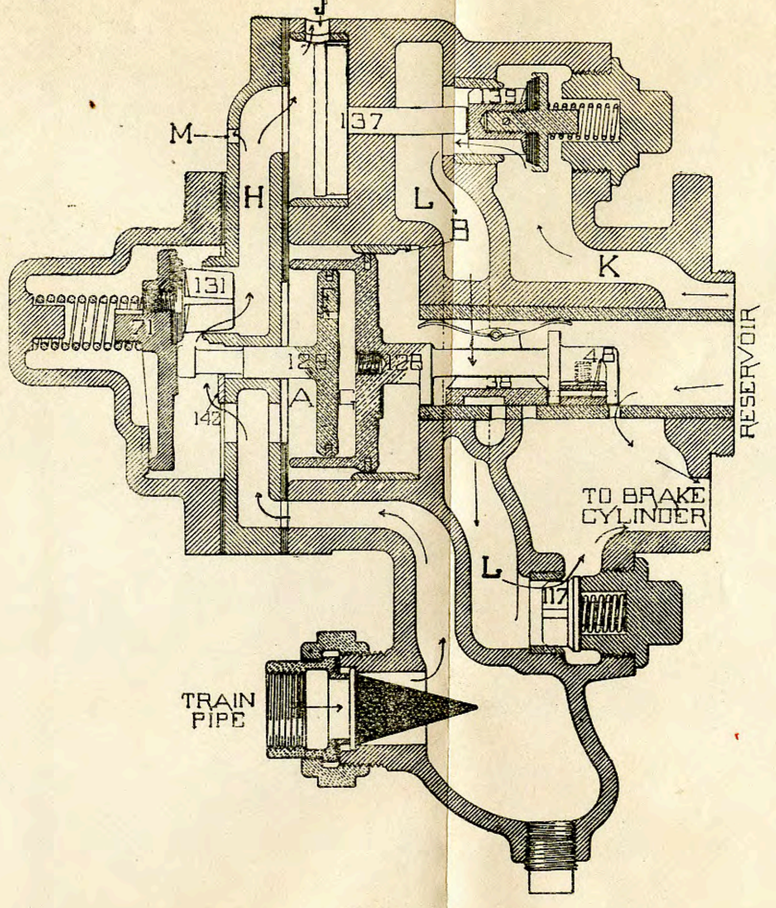


Fig. 4.
Emergency Position.

Plate 16—The New York Quick Action Triple Valve.

ENGINEER'S BRAKE VALVE.
(Westinghouse.)

As the operation of the triple valves is governed by the train pipe pressure and as this pressure is controlled by the engineer's brake valve, it follows that the correct operation of the brakes is largely dependent on the proper action and manipulation of this brake valve.

Plates 17, 18, 19, 20 and 21 illustrate the modern or G-6 engineer's brake valve. Plate 17 is a section through the main reservoir and train pipe connections, showing practically all of the front half removed. Plate 18 is a section at a right-angle to Plate 17, but with a little less than a half section removed.

Fig. 3 of Plate 19 is a section across the top of the valve at the rotary valve seat. Figs. 1 and 2 show respectively the face of the rotary valve and its top, the slot in the latter receiving the wedge shaped portion of key 12, Plate 17, which turns the rotary valve. The rotary valve has three ports through it, *a*, *j* and *r*, and in its face the long groove *p*. *c*, *c* and the three small circles indicate holes leading from the face into a single, large cavity shown by the full and the broken line passing around the large openings and across the outer edge of the smaller ones. The circle at the middle of Fig. 1 indicates the pin which holds the rotary valve central, shown also by dotted lines just above 3 in Plate 17.

Plate 20 is an enlarged view of the slide valve feed valve as shown in Plate 18, and Plate 21 is another section of this part at a right angle to Plate 20.

As a connection with the main reservoir is made at X, Plate 17, main reservoir pressure can always pass freely through *A*, *A* to the top of the rotary valve 14. The pump governor and red hand of the air gauge are also connected to this pressure, as shown.

The train pipe is connected at Y. This brings train pipe pressure under the equalizing piston 18 and, through passageway *l*, *l*, to the lower face of the rotary valve 14, Plates 17 and 18. The lower end of the stem of equalizing piston 18, Plate 17, acts as a valve, opening and closing the passageway *m*, *n* and n^1 by which the train pipe pressure is discharged to the atmosphere in all service applications.

The small chamber D above equalizing piston 18, Plates 17 and 18, has a passageway through *S*, *S*, Plate 18, to the tee shaped fitting 15, Plate 17, to which the black hand of the air gauge and the equalizing reservoir are connected. The purpose of the latter is simply to enlarge the volume of chamber D. As the pressures above and below equalizing piston 18 are ordinarily equal, the black hand indicates train pipe pressure, even though not directly connected to it.

Preliminary exhaust port *e* and equalizing port *g*, Plates 17 and Fig. 3 of 19, run from chamber D above piston 18 to the face of the rotary valve 14. Any pressure discharged from chamber D must pass out through *e*, made very small at its top by means of a bush.

Feed port *f*, *f*, Plate 18, delivers pressure to the feed valve, and after it has passed through the latter

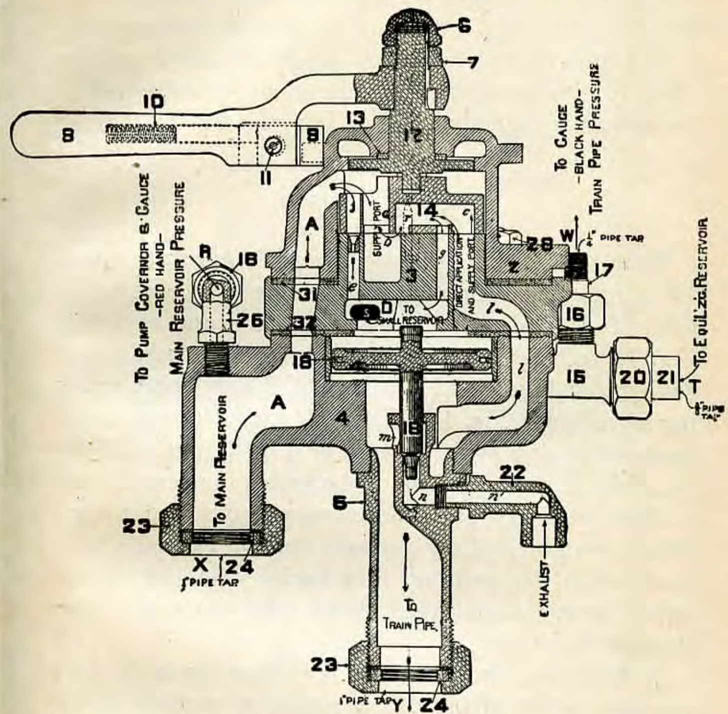


Plate 17—G-6 Engineer's Brake Valve. Release Position. Front View.

it is carried to the train pipe port *l*, Fig. 3 of Plate 19, by the continuation *i* of the feed port, both *f* and *i* being here indicated by dotted lines.

The top of the direct application and exhaust port *k* is shown by Fig. 3 of Plate 19, and its continuation to the atmosphere is indicated by dotted lines, ending close to the bracket stud. A cavity in the rotary valve seat is indicated by *b*, Plates 17 and 19.

RELEASE POSITION.

Plate 17 shows the brake valve with its rotary valve 14 in release position, being the one at the extreme left. The dividing wall between port *a* and cavity *c*, Fig. 1 of Plate 19, now stands across the middle of cavity *b* of Fig. 3 and of Plate 17. The larger opening of cavity c, Fig. 1 of Plate 19, extends over direct application and supply port *l* of Fig. 3 and of Plate 17, which is the beginning of the train pipe connection.

Main reservoir pressure, always above the rotary valve, can flow rapidly through port *a*, Plate 17, into cavity *b* in the seat, up into cavity *c* in the rotary valve, across *c* and then down into the train pipe through *l*.

At the same time that this is raising the train pipe pressure under piston 18, a supply is passing down ports *j* and *e* and, from cavity *c*, through one of the three small holes in the rotary valve and equalizing port *g* in the seat, to the top of piston 18, thus equally increasing the pressure above it with that of the train pipe below.

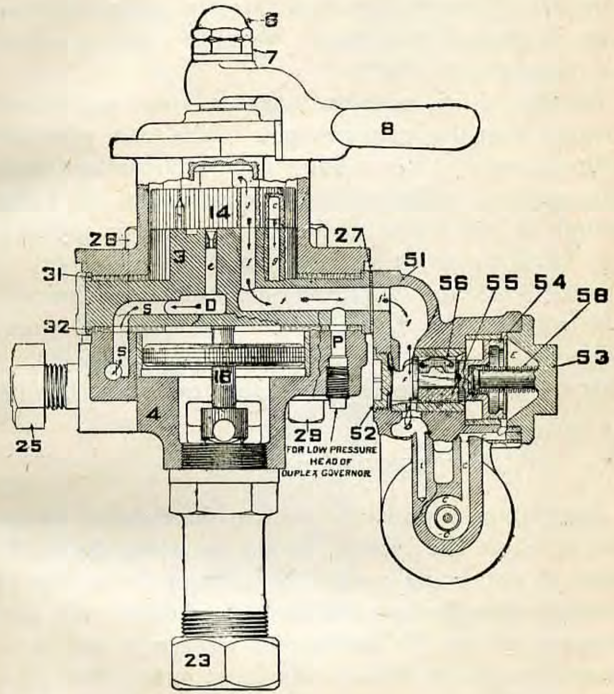


Plate 18—G-6 Engineer's Brake Valve. Running Position. Side View.

Release position is used to obtain the quick and considerable rise in train pipe pressure required to insure a prompt release of applied brakes. It should also be employed when necessary to quickly charge or recharge the auxiliary reservoirs, the latter occurring when decending steep grades where the time available for recharging is short.

But as release position makes a large and direct opening from the main reservoir to the train pipe and as the pump governor is adjusted above standard train pipe pressure, release position should not be used long enough to overcharge the brakes. To aid in preventing forgetfulness, the very small warning port *r*, Plates 17, 18 and 19, stands over direct application and exhaust port *k*, Fig. 3 of Plate 19. The sound made by the air this discharges to the atmosphere calls attention to the position of the brake valve handle.

RUNNING POSITION.

Running position is the next to the right of release and is where the handle should be when the brake valve is not being used. Its purpose is to supply ordinary train leakage, maintain the desired train pipe pressure and aid in keeping in reserve in the main reservoir a higher pressure than that in the train pipe, such being termed "excess" pressure. It is shown by Plates 18, 20 and 21, and other of the ports it brings into use by Plates 17 and 19.

The rotary valve 14, Plate 18, now has port *j* over port *f* in the seat, preliminary exhaust port *e* is closed,

ROTARY VALVE.

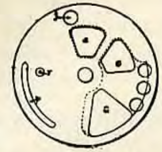


Fig. 1.
Face View.

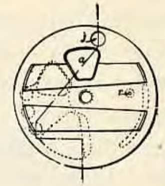


Fig. 2.
Top View.

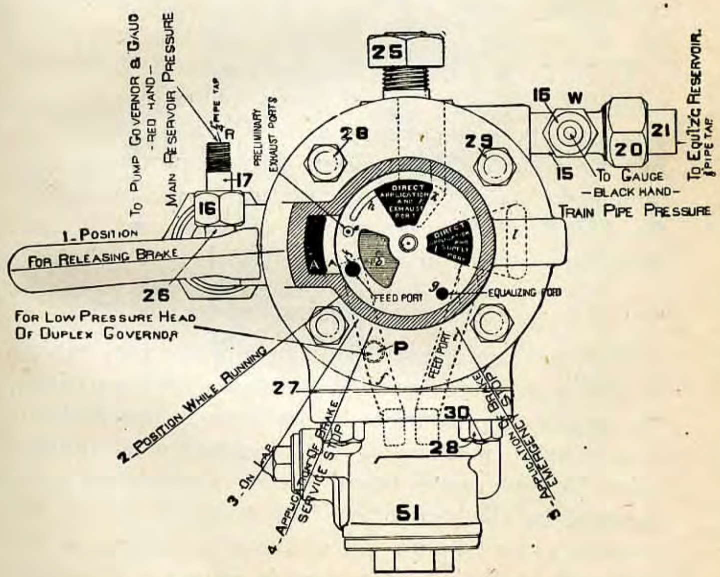


Fig. 3.—Top View, Rotary Valve Removed.
Plate 19—G-6 Engineer's Brake Valve.

the dividing wall between port *a* and cavity *c*, Fig. 1 of Plate 19, is now over a blank portion of the seat, thus separating them, another of the three small holes is connecting cavity *c* with equalizing port *g*, and the larger opening in cavity *c* is still over direct application and supply port *l*.

Main reservoir pressure flows through port *j* in the rotary valve, Plate 18, ports *f*, *f* in the rotary valve seat, f^1, *f*, F and *b* of this Plate and Plates 20 and 21, up port *i*, *i* to the right in Plate 21 and through feed port *i* in the seat, Fig. 3 of Plate 19, into direct application and supply port *l* at a point just below the face of the rotary valve, as indicated by the arrows.

While this is supplying the train pipe the latter is connected with the top of piston 18 by equalizing port *g* in the same manner as is shown in Plate 17. But the air now flowing down through port *g* comes from port *l*, and port *g* is connected with cavity *c*, Fig. 1 of Plate 19, by another of the three small holes than the one used in release position.

SLIDE VALVE FEED VALVE.

Plate 20 is an enlarged side view of the feed valve as shown on Plate 18. This device is for regulating the train pipe pressure while the brake valve handle is in *running position* only. It consists of a supply valve 55 (slide valve type), having a spring 56 and operated by the piston 54. This piston is fitted accurately to its cylinder, but as it has no packing rings there will be some leakage past it when the pressure on its left is higher than that on its right.

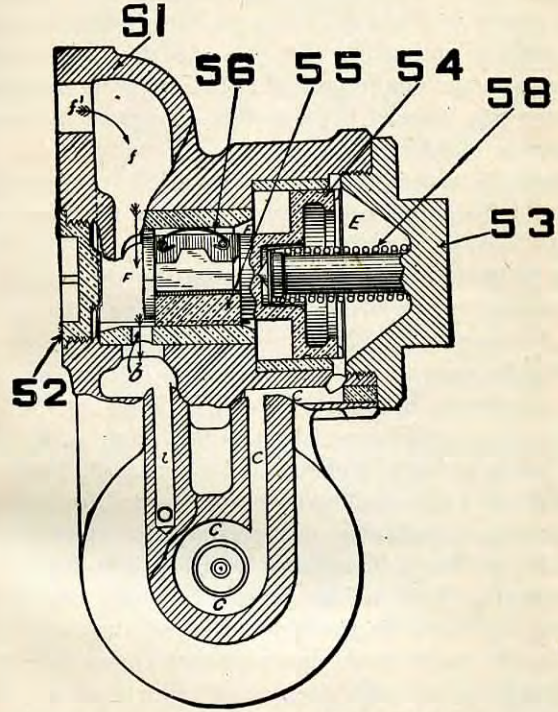


Plate 20—Slide Valve Feed Valve, Side View.

From chamber *E* at the right of the piston a port *c, c* leads down to the circular cavity *c, c* in the center of which is a brass bush. This bush has a port through it, governed by the regulating valve, 59, here removed but shown in Plate 21. This valve is pressed toward its seat by spring 60. Its stem at the right of seat *a* rests on the diaphragm 57. The latter is composed of two thin discs of brass and is similar to the pump governor diaphragm.

Space *G* at the left of diaphragm 57 is in constant communication with train pipe pressure through small port *i, i* connecting it with large port *i, i*. The train pipe pressure in space *G* is opposed by the tension of regulating spring 67, adjusted by its nut 65, acting on the diaphragm 57 by pressing on the spindle 64.

Regulating valve 59 is to open, as shown, or close the connection between chamber *E*, Plate 20, and the train pipe. It is opened by the diaphragm and, when the latter permits, is closed by its spring 60, Plate 21.

The operation of the valve will be explained on the assumption that with no pressure the brake valve handle is placed in running position and the pump is started. With no air pressure present the piston spring 58, Plate 20, would have forced the piston and its supply valve to the left and thus closed port *b*.

As soon as any main reservoir pressure is accumulated it will start to leak past piston 54, but as the regulating valve 59 will then be held open, such slight leakage will pass directly to the train pipe. When sufficient main reservoir pressure has been accumulated, about 6 or 7 pounds, to overcome the tension of the piston spring

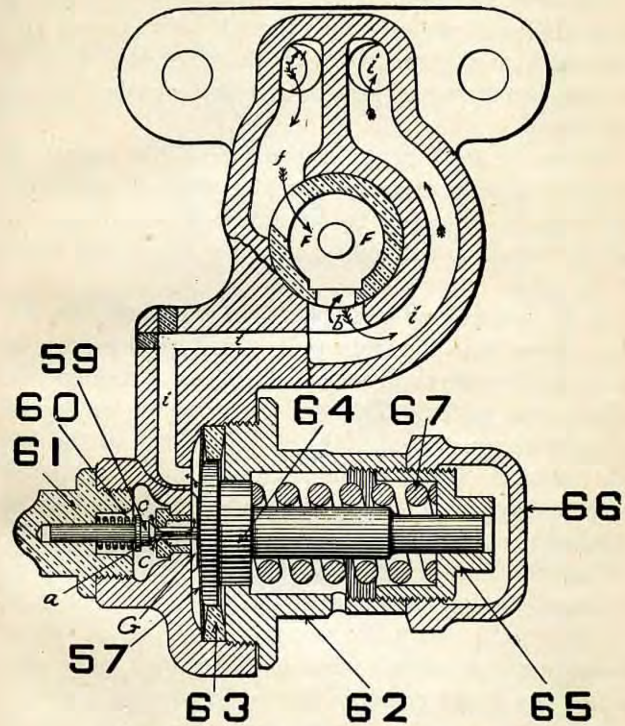


Plate 21—Slide Valve Feed Valve, Front View.

58 the piston and supply valve will be forced to the right as shown, thus starting the feed through port *b* into the train pipe.

The pressure required to compress the piston spring 58 is indicated on the air gauge, if it is correct and the pump speed is moderate, by the difference between its two hands when pressure is being pumped up on the engine.

When the feed into the train pipe has raised its pressure to 70 pounds, at which regulating spring 67, Plate 21, is supposed to be adjusted, diaphragm 57 will be forced to the right and allow regulating valve 59 to seat.

As the air leaking past piston 54, Plate 20, can not now escape into the train pipe it will quickly raise in chamber *E* to the main reservoir pressure on the opposite side of the piston. This will allow piston spring 58 to force the piston and the supply valve to the left and cut off the feed into the train pipe until a reduction from leakage or a brake application has resulted in regulating valve 59 being again opened.

Though the feed into the train pipe will cease when the supply valve has closed, the pump will continue working until the main reservoir pressure at which its governor is adjusted has been attained, thus providing the excess pressure carried in running position.

Full release position should invariably be used to release the brakes, but the valve handle should be brought to running position, except in descending heavy grades with freight trains, before the auxiliary reservoirs have charged to 70 lbs. Otherwise there is liable to

be trouble from brakes creeping on, owing to the feed valve not supplying the leakage until the pressure has reduced slightly below 70 lbs. This shows the necessity for keeping the warning port free from gum or any other obstruction.

If the train pipe is accidently overcharged it should at once be reduced by applying and releasing, if a passenger train. If a freight train this should be done only while standing so as to avoid danger of stalling or breaking in two.

The proper length of time to leave the brake valve in release position to insure the release of brakes and avoid overcharging under various conditions is dealt with under "train handling."

LAP POSITION.

The next position to the right of running position is lap. As in it the rotary valve 14 merely closes all ports, it is not illustrated. This position and the two which will be explained later, cut off all communication between the main reservoir and other brake valve connections.

When on lap the brake valve neither feeds into nor discharges from the train pipe. It is used to hold brakes applied, to prevent them from recharging, as when making couplings, and to save the main reservoir pressure in case of a break in two, burst hose or when the conductor's valve is used.

As lap stops all feed into the train pipe it follows that any leakage from same will then reduce its pressure, thereby tending to increase a brake application made, or, if rapid enough, to apply brakes previously in release.

As it is possible for train pipe pressure to leak down so gradually, when unsupplied, as to fail to apply brakes, and as low pressure when undesired can result seriously, the valve should never be left on lap unless absolutely necessary.

DUPLEX PUMP GOVERNOR CONNECTION.

When the duplex pump governor, Plate 6, is used with the ordinary brake apparatus the low pressure head is connected at *P*, Plate 18, to the feed port *f*. The high pressure head is connected direct with main reservoir pressure. Assuming the low pressure head is set for 85 pounds and the high pressure head for 120 pounds, the operation will be as follows.

So long as the brake valve handle is in running position the low pressure head will be in direct communication with main reservoir pressure, thus limiting the latter to 85 pounds or 15 pounds above the standard train pipe pressure.

When the brake valve handle is brought to lap position, service and emergency having a similar effect on the governor, the rotary valve cuts off main reservoir pressure from feed port *f*. As the feed valve is almost constantly supplying the train pipe the pressure in the feed port and low pressure governor head at once drops to 70 pounds or lower. This causes the pump to start promptly and, if the

time is adequate, results in it raising the main reservoir pressure to 120 pounds.

Among the advantages of this arrangement are a comparatively low pressure for the pump to work against when little excess pressure is needed, yet automatically insuring a high main reservoir pressure for releasing and, when descending steep grades, quickly recharging the brakes.

SERVICE APPLICATION POSITION.

To obtain the best results in the gradual or service application of brakes it is necessary (1) that the train pipe reduction with short trains shall not be so rapid as to cause the emergency operation of quick action triple valves; (2) that the speed of train pipe reduction shall lessen with increased length of trains where such are very long as this decreases the difference in braking power between the head and rear ends, which difference is due to the more rapid fall in train pipe pressure on the cars nearest the engine; (3) that the engineer shall not have to operate the brake valve differently with various lengths of trains in order to obtain similar train pipe reductions; and (4) that with trains of any considerable length the train pipe discharge be closed off gradually so as to prevent the train pipe pressure raising near the engine and releasing the head brakes. These results are accomplised as follows:

To make a service reduction the brake valve handle is brought to the fourth or service application position. Groove *p* in the face of the rotary valve, Fig. 1 of Plate 19, then connects preliminary exhaust port *e*, Fig. 3 of Plate 19 and Plates 17 and 18, with direct application and exhaust port *k*, Fig. 3 of Plate 19.

This causes a reduction in the pressure above piston 18, Plate 17, which pressure was previously the same as the train pipe pressure beneath the piston. When the desired reduction has been made, indicated by the black hand of the gauge, the valve handle is returned to lap.

Reducing the pressure above piston 18 below that of the train pipe beneath it causes the piston to rise. This draws from its seat the valve formed by the lower end of the piston stem and makes an opening through *m*, *n* and n^1 by which the train pipe pressure discharges to the atmosphere.

When this discharge has reduced the train pipe pressure a trifle below the pressure remaining above the piston the latter starts down and, with a short train, closes at once.

With a long train the pressure at the head end of the train pipe will be a few pounds lower than that at the rear when the piston starts down. Under such conditions it closes gradually. This equalizes the train pipe pressure and prevents the rise at the head end which would occur and release brakes if the discharge was stopped abruptly.

To make a given reduction from the pressure above piston 18 *always requires the same length of time because the volume does not vary.* But the time

required by the piston to make an equal reduction in the train pipe pressure *increases with the length of the train pipe in use.* With trains of any considerable length this discharge continues after the valve handle has been returned to lap.

The relation between the amount of reduction made and length of the train pipe discharge should always be observed as by it any material shortening of the train pipe, such an unintentionally closed angle cock, can be detected, often in season to prevent an accident.

EMERGENCY APPLICATION POSITION.

Emergency application position is the last to tne right and as its name implies, should be used only in emergencies, as when life or property is in danger. By making a large and direct opening from the train pipe to the atmosphere it causes the sudden and heavy train pipe reduction needed to bring about the quick action operation of brakes fitted with this type of triple valve. When used the valve handle should be left in this position until it is desired to release.

With the handle in emergency application position one of the two large openings of cavity *c* in the rotary valve, Fig. 1, Plate 19, stands, over direct application and supply port *l*, Fig. 3, and the other one is over direct application and exhaust port *k*. This permits the train pipe pressure to flow rapidly through cavity *c*, *c* to the atmosphere.

BRAKE VALVE CUT-OUT COCK.

A cut-out cock is placed in the train pipe just below the brake valve. Its purpose is to cut-out the brake valves on all but the leading engine where more than one are coupled in the same train. This allows the engineer of the head engine to operate the brakes without interference from the other engines.

CARE OF THE BRAKE VALVE.

The handle bolt 9, Plate 17, should mark the positions plainly by feeling. Its sides where it works in the handle slot and the face of the quadrant where it bears should be kept lubricated.

About once in two weeks the brake valve, including the feed valve, should be taken apart for cleaning and lubricating. All dirt and gum should be removed taking care not to scratch or bruise any part. The rotary valve 14, washer 13 and equalizing piston 18 should be lightly coated on their wearing surfaces with a good, heavy lubricant that will not gum, such as that used in brake cylinders.

The projection below the valve seat on the stem of piston 18 and the space it extends into should be cleaned of all gum as the space around the smallest part of this stem, instead of the lift of the piston, governs the maximum speed of discharge.

The leather gasket 32 should be given a light coat of brake cylinder grease to preserve it. This gasket extends above the piston for the latter to strike

against. The piston should make a perfect joint as this is intended to guard against leakage from the train pipe into chamber *D* when a service application is being made with a long train. The piston packing ring is subjected to so much dirt that it can not be depended upon to remain sufficiently tight to prevent such leakage for any considerable length of time.

The brake valve should never be without the angle fitting 22 as the size and shape of the port in this fitting have an important bearing on the action of the brake valve.

Rubber gasket 31 should be kept free from oil and coated with dry graphite as this prevents it from sticking.

The preliminary exhaust port *e* should be cleaned with a pointed piece of hard wood, but never with metal as the latter would alter its size. If increased it would cause undesired quick action with very short trains.

All joints should be kept air tight. To better insure this the six bolts and several unions should occasionally be tested with a wrench.

Where the feed valve is cleaned on the engine the work can be done best with pressure in the main reservoir so as to blow out all dirt from the valve when the working parts are removed. Keep the valve handle in emergency application position except when blowing out the ports.

After cleaning the piston and supply valve, apply a light coat of valve oil to the bearing surfaces on them and spring 56. Examine piston spring 58 for corrosion or wear and lightly coat it and the stem of cap nut 53 with grease or valve oil.

Be particularly careful not to bruise, bend or scratch the parts or in any way alter their dimensions. While the regulating valve should be cleaned and its ports blown out at the same time, it should be replaced dry. The diaphragm, regulating spring and connected parts do not require as freqeunt attention as do the other portions of the feed valve.

DEFECTS.

Leaky Rotary Valve. This is a. serious defect where, with the brake valve on lap, it increases the train pipe pressure sufficiently to release brakes. To test for it, with the engine only and standard pressures make a 10 pound service reduction, return the valve handle to lap and note carefully whether train pipe pressure increases. If so tighten the four main bolts in brake valve and test again. If it still exists report the rotary valve.

In rare cases the leak is across the leather gasket 32 where it separates main reservoir pressure from that above equalizing piston 18. This explains the object of tightening the four bolts.

Leak at Train Pipe Exhaust Fitting 22. This is due to one of three causes. If the valve seat on the lower end of the stem of piston 18 is defective the leak will occur in running as well as other positions.

Where the leak occurs only occasionally and is more noticable with long trains, if jarring the body of the valve lightly will stop the leak it is due to a leaky packing ring 19, often coupled with dirt and lack of lubrication.

If the discharge will not cease with the handle on lap, but does in running position it is due to a leak from the pressure above equalizing piston 18. Such leakage can occur past the leather gasket 32, in the connection to the black hand of air gauge or the one to the equalizing reservoir.

Do not confuse it with the excessively long discharge which is liable to follow a train pipe reduction of over 20 pounds as such indicates no fault of the brake valve, but is due to back-leakage through triple valves.

Black Hand Raises During a Service Reduction. This occurs only with trains of such length that the train pipe discharge must continue for some seconds after the valve handle is returned to lap. It is undesirable as it reduces the intended train pipe reduction, and is due to piston 18 failing to make a perfect joint where it strikes on leather gasket 32.

Too Slow or Too Rapid Service Reduction. Where it appears that the service reduction is either too slow or too rapid the air brake repairman should examine the valve to ascertain if its ports and fittings are standard.

Feed Valve Operates Incorrectly. If in running position the train pipe pressure increases above the standard and can not be regulated by the feed valve adjustment, first test for a leaky rotary valve. If not leaky, tighten the nuts securing the feed valve to the brake valve and see that no leakage exists at either feed valve cap nut. Where these fail to remedy the fault the valve needs cleaning or repairs.

Where this increase occurs only at times it indicates the supply valve piston 54 is not working freely, due to grit, gum, a bruise or a weak piston spring 58.

F-6 BRAKE VALVE.

The F-6 engineer's brake valve has what is known as the old style feed valve, in all other respects being practically the same as the G-6 type. Hence, its feed valve only will be explained.

Plate 22 illustrates the old style feed valve. It is secured to the brake valve in the same manner as is the standard or slide valve feed valve. Port f^1 connects with feed port *f* leading to the rotary valve seat in the brake valve, and port *i*, indicated by dotted lines, joins the continuation *i* of the feed port, Fig. 3 of Plate 19, leading to the train pipe.

Train pipe pressure is in constant communication with chamber *B* above piston 45, Plate 22, tending to drive it downward. This is resisted by regulating spring 39, the tension of which is adjusted by regulating nut 41. The rubber diaphragm 43 is to prevent leakage and yet allow free movement of the piston.

Supply valve 34 controls the opening into the train pipe. It rests on the upper stem of the piston rod 37, is opened when piston 45 rises and is closed

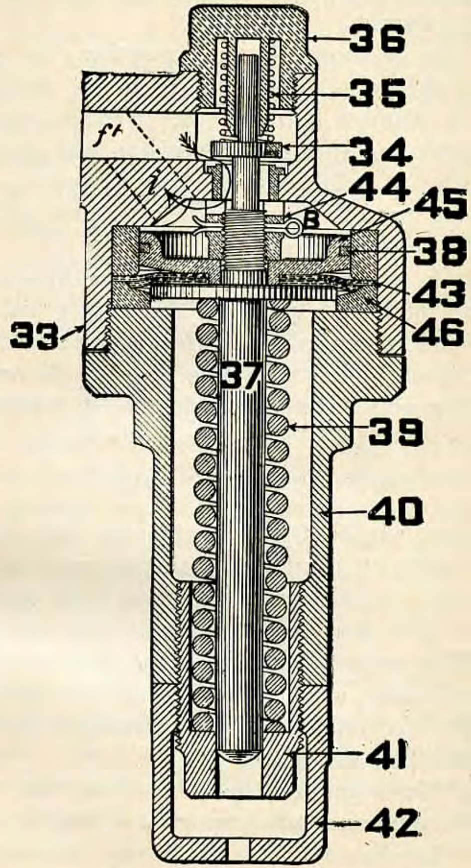


Plate 22—Old Style Feed Valve

by its spring 35 when the piston descends. Three projections on the top of piston nut 44 arrest the upward movement.

The valve is shown in feed position, the arrow indicating the flow of the air. When the train pipe pressure in chamber *B* commences to exceed the tension of regulating spring 39 the piston will gradually start down. It will continue this movement until the opening past the supply valve is just sufficient to feed the train leakage.

If the train pipe pressure is raised above this amount, by the use of release position, the supply valve 34 will close and remain so until by leakage or a reduction made otherwise the train pipe pressure is reduced below the pressure for which the feed valve is adjusted.

CARE OF THE FEED VALVE.

To adjust the feed valve with no train brakes coupled, pump up maximum main reservoir pressure and open wide the bleeder in the driver brake auxiliary reservoir. This leak is to represent that of a long train. After every alteration of the feed valve regulating nut make a 15 pound service reduction and return the valve handle *direct* to running position, but *do not* move to release.

Having thus regulated the valve, then with maximum train pipe and main reservoir pressures, move the valve handle to release for about two seconds, return it to running position and, after the leakage has reduced the train pipe pressure to a point where

the feed is supplying it, note what, if any, difference there is from the amount previously obtained. A slight difference is to be expected, but when [redacted] THR pounds or more it indicates undue resistance to the movement of the piston and should be reported for repairs.

This same method applies as well when regulating the slide valve feed valve.

The nuts securing the feed valve to the brake valve should be kept tight with both feed valves.

The spring box 40 should be drawn but little tighter than is possible without a wrench. Care must be exercised to avoid unintentionally tightening it more when drawing the check-nut 42. The spring box presses against the diaphragm ring 46 and any considerable pressure will crush the diaphragm.

To remove the working parts place the brake valve handle in emergency and then take off cap nut 36. Ordinarily the lower parts should not be taken out, but if desirable to do so remove spring box 40.

If the piston can not be drawn out by hand, replace cap nut 36, take firm hold of the piston rod and with the brake valve handle, gradually admit pressure to the train pipe. This will blow out the piston. Do not allow it to fall. Never use a metal punch to drive it out.

Metal must not be used when cleaning the supply valve and its seat as to do so will cause damage.

DEFECTS.

Pressure Feeds Up Too High. Where this fault occurs and can not be remedied by adjustment, first test for a leaky rotary valve, and tighten the feed valve nuts. If the fault is in the feed valve the supply valve 34 does not seat properly. This may be due to dirt, a distorted diaphragm or a bent valve guide in cap nut 36. The latter is caused by hammering on the nut, an inexcusable action.

It is of the utmost importance that the feed valve be properly maintained. Therefore, engineers should report any defects promptly.

D-8 BRAKE VALVE.

The only important difference in either construction or operation between the G-6 and D-8 brake valves is in running position. Instead of a feed valve it has an excess pressure valve, Plate 23 and Fig. 2 of Plate 24, midway in the feed port *f*, f^1.

The beginning and termination of the feed port are the same as in the modern brake valve, but midway in the port is the excess pressure valve 21, Plate 23. It is held to its seat by spring 20 and any pressure in the train pipe. With the valve handle in running position the main reservoir pressure acts to unseat the valve, but can not do so until it is a little higher than the train pipe and spring pressure combined, on the opposite side.

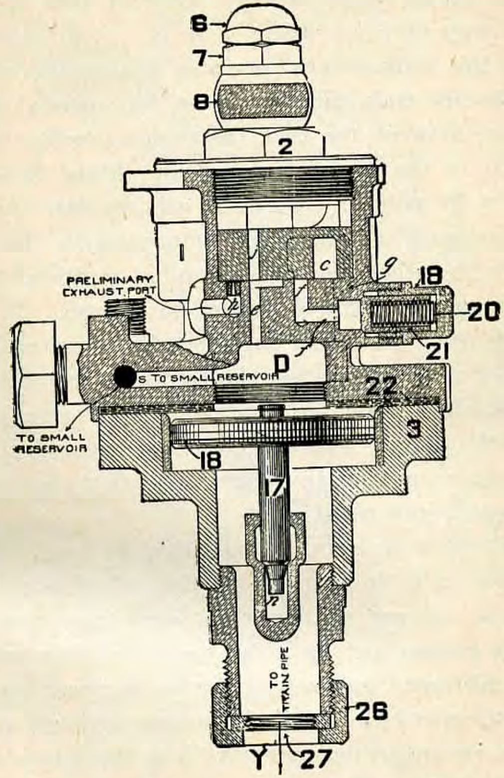


Plate 23—D-8 Engineer's Brake Valve, Side View.

Therefore, in running position there must be had and maintained the full amount of excess pressure for which spring 20 is adjusted in order that the train pipe may be fed.

As this arrangement regulates neither the main reservoir nor train pipe pressures, but merely the difference between the two, the pump governor is connected to the train pipe pressure, Plate 25, and is set for 70 pounds. Hence, it will regulate the train pipe pressure at the same amount with the valve handle in either release or running position, but no excess pressure will be carried in release.

Whenever the brake valve handle is moved to the right of running position the feed into the train pipe will be cut off and the governor will have no control over the pump. Therefore it then rests with the engineer to see that an excessively high main reservoir pressure is not obtained.

The excess pressure valve spring 20 should be adjusted to carry 10 pounds. As this valve has no warning port and can not cause too high train pipe pressure in release position it can be carried there without other detriment than resulting from no excess pressure.

In the service position preliminary exhaust ports *e* and *h*, are connected by cavity *p* in the rotary valve, Figs. 1 and 2 of Plate 24, causing the same action as with the modern brake valve. Port *h* has the small opening and leads direct to the atmosphere.

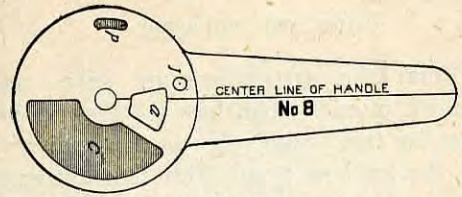


Fig. 1.
Face Of Rotary Valve.

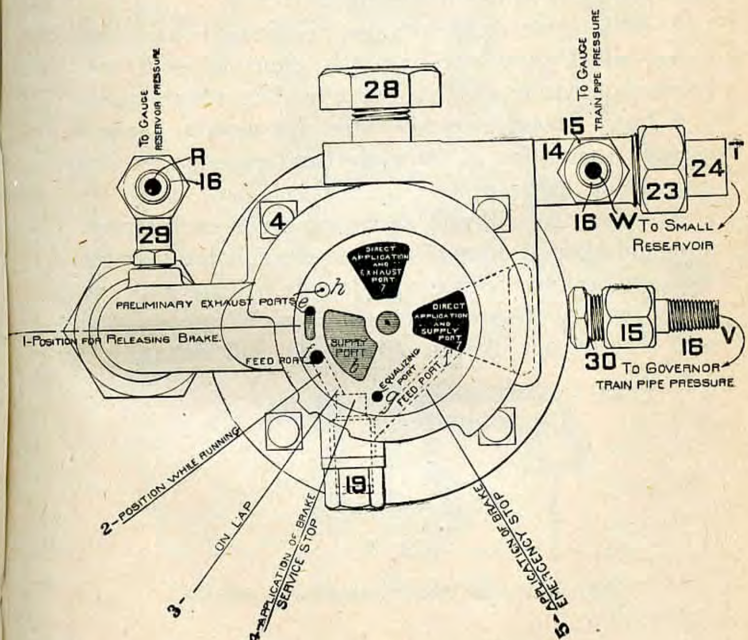


Fig. 2.
Top View, Rotary Valve Removed.
Plate 24—D-8 Engineer's Brake Valve.

CARE AND DEFECTS.

Except that the excess pressure valve requires cleaning much oftener than does the feed valve, the care needed by this brake valve is the same as is required by the modern type. But more attention is needed by the D-8 to insure it marking positions correctly as the handle spring 9 is less substantial and the quadrant wears more rapidly.

A weak, loose or broken handle spring is a serious defect which should be promptly remedied as it conduces to a wrong position being used unintentionally.

A leaky excess pressure valve will usually cause a regular fluctuation of train pipe and excess pressures in running position.

A spring too stiff will carry too much excess pressure and make it more difficult to use running position without brakes sticking occasionally. Gum may entirely prevent the excess pressure valve from opening and thereby act like an excessively stiff spring.

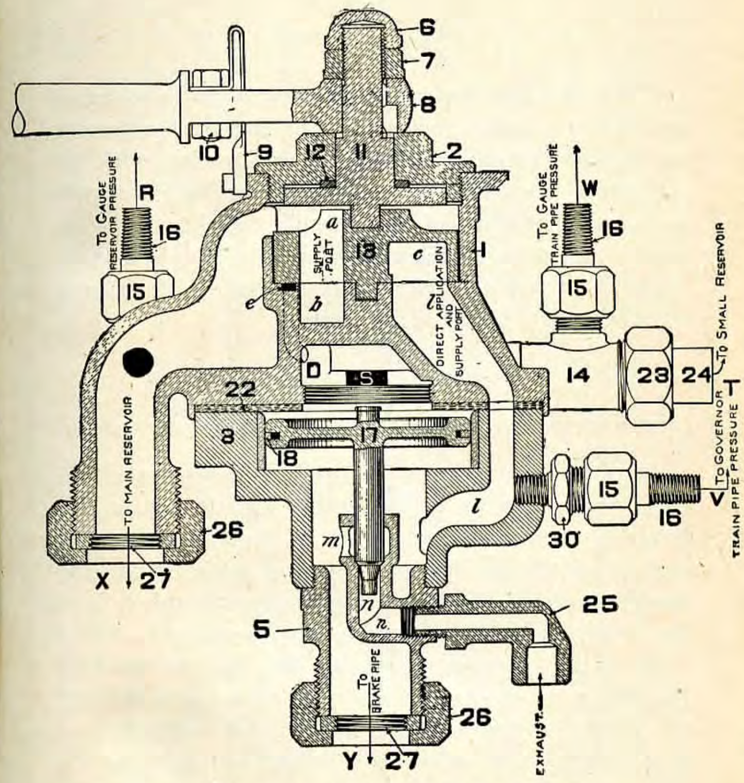


Plate 25—D-8 Engineer's Brake Valve, Front View.

THE COMBINED AUTOMATIC AND STRAIGHT-AIR APPARATUS.

(Westinghouse.)

The Combined Automatic and Straight-Air Engine and Tender Brake consists of the *standard automatic arrangement* employed on engine and tender, with the *addition* of a straight-air brake valve and a few simple parts which permit of the use of straight-air on the engine and tender brakes *without interfering with their automatic action when the automatic brake valve is used, both being kept cut in at all times.*

CONSTRUCTION AND OPERATION.

GENERAL ARRANGEMENT OF THE COMBINED APPARATUS.

Plate 26 illustrates the general arrangement of the combined apparatus. Connection with the automatic is made at three points; viz., to the main reservoir and to the brake cylinder pipes of both driver and tender brakes. The straight-air supply is taken from the MAIN RESERVOIR PIPE to the automatic brake valve so as to insure clean, dry air. Before reaching the STRAIGHT-AIR BRAKE VALVE it must pass through the REDUCING VALVE, set at 45 lbs., this consisting of a standard slide valve feed valve, as used on the automatic brake valve, attached to a special pipe connection made for the purpose.

A DOUBLE CHECK VALVE is inserted each on the tender and engine in the pipe leading from the

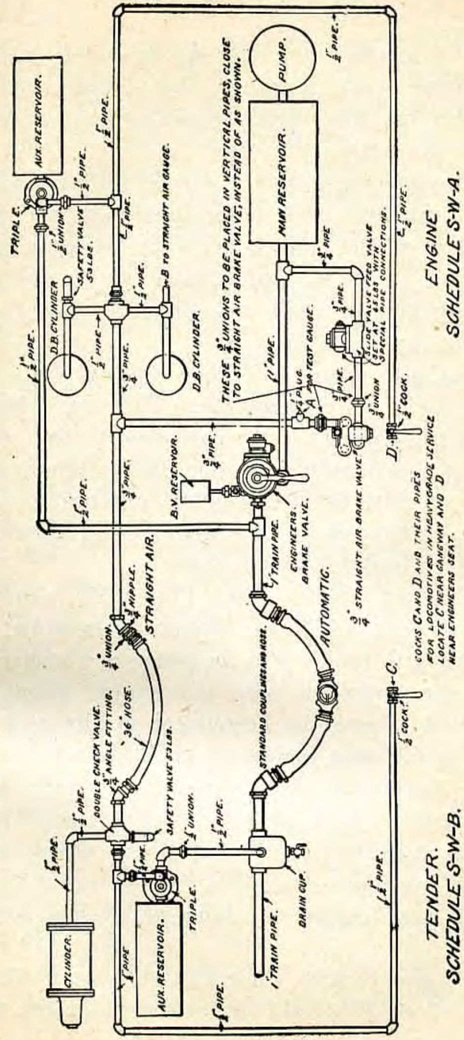


Plate 26—General Arrangement, Combined Automatic and Straight-Air Apparatus.

triple valve to the brake cylinder or cylinders so that in automatic brake operation the pressure will have to pass through this double check valve in getting to and from the brake cylinder.

The pipe leading from the straight-air brake valve has two branches, each entering one of the double check valves at the end opposite the triple valve connection, so that in application and release the straight-air pressure will also have to flow through the double check valves.

The two side openings of the double check valve are brake cylinder connections. They are joined by a cored passageway. If convenient the SAFETY VALVE may be screwed into one on the tender brake, as shown, or, with the driver brake, one brake cylinder should be connected to each and the safety valve in either driver brake cylinder pipe.

Each SAFETY VALVE (See Plate 39) should be adjusted to open at 53 lbs., should be in direct communication with brake cylinder pressure whether automatic or straight-air is used and should either point up or a little above the horizontal so dirt and water can not accumulate inside.

As the straight-air should never give over 45 lbs. cylinder pressure and the automatic not over 50 lbs., a correctly adjusted safety valve will never operate except an improper condition exists, but under the latter will guard against a dangerously high cylinder pressure.

Cocks C and D with their pipes are for road locomotives. Cock C should be located adjacent to the

gangway so it can be operated when running, and D near the engineer's seat. In descending heavy grades both are left open. The driver and tender auxiliary reservoirs are recharged with those of the train, but automatic application is prevented on the brakes of the former, thus permitting of the greatest use practicable, without danger of loosening tires, of the tender and driver brakes when recharging the train brakes, the critical operation in braking down steep grades.

A and B indicate gauge connections. The straight-air gauge should be connected so it will show the driver brake cylinder pressure in automatic as well as straight-air applications. This connection may be made at any convenient point between the double check valve and the brake cylinders and is indicated in general by B.

In order that the straight-air gauge may be tested without removal, a tee is provided in the straight-air pipe to the double check valves, as indicated at A. Removal of the $\frac{1}{4}$-inch plug will allow a test gauge to be temporarily connected.

SPECIAL HOSE CONNECTION.

A special hose makes the connection between the engine and tender. As it differs from the automatic a wrong coupling can not be made. Low pressure and little movement insure long life. The union end being forward permits of cutting off back of that point, by the use of a blind gasket, in case a burst hose or bad order tender brake renders this temporarily desirable.

DOUBLE CHECK VALVE.

Plate 27 illustrates the double check valve in section, the several connections being there indicated. Between the two seats, *a* and *b*, is a piston valve 10, having on each end a leather face 6. The piston valve is shorter than the distance between its two seats, and the bush in which it works has two series of ports *c* and c^1. With the piston valve against seat *b*, as shown, ports *c* afford a free passage for the air between the straight-air brake valve and the brake cylinder. The opening leading to the triple valve, which is now in release position, is closed so no leakage can occur.

Now, with the straight-air brake valve in release position, where it should be when not in use, assume that an automatic application is made. The air from the triple valve on entering the double check valve, will force the piston valve to the right against seat *a*, thus preventing any escape at the straight-air brake valve and opening ports c^1, so the air can flow on into the brake cylinder, returning the same way in release.

The double check valve must be in a horizontal position so its piston valve will not be moved except by air pressure. Then the mere act of using either automatic or straight-air will cause its piston valve to automatically move to the proper position.

As cocks C and D are connected between the driver and tender triple valves and their double check valves, leaving them open will prevent automatic action on these brakes by allowing the air to pass direct to the atmosphere instead of through the double check valves.

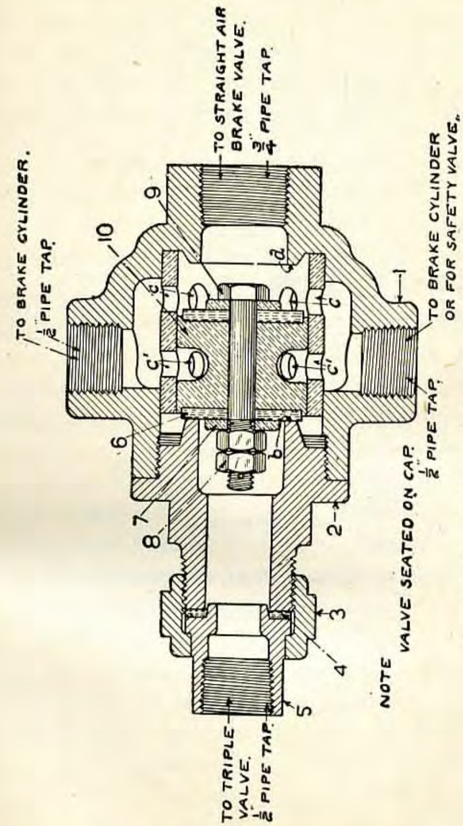


Plate 27—Double Check Valve, Straight-Air Position.

REDUCING VALVE PIPE BRACKET.

Plate 28 illustrates the special pipe bracket to which the slide valve feed valve, acting as a reducing valve for the straight-air, is connected, inlet port *A* and outlet port *B* coming opposite the similar ports in the feed valve. The arrow lays across the dividing wall.

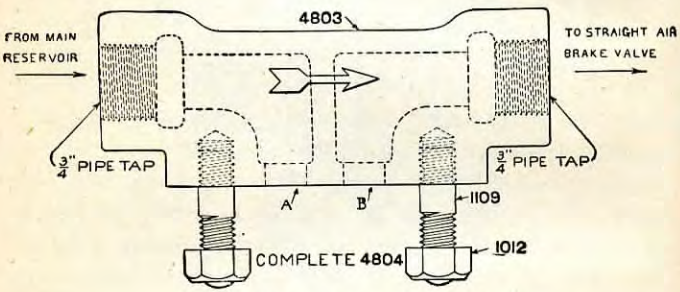


Plate 28—Reducing Valve Pipe Bracket.

STRAIGHT-AIR BRAKE VALVE.

The distinctively advantageous features of the straight-air brake valve employed, illustrated by Plates 29, 30 and 31, are (1) the ability to "feel" when, where and how much it is opening the application and release ports; (2) its uniformity of action, there being no parts which, when dry, cause it to work hard; (3) and the long time it will run without repairs, coupled with the ease and cheapness with which such can be made when needed.

Letters cast on the body indicate respectively its main reservoir, train pipe and exhaust openings. The latter should have only a street ell to turn the discharge in the direction desired, the sound aiding the engineer in operation. The other two connections should have unions near by to facilitate replacement.

The valve should be substantially secured and so located as to be easily operated by the engineer when looking forward or back out of the side cab window, this latter being of the utmost importance in facilitating work and reducing incident damage. Where the conditions permit, the best location is against the cab side at a convenient height and a trifle forward of the edge of the side window which opens. The handle should be, in this case, on the boiler side so that in release it will be nearest the engineer, its motion in operation being parallel to the cab side.

Plate 29 is a sectional view parallel with the shaft 2, operated by the handle 4, which opens application valve 8 or release valve 9. As indicated by *b*, *b*1 and

$b2$, the space above admission valve 8 is connected with the one below exhaust valve 9. The leather gasket 6 makes the joint at the shaft collar.

Plate 30 is a section across the shaft at application valve 8, showing the connection W by which main reservoir pressure, reduced to 45 lbs., reaches the lower side of valve 8 through cavity *a*.

Plate 31 is a similar section across the shaft at exhaust valve 9, showing the cavity $b2$ below this valve, the train pipe connection at X leading to the double check valves and, through them, to the brake cylinders; also, passageway *c* leading from above release valve 9 out through the exhaust opening to the atmosphere.

Shaft 2 is slotted out to the middle at two points and valves 8 and 9 are just enough off the shaft center line that the stem of each valve will end just beneath the flanged portion of the steel tappet piece riveted into each of the shaft slots. As shown by the section of valve 9, Plate 31, these have steel caps to reduce the wear and are fitted with leather seats.

In the three views the handle 4 is on lap position, valves 8 and 9 being held to their seats by their springs 10 and 11 and any air pressure below them. Moving handle 4, Plate 29, toward the reader, which is to the right in Plates 30 and 31, unseats application valve 8 and allows main reservoir pressure to flow by it from *a*, pass down from *b* through $b1$ to $b2$ which brings it under release valve 9 and in communication with the pipe at X by which it is carried to the double check valves and, through them, to the cylinders, applying the brakes. Moving handle 4 in the reverse

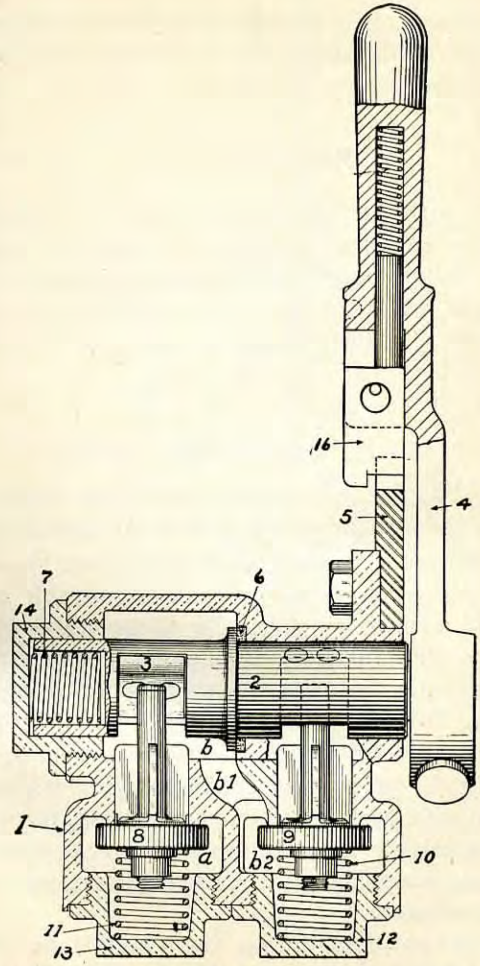


Plate 29—Straight-Air Brake Valve. Lap Position. Side View.

direction and past lap position will, having earlier permitted application valve 8 to seat, open release valve 9 and release the brakes.

MAINTENANCE.

The straight-air apparatus is subject to few defects and these are easily located and remedied. Also, it aids in maintaining the automatic apparatus of the driver and tender brakes. The possible defects with their tests, remedies and how to aid in preventing them are as follows:

REDUCING AND SAFETY VALVES.

If the straight-air reducing valve is set too low the straight-air will not hold well, but the automatic will not be affected. Too high adjustment (over 45 pounds) will give more brake power than is desirable and, if above 53 pounds, will cause the safety valves to blow and waste air in full application position of the straight-air brake valve. Safety valves set too low (correct adjustment 53 lbs.) or that leak when seated, will also cause the waste of air just described. If set too high they will not prevent an excessive cylinder pressure, liable to slide wheels and damage rigging, in case the reducing valve is adjusted too high, is out of order or automatic is applied with straight-air set, an unwarranted operation.

The straight-air reducing valve should be cleaned and lubricated every two weeks and should in no case

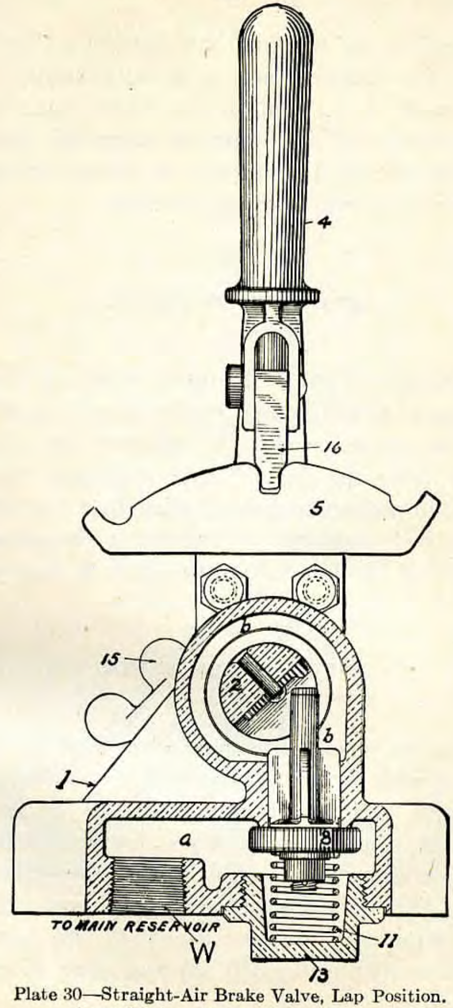


Plate 30—Straight-Air Brake Valve, Lap Position. Cross-Section At Application Valve.

be allowed to go without this attention for over a month. The quickest and most satisfactory way to do this work is to replace one valve with another cleaned, lubricated and correctly adjusted, these features being attended to in the air brake repair room or elsewhere having special provision.

STRAIGHT-AIR GAUGE.

The straight-air gauge should be tested once a month for accuracy, and indicated repairs should be promptly made. Where an accurately adjusted and operating reducing valve has just been applied and the gauge indicates 45 pounds under full straight-air application, this may be considered as indicating the gauge is in good order if the hand does not stick at any point

DOUBLE CHECK VALVE.

The double check valve can leak at either of its two seats. If with brakes off there is no blow at either triple valve exhaust port, but there is one with straight-air applied, then that double check valve leather seat toward the triple valve connection is defective. The opposite one being in bad order will cause a blow at the exhaust port of the straight-air brake valve with automatic set and none with brakes released.

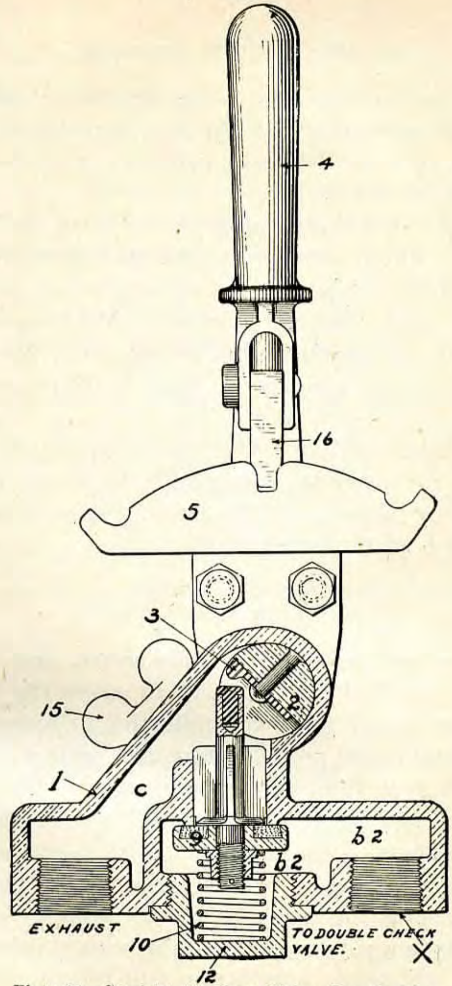


Plate 31—Straight-Air Brake Valve, Lap Position. Cross-Section At Release Valve.

BRAKE CYLINDER LEAKAGE.

All of the leakage previously mentioned, also any in the pipe to the air gauge, the pipes from the straight-air brake valve to the brake cylinders or in the latter will be indicated as follows:

With pressure fully pumped up, note the pump strokes per minute required to maintain it; then, place the straight-air brake valve in full application position, wait until main reservoir pressure is fully restored and again count the pump strokes per minute. The difference will be due to leakage at some of the places mentioned.

With the straight-air brake valve in application position any such leakage can readily be found as it is constantly supplied. Piston travel can be accurately determined at the same time.

STRAIGHT-AIR BRAKE VALVE.

The springs beneath the application and release valves 8 and 9, Plate 29, tend to move the handle toward lap if it is in either application or release position. Notches are provided to guard against this and it must be seen that wear or weakening of the handle spring will not permit the handle to work away from these positions. This is particularly important with the release position, in which the jarring of the engine in motion aids the spring below the release valve, as if the handle was to work up so the release valve could close, an automatic application and release might be followed by the driver and tender brakes sticking.

Leakage at application valve 8, Plate 30, will cause the brakes to creep on with the handle on lap, and a steady blow at the exhaust with the handle in release. A leak past release valve 9 or washer 6, Plate 29, will cause a steady blow at the brake valve exhaust with the straight-air applied.

BRAKES STICKING.

Failure of the driver and tender brakes to release indicates that their triple valves or the straight-air brake valve are not in release position. The remedy is evident. The fault will be avoided by maintaining at least 10 pounds excess pressure when straight-air is being used and keeping the straight-air brake valve in release when automatic is being employed.

WHEEL SLIDING.

Wheel sliding, to the extent of causing flattening, is inexcusable with the straight-air. The straight-air pressure being 5 lbs. lower than should be obtained with automatic fully applied, reduces the liability of sliding. But if, by reason of a slippery rail and strong straight-air application, sliding does commence, the prompt release possible will prevent damage to wheels. Therefore, the straight-air pressure should not be adjusted below 45 pounds. When the rail is bad and speed is low the engineer should not use the full straight-air pressure.

TRAIN AIR SIGNAL APPARATUS.

(Westinghouse.)

Plates 32, 33 and 34 show the train air signal apparatus for transmitting signals from the train to the engineer.

The supply of air for operating the signal apparatus is taken from the main reservoir on the engine, the pressure being reduced to 40 pounds, the standard, by the air-signal reducing valve.

A separate line of three-quarter-inch pipe extends throughout the entire train and is united between the engine, tender and cars with hose and couplings in the same manner as the air brake system; but owing to a difference in the brake and signal hose couplings they cannot be connected.

Signals are given from the train by causing a sharp discharge of air from the car discharge valve, which momentarily reduces the pressure throughout the entire length of the signal pipe and all its connections. The effect of this is to cause the signal valve on the engine to discharge a small amount of air through a small whistle in the cab, sounding a blast corresponding to each pull of the cord. It is important that the car discharge valve be operated properly or else correct signals will not be given to the engineer.

The signal apparatus works on a principle similar to that of the air brake to the extent that when the pressure has been reduced in the signal pipe and signal valve it must be given sufficient time to equalize before a signal can again be transmitted. To obtain the best results pull the cord firmly and quickly, hold the discharge valve wide open one second for each blast desired of the signal whistle and allow it to remain closed about three seconds between discharges to permit of equalization. With trains of over twelve cars allow at least four seconds between discharges.

The same care and attention should be given to the whistle signal pipe, hose and couplings to prevent leakage as is given to the air brake system.

CAR DISCHARGE VALVE.

A branch pipe extends from the main signal pipe to the car discharge valve, Plate 32, and has in it near the latter a cock to permit of cutting out the car discharge valve if leaking.

The car discharge valve is usually located over the end door of the car. A small wire cord is attached to lever 5 to permit of operating the valve. When the signal cord is pulled the lever 5 comes in contact with the stem of the discharge valve 3, forcing it off its seat, against the resistance of the air pressure and spring 4, thus allowing pressure from signal pipe to escape to the atmosphere through port *a*. When the signal cord is released spring 4, together with the air pressure, forces discharge valve 3 to its seat.

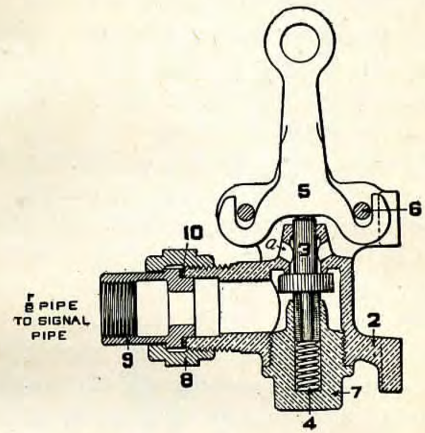


Plate 32—Car Discharge Valve.

SIGNAL VALVE AND WHISTLE.

Plate 33 shows the signal valve and the signal whistle connected as in practice. A branch pipe from Y connects the former with the signal train pipe on the engine.

A diaphragm 12 of especially prepared rubber divides the body of the valve into two chambers of unequal size. Attached to the diaphragm is its stem 10 which passes down through bush 9 and, bearing on seat 7, acts as a valve to discharge air pressure through passageway *e* and the pipe to the whistle, thus blowing the latter.

The diaphragm stem 10 has a groove around it just above *f* and when seated, as shown, the full portion just above this groove makes a rather neat fit in bush 9. Below the groove the stem is triangular so as to allow air pressure to pass it freely and yet guide the stem true to its seat 7.

Pressure from the signal train pipe enters the signal valve at Y, passes through the small port *d* to chamber *A*, through port *C*, *C* to the space above valve seat 7 and feeds slowly past the close fit of the stem, at the top of bush 9, into chamber *B*.

Signals can not be given until the pressures in chambers *A* and *B* are equal. The former charges quickly, but chamber *B* comparatively slow. If the stem fitted loosely at the top of bush 9 the signal valve would not work accurately, if at all, with a train of any considerable length. Consequently this fit must never be changed from the standard and

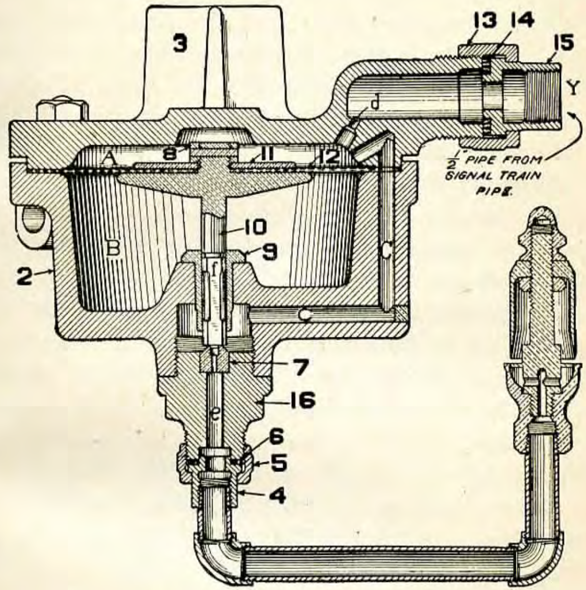


Plate 33—Signal Valve and Whistle.

ample time between signals, ordinarily three seconds, must be allowed for chamber *B* to recharge.

A sudden reduction in pressure at any point in the signal train pipe, as follows opening the car discharge valve, causes the pressure to fall quickly in chamber *A*, but not in chamber *B*, because of its greater size and the close fit of the stem at the top of bush 9. The higher pressure in chamber *B* then raises diaphragm 12. This lifts its stem 10 from the seat 7 and causes a discharge of air through the signal whistle, thus blowing it.

When stem 10 is lifted the neatly fitting portion is raised above bush 9, thus allowing chamber *B* pressure to reduce quickly by flowing down through bush 9 and out to the whistle. This reduction and the rise of pressure in chamber *A*, which occurs as soon as the car discharge valve is allowed to close, drives the diaphragm and its stem downward, closes the opening to the whistle and slowly recharges chamber *B*.

The standard location of the signal valve is in the cab to prevent freezing in cold weather. It must not be subjected to extreme heat.

While the top or bell of the signal whistle is adjustable, yet when once made right it should not be altered as improper action on its part is usually due to some other cause than incorrect adjustment.

The whistle should never be in contact with the cab or so located as to be directly in a strong draft as either is liable to prevent correct action.

AIR-SIGNAL REDUCING VALVE.

Plate 34 shows the reducing valve. It should be inside of the cab to prevent freezing in cold weather, but must not be placed in a very hot location as this would injure the rubber diaphragm. It should be accessible for cleaning. It is connected to the main reservoir pressure at *A* and to the signal pipe at *B*.

Near the connection A will be noticed a choke 22. This is to prevent a too rapid feed into the signal line, as such would seriously interfere with the correct operation of the signal valve. Because of this the size of the choke opening must never be altered.

Just to the right of the choke will be noted a cut-out cock 21. This is to permit of cutting out the reducing valve for cleaning or other purposes.

Except that the supply valve 4 is a little different in shape, the construction and operation of the signal reducing valve is practically identical with the old style feed valve furnished with the F-6 brake valve. Therefore, the description of this feed valve will cover the signal reducing valve, except the choke and the cut-out cock, both as regards operation and defects. The valve is shown open, supplying pressure to the signal pipe, and arrows indicate the flow of air through it.

The standard signal train pipe pressure is 40 pounds and the reducing valve should be kept adjusted for this amount.

All modern apparatus is supplied with a special strainer which should be located close to the reducing valve and connected to it at *A*. Its purpose is to protect the reducing valve from dirt.

DEFECTS IN THE CAR DISCHARGE VALVE.

A leak at the car discharge valve is usually caused by dirt collecting on the rubber seat of discharge valve 3, thus preventing the valve from seating. Opening and closing the valve will sometimes remedy the trouble by blowing the dirt off the seat. If this fails and the leak is strong enough to cause the whistle to blow, the car discharge valve should be cut out by turning the handle of its cut-out cock until the groove in the end of the plug to which the handle is attached, stands crosswise with the branch pipe. A tight cord will also cause the car discharge valve to leak. If no exhaust occurs at the car discharge valve when the latter is opened and signal pipe is charged, examine the groove in the cut-out cock; this groove should stand lengthwise with the branch pipe to permit of air reaching the car discharge valve. Any defects in the car discharge valve or in any part of the signal apparatus on cars should be reported by defect card to the inspector on arrival at terminal.

The signal valve should cause the whistle to blow every time the car discharge valve is opened, if a sufficient length of time is allowed between signals. On the other hand, the small amount of leakage usually existing in the signal pipe, hose and couplings, should not cause the signal valve to operate.

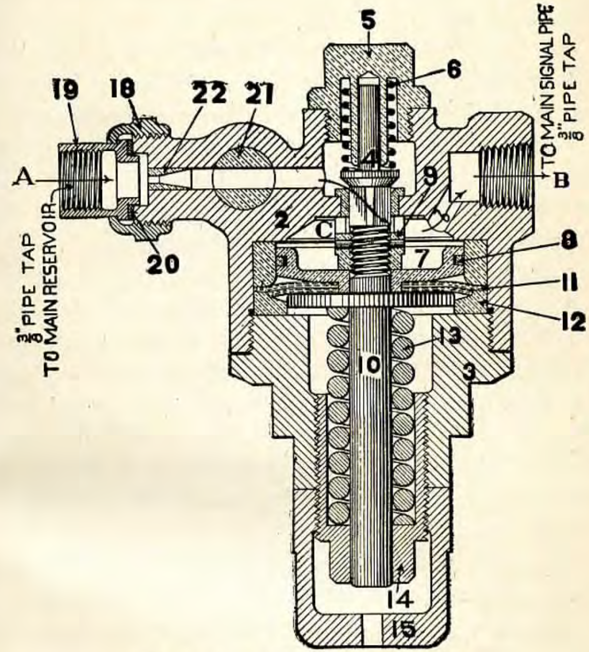


Plate 34—Air-Signal Reducing Valve.

Wear on the end of the upper stem of valve 3 in the car discharge valve will reduce the valve opening made in use and, with defects in the signal valve, may result in the latter failing to respond from one car where it will from another car even farther from the engine.

FAILURE TO WHISTLE.

Where the whistle does not act it should first be seen that the cut-out cock in the reducing valve is cut in so that the signal line can charge. Other causes for the signal pipe not being charged are a too low adjustment of the reducing valve and a cut-out cock closed on the tender or some car.

In the signal valve a baggy or distorted diaphragm, a too loose fit of stem 10 where it enters the top of bush 9 and dirt or frost in the port of seat 7 will cause the signal valve to fail to respond. An accumulation of frost in the port of seat 7 in cold weather is likely to follow slight leakage at the valve seat if the signal valve is exposed to low temperature. Ice in the pipe between the signal valve and whistle will cause a similar failure.

The small ports in the bowl of the whistle being chocked, wrong adjustment of the bell, the bell out of line or a strong wind striking the whistle will cause a failure.

Another possible cause is insufficient opening at the car discharge valve as explained under defects of this part.

The accumulation of gum is hastened by failure to keep the main reservoir drained, an overheated pump, or the use of engine or other light oil in the pump air cylinder.

WHISTLE BLOWS WHEN NOT DESIRED.

A blast of the whistle indicates that a reduction has been made in the signal pipe pressure. When this occurs following the release of brakes it denotes that the reducing valve had previously permitted the signal pipe pressure to equalize with that in the main reservoir. The back-flow into the latter, following the brake release, causes the signal pipe reduction. This fault is due to a too high adjustment of the reducing valve or a defective condition of the latter.

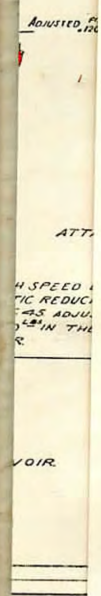
Other causes for unintended signal blasts are a swinging cord or one accidentally struck, as in making up berths, etc., and signal pipe leakage. The latter is liable to cause this trouble only where it varies and particularly in case gum makes a very close fit where the stem 10 enters the top of bush 9 in the signal valve. An erratic working reducing valve will aid in causing this trouble.

TESTING.

Repairmen should be provided with a device for determining the adjustment and action of the reducing valve and for making a sharp but not too heavy reduction in the signal pipe pressure to test the sensitiveness of the signal valve. The use of the cock at the rear of the tender is unreliable and damages the signal valve diaphragm.

AIR WHISTLE OR BELL CORD SIGNALS.
(Rule 216.)

Sound.		Indication.
(a)	Two	When train is standing, start.
(b)	Two	When train is running, stop at once.
(c)	Three	When train is standing, back.
(d)	Three	When train is running, stop at next station.
(e)	Four	When train is standing, release air brakes.
(f)	Four	When train is running, reduce speed.
(g)	Five	When train is standing, call for flagman.
(h)	Five	When train is running, shut off steam heat.



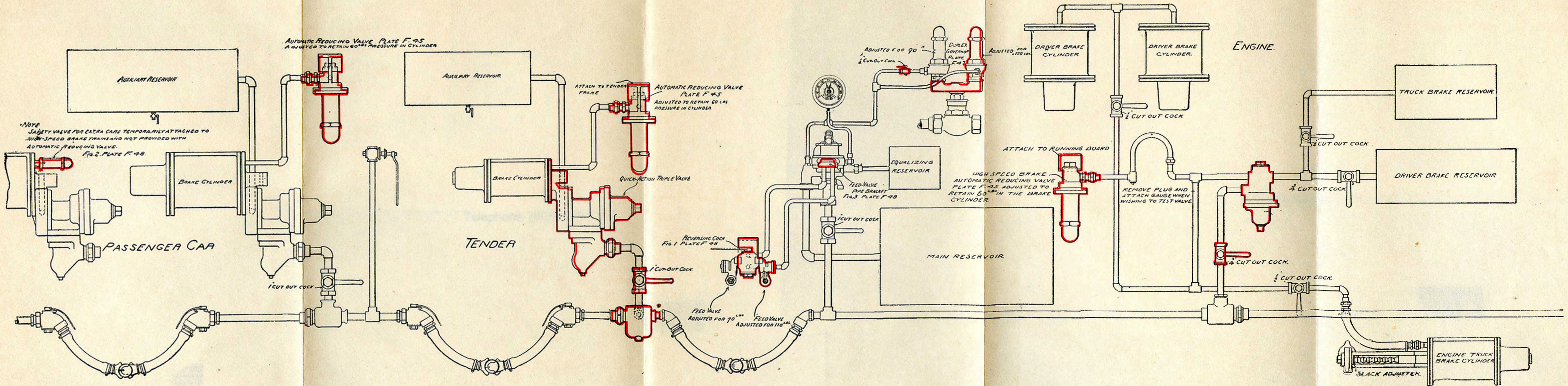


PLATE 35—GENERAL ARRANGEMENT HIGH SPEED BRAKE.

WESTINGHOUSE HIGH SPEED BRAKE.

With a train having the standard quick action passenger brake the increased distance required for stopping, as compared with that at 30 miles per hour, would be as follows: 40 miles per hour, nearly twice as great; 50 miles per hour, over three times as great; and 60 miles per hour, about five times as great.

All familiar with train service know that the emergency application of the air brakes causes a severe shock at very low speeds, but that at high speeds it is felt no more than is a moderate service application made at eight or ten miles per hour. The cause of this is the difference in brake shoe friction due to speed, as explained under "Enginemen and Trainmen."

In England in 1878 Captain Douglas Galton and Mr. George Westinghouse conducted tests which demonstrated the comparative inefficiency at high speeds, of the ordinary brake force and that one of the main reasons for this was the serious reduction in brake shoe friction. At the same time they proved that by greatly increasing the brake shoe pressure while the speed was high the loss of holding power, due to poor shoe friction, could largely be compensated for; also, that by gradually lowering this brake shoe pressure as the speed reduced they could avoid any increased tendency toward wheel sliding. It is upon these three principles that the operation of the high speed brake is based.

Where the brake rigging is of adequate strength the only change required to convert a car from the standard quick action brake to the high speed brake is to attach the automatic reducing valve, as is shown by Plate 36. The valve is piped direct to the brake cylinder. Instead of 70 pounds, a train pipe pressure of 110 pounds is carried.

Plate 35 shows the complete air equipment for the engine, tender and one car, together with the special and temporary provision when a car not fitted with an automatic reducing valve is placed in a high speed braked train. The changes from the old standard apparatus are outlined in red.

A feed valve pipe bracket is attached to the engineer's brake valve in place of the standard pressure feed valve and the latter is connected to the left or low pressure side of the reversing cock. On the opposite side is the high pressure feed valve, adjusted at 110 pounds. The reversing cock is connected to the feed valve pipe bracket and is merely to permit of quickly changing from one to the other of the two feed valves, the one over which the handle stands being cut in.

The "special driver and engine truck brake triple valve" with its $\frac{3}{4}$-inch cut-out cock are now standard for all engine brakes, there being two sizes of the triple valve.

The duplex pump governor is the same as explained elsewhere in this book, but one pipe connection is made differently. The low pressure head, used when the locomotive is in service requiring but 70 pounds

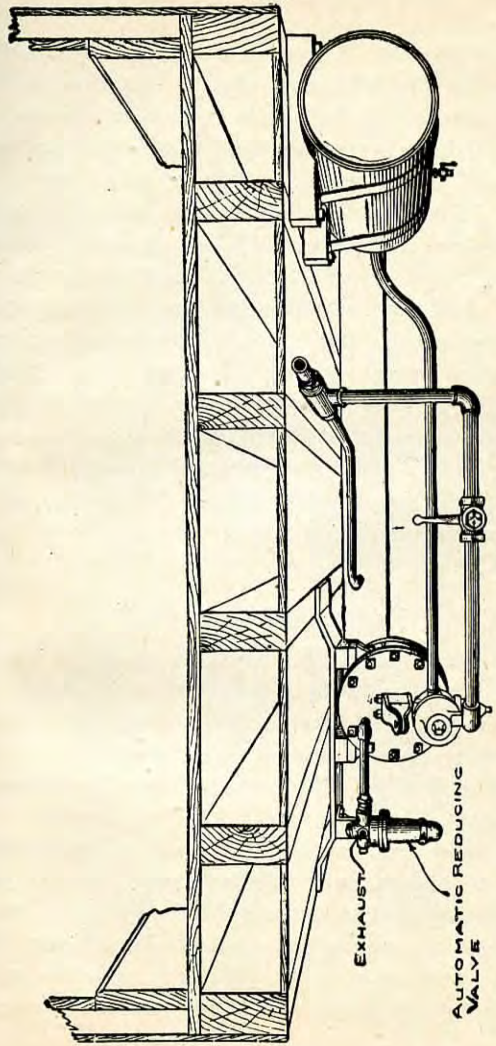


Plate 36—Automatic Reducing Valve Applied to Car.

train pipe pressure, has a cut-out cock for rendering it inoperative in high-speed service. Another method, which renders the $\frac{1}{4}$-inch cut-out cock unnecessary, is to connect the low pressure head to the standard pressure side of the reversing cock, provision being made for this. The reversing cock handle will then at the same time cut-in or cut-out the low pressure governor head and the 70 pound pressure feed valve. An additional advantage is that with these parts cut in, as in ordinary service, the action of the duplex governor is the same as where this part is connected to the feed port of the engineer's brake valve.

The engine, tender and each car are fitted with automatic reducing valves, as shown. The quick action triple valve, now standard for all passenger tenders, should replace the plain triple valve if the tender is so fitted.

AUTOMATIC REDUCING VALVE.

The automatic reducing valve is shown in section in Plate 37. Fig. 2 is a sectional view across the exhaust at Y, Fig. 1, and is to show the pipe connection to the brake cylinder, this being on the side removed in Fig. 1. The opening opposite fitting 14 is plugged.

Fig. 1 shows the piston 4, the top of which is always exposed to any pressure in the brake cylinder. Such pressure is resisted by the regulating spring 11, which is adjusted by regulating nut 12. The spring holds the piston at the top of its cylinder *c*, as shown, unless the cylinder pressure exceeds 60 pounds, being the

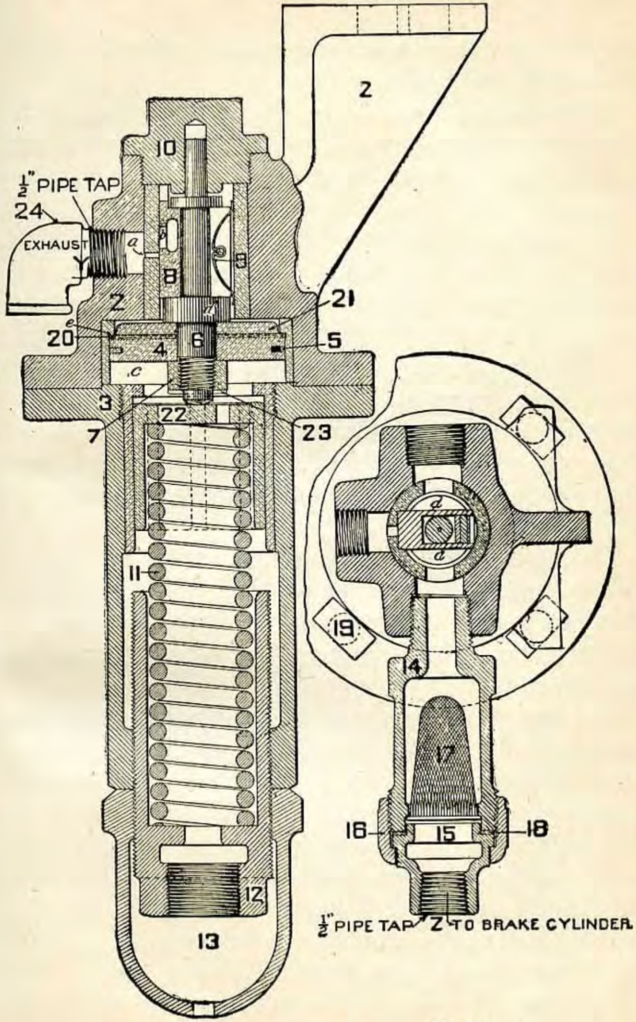


Fig. 1. Fig. 2.
Plate 37—Automatic Reducing Valve.

amount on which brake leverage is ordinarily based with quick action triple valves.

With piston 4 as shown, its leather washer 20 makes an air tight joint at *e*, packing ring 5 preventing any material leakage during the brief time the valve is in action.

Piston stem 6 has two collars between which slide valve 8 is located, causing the slide valve to move with the piston. The slide valve is held to its seat by its spring 9 and any pressure in the brake cylinder. This latter pressure always has access to the face of the slide valve at *b*, the oblong opening to the right of this letter running across the slide valve. When the piston has been forced down until ports *b* and *a* connect, brake cylinder pressure discharges to the atmosphere.

Figs. 1, 2 and 3 of Plate 38 show slide valve 8 in its three positions. So long as brake cylinder pressure does not exceed 60 pounds the triangular port *b* remains above the oblong port *a*, Fig. 1, preventing any discharge.

The use of emergency with 110 pounds train pipe pressure will give about 85 pounds in the brake cylinder, being 40 per cent. over that obtained from 70 pounds train pipe pressure. The violent admission of this high pressure causes the piston and slide valve to move rapidly to the position shown in Fig. 2 in which the narrow, upper end of the triangular port *b* exposes part only of port *a*, thus slowly reducing the cylinder pressure while the train is at its highest speed. But as the pressure reduces the regulating spring gradu-

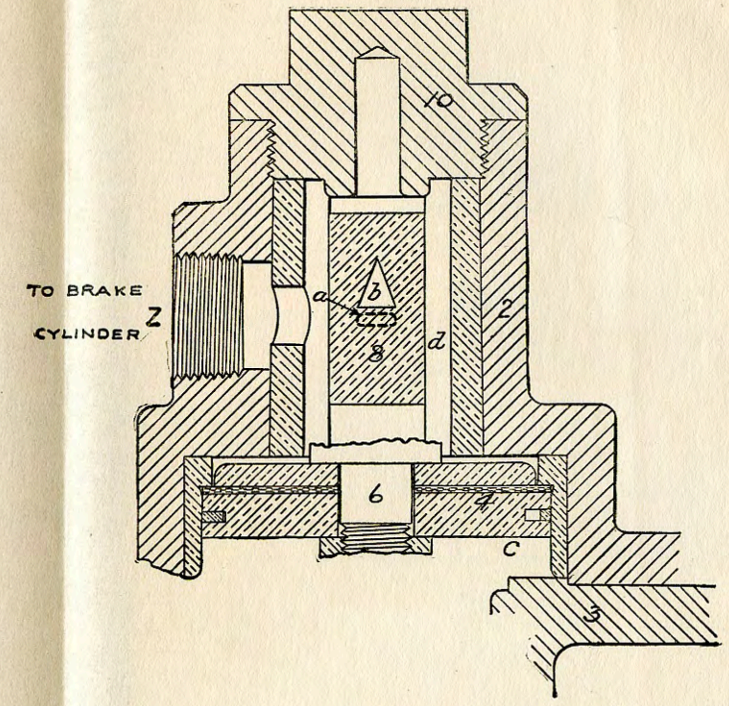


Fig. 1.

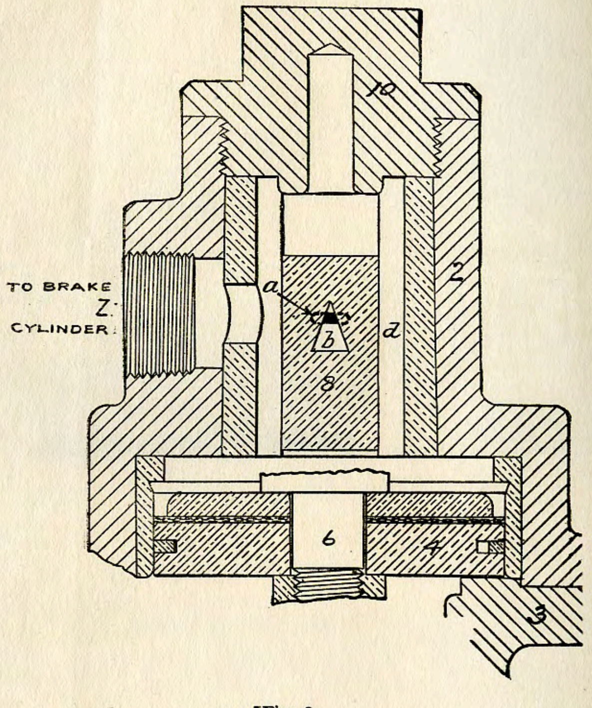


Fig. 2.

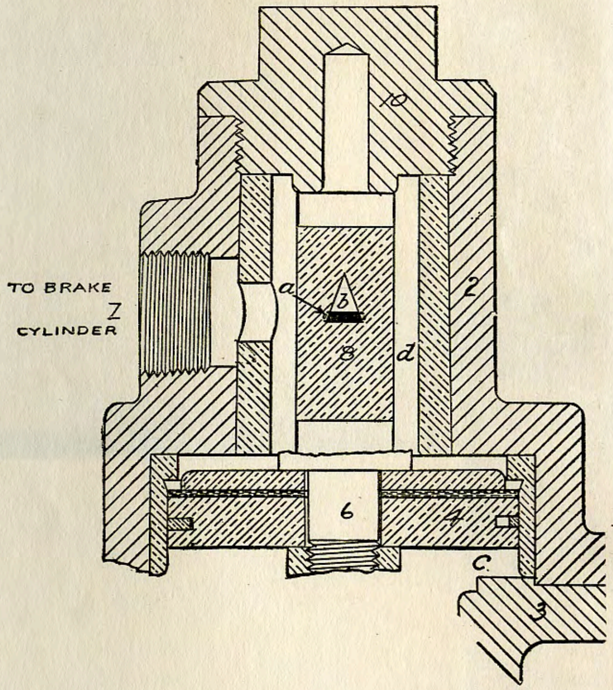


Fig. 3.

PLATE 38—SLIDE VALVE AND SEAT—HIGH SPEED REDUCING VALVE.

ally forces the piston and slide valve upward, and increases the rapidity of air discharge until it reaches its maximum as shown by Fig. 3. This quickly brings the cylinder pressure to 60 pounds, causing the valve to close, Fig. 1, and retain this amount.

If a service reduction is made sufficiently heavy to give a little more than 60 pounds brake cylinder pressure, the valve parts at once move to the position shown in Fig. 3 and thus prevent a further increase even though the reduction is continued.

As a 20 pound train pipe reduction from 110 pounds gives the same brake cylinder pressure as from 70 pounds, it follows that three such applications can be made without recharging and yet have as much holding power in the last as would be obtained with the first in ordinary service. This is especially valuable approaching obscure points and at terminals where, following a speed reduction and brake release, a quick stop may be desirable. With the two application method of braking it also saves time, while reducing the likelihood of wheel sliding.

When a car not fitted with an automatic reducing valve is temporarily placed in a high speed braked train a safety valve, Plate 39, set at 60 pounds is for such time connected with the brake cylinder.

It should be understood that the pump governor pressures given on Plate 35 are not arbitrary and that trains of over five cars call for a little more than 120 pounds main reservoir pressure.

The automatic reducing valve needs the same attention as regards cleaning, lubricating and testing,

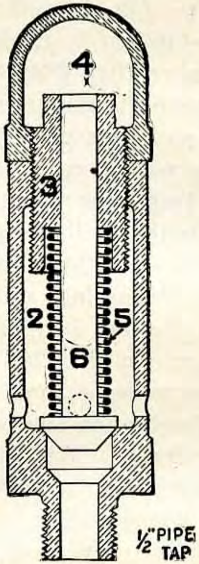


Plate 39—Safety Valve.

as is required to keep the triple valve in good order. Letters cast on the body show with what sizes of cylinders each valve should be used. Its possible defects are leakage and wrong adjustment.

ENGINEMEN.

To insure the satisfactory operation of the engine brake and signal apparatus and guard against delays caused by failure of same, the incoming engineer should make a thorough inspection, reporting needed repairs, and the outgoing engineer should, before leaving the vicinity of the roundhouse, determine whether the apparatus is in proper condition to make the trip. Maximum pressure should be pumped up in ample time to make all necessary tests without causing a train delay. The air pump being the source of supply for the air brake, air signal and various other air using devices on the engine, it should be given the most particular attention.

TESTING FOR AND LOCATING DEFECTS IN THE ENGINE BRAKE APPARATUS.

The possible defects in the air pump, pump governor, engineers brake valve, triple valve and whistle signal system, are described under the head of "defects" following the description of construction and operation of the apparatus mentioned.

DRAINING MAIN RESERVOIR, ETC.

The main reservoir is provided for the purpose of carrying a large supply of air, to be used in releasing and recharging the brakes, and as a catch basin for dirt, oil and moisture discharged from the pump. The larger its volume the better. To make use of all of the available space and avoid the danger of water from it passing into the train pipe it should be drained every day.

The tender drain cup, which is a small chamber for catching water and dirt, should also be drained every day. In addition, the cocks on the rear of the tender should be opened, before leaving the roundhouse, to blow out any water or dirt there may be in the pipes. When blowing out the whistle signal pipes the cock should be opened slowly to prevent injury to the rubber diaphragm in the signal valve. It is very important at any time, but more particularly in freezing weather, that the air brake and whistle signal systems be free from water and dirt.

LEAKAGE.

The opportunities for leakage on the modern engine are numerous, for, in many cases main reservoir pressure is utilized for operating the bell ringer, sander, blow-off cocks, ash pan slide cylinder and separate exhaust valve (compound engine). The engineer should give the same attention to keeping down leakage in these parts as in the brake and signal systems.

Brake cylinder leakage is often increased by very cold weather, and, as a result, there will be a considerable loss in the efficiency of the brakes. Under such conditions, following a long interval of non-use, the effect of the brake cylinder leakage and other features that reduce the efficiency of the brake is made apparent by the brakes not taking hold as well as otherwise with a given reduction. Better results

are obtained by making the first reduction a heavy one. This will have a tendency to expand the leather packing, making it more pliable, and will quickly rub off any ice or snow between shoes and wheels, bringing them to a good bearing.

DRIVER AND TENDER BRAKES.

The driver and tender brakes must never be cut out unless defective (this does not apply to driver brakes in mountain service). The value of a good driver and tender brake in mountain, as well as in other service, is not generally appreciated. The braking power of an engine weighing 132,000 pounds on drivers, and a tender weighing 38,000 pounds when empty, is equal to that on about six cars of 30,000 pounds light weight. The most prolific cause of inefficient driver and tender brakes is leaky brake cylinder pipes and piston packing leathers, especially with the driver brakes.

To obtain the best results a special grease compound should be used for lubricating the leather and cylinder. While water gives temporary relief in stopping leakage in cylinder packing, its use leads to the destruction of the leather on account of the latter drying and cracking after the water evaporates; for that reason water must not be used.

The braking power is based on seventy pounds auxiliary reservoir and train line pressure, with which, from a full service application, a pressure of fifty pounds to the square inch should be developed in the cylinders. In order to properly adjust the piston travel an air gauge should be attached to the cylinders and the piston travel adjusted by the gauge. A pressure of 50 pounds having been developed, measurements of the piston travel should be made and recorded in order that in later adjustments, the travel may be maintained as nearly as possible at that which develops 50 pounds.

Attaching an air gauge to driver brake cylinders occasionally will reveal some startling information in the way of leakage, when the brake is considered efficient, and the same will apply also to the tender brake in many cases.

When adjusting the piston travel on a cam driver brake, care should be exercised to have the point of contact of the cams in a vertical line with the piston rod when the brake is applied.

DETACHING CARS AND GENERAL SWITCHING.

Under ordinary conditions, before detaching the engine, or any cars, the brakes should be released on the whole train, so as not to cause inconvenience in switching.

To insure the prompt release of brakes following the makings of couplings, the engineer should always endeavor to have the main reservoir pressure as high as the governor will allow, and to keep the train pipe and auxiliary reservoir pressure of engine and cars attached, below the maximum until after all hose are coupled up and angle cocks are opened.

DOUBLE HEADERS.

The rules regulating the running of double headers are contained in the rules and regulations of the operating department.

TRAIN PIPE EXHAUST.

When operating the brake valve the engineer should listen to the train pipe air discharging from it. A little experience will soon enable him to tell if the discharge of air is in proportion to the number of air cars in train. In the event of an angle cock becoming closed accidentally or otherwise, the engineer can, if he has observed previous conditions, detect it at once and be in a much better position to avert disaster.

The absence of the train pipe exhaust angle fitting or the application of one not having the proper size hole will affect the operation of the brakes. Never attach a pipe to the train pipe exhaust fitting to carry the sound of the exhaust out of hearing.

BRAKES APPLIED FROM THE TRAIN CAUSED BY BURST HOSE, TRAIN BROKEN IN TWO OR BY USE OF CONDUCTOR'S VALVE.

Burst air hose, or train broken in two, causing hose couplings to pull apart, will suddenly apply the brakes on both sections of the train. In that event the engineer should immediately place the brake valve on lap and close the engine throttle, which will prevent the sections of train from separating to any great extent, and the shock will not be as great if both sections come together as it would if the engineer endeavored to keep the sections as far apart as possible by working steam.

If necessary to move the front section back before coupling up, the brakes on it should be released and the brake valve immediately returned to lap position to avoid recharging the auxiliary reservoirs and to save main reservoir pressure for releasing the brakes on the whole train after it is coupled together.

If a burst hose is hard to locate, the engineer should keep a little pressure going back until trainmen discover the defect.

TRYING THE AIR GAUGE.

In order to have the brakes develop full power in an emergency or at other times when needed, it is important that the maximum pressure be carried; on the other hand, it is also important that the maximum pressure be not exceeded, as wheels may be slid flat by such cause. In view of the above conditions the air gauge should be tried frequently by the engineer, and when found inaccurate the fact should be promptly reported in the regular manner for test, as explained under "Air Gauge."

WATCHING THE AIR GAUGE.

In order to obtain an idea of the condition of the brakes in a train, the amount of leakage and how it affects the braking power, after the brakes have been applied and brake valve has been placed on lap the air gauge should be observed frequently. Instances have been known in which the air was

lost and the fact not discovered until it was necessary to stop; then it was too late.

The following "Tests for Engine Air Appliances" are to aid the engineer in determining the condition of the air-using devices and locating any existing defects in same. Much of the information can be obtained before the terminal is reached, such as the condition of the air gauge, pump governor, triple valves, driver and tender brake cylinders and the feed valve; also, that referring to the general working of the pump. The probability of leakage past the air piston or back into the cylinder from the main reservoir is indicated by symptoms easily observed, there being a burned appearance of the air cylinder near the discharge valves, a quiet working pump with full pressure and low speed and a suction during a portion only of each stroke under the same conditions. The latter should be determined by listening at the suction opening.

As implied, the number of strokes per minute given in regard to supplying leakage does not mean the best condition possible, and an endeavor should be made to keep such low.

TEST FOR ENGINE AIR-APPLIANCES.

AIR PUMP.

Note whether with ample steam pressure and throttle the pump will run steadily and sufficiently fast, when working against about 90 pounds pressure, and not controlled by the governor; also observe whether there is any unusual click or pound.

AIR CYLINDER TEST.

Raise the pressure to about 90 pounds and open the air cylinder oil cup. Then stop the pump, and when the piston rod is seen to be at rest, see if any air is blowing out of the oil cup. If so, there is a leak from the main reservoir past the air valves or their cages into the cylinder.

If there is no such leakage, start the pump, and with the oil cup yet open and the same main reservoir pressure, regulate the speed to 30 single strokes or exhausts per minute. Now, *on each down stroke* hold a finger just above, but not on the oil cup, to note if any air blows out. If the first test showed no back leakage from the main reservoir, then any such blow at the cup will be leakage past the air piston packing rings. In any case where leakage exists for nearly one-fourth or more of the down stroke prompt repairs should be made.

In all of these tests it is important to have about 90 pounds air pressure, and in the last, that the strokes be regulated as instructed. A sticking upper receiving valve will interfere with the air cylinder test and should first be remedied.

AIR GAUGE.

With air pressures near those ordinarily carried, place the brake valve handle in full release. If the gauge hands are correct, they will then both indicate the same. Where they vary 3 pounds or more, report the gauge to be tested and corrected.

FEED VALVE.

With either the F-6 or G-6 engineer's valve in running position, ample pump speed to keep up the pressure and the driver brake auxiliary reservoir bleeder open, note whether 70 pounds train pipe pressure is maintained, as it should be; if not, report the feed valve to be regulated.

Next, close the driver brake bleeder, and if the train pipe pressure raises 5 pounds or more, report that the train pipe pressure leaks up with light engine.

PUMP GOVERNOR.

During the test just described, note what, if any, variation takes place in the main reservoir pressure by reason of the pump governor action.

With all but the F-6 or G-6 engineer's valves, place the handle in full release, and when the governor is regulating the pressure, note how much, if any, variation takes place. Where, with any engineer's valve, the governor varies to exceed 3 pounds, report *the fact.*

ENGINEER'S VALVE.

With standard train pipe pressure make a 10 pounds service reduction, return to lap and note whether any increase in train pipe pressure follows. If so report the *fact.*

DRIVER AND TENDER BRAKES.

With 70 pounds train pipe and auxiliary reservoir pressure, make a 20 pounds service reduction, place the handle on lap, go quickly to one driver brake cylinder and note carefully whether the piston rod moves back at all. If so, report that driver brake leaks off, stating where the leak or leaks exist.

Test and report the same for the tender brake. The piston travel of this brake should be reported for adjustment, stating the amount existing, when over 8 inches or less than 5½ inches.

Each of the driver brake pistons should travel about the same amount, and when *that of the two combined* exceeds 10 inches, report for adjustment. The shortest travel, with that of the two sides combined, should not be less than 4 inches for cam brakes and 7 inches for others.

TRIPLE VALVES.

Note during both application and release whether there is on engine or tender any leakage at the triple valve exhaust port, reporting any such.

OTHER LEAKAGE.

With the air pump working against the governor and the engineer's valve in running position, if the F-6 or G-6 valve and full release with all others, note the number of single strokes per minute required to maintain the pressure.

AIR SANDER.

Next, open the sander throttle until the sand flows properly on both sides, then again note the number of single pump strokes per minute required to maintain the pressures, the valve handle yet being in the same position.

SEPARATE EXHAUST VALVE PISTON.

With the cross compound engine simpled, note the number of pump strokes required with air on the separate exhaust valve piston over that required to supply the engine leakage alone.

With the pump in fair condition and no considerable leakage elsewhere, the number of single strokes per minute required to supply brake leakage alone will not exceed 15 to 20 strokes per minute; the additional number required to supply the air sander will not be over 25 or 30; and that for the separate exhaust valve piston (cross compound engine) with air sander shut off will not be over 15 to 20.

The bell ringer should also be tested and any leakage from it or its pipe should be promptly reported and repaired.

The air sander warning port should be kept in good order as it aids in preventing loss of both air and sand.

Rules and Regulations: Numbers (226), (552), (561), (562), and (563).

TRAINMEN.

CONDUCTOR'S VALVE.

A conductor's valve is located in each passenger equipment car and caboose; its purpose is to apply the brakes in cases of emergency, and it should not be used otherwise. With the old style valve in which the discharge valve is held to its seat by a spring, the valve should be held open (when necessary to use it) until train is stopped, or the necessity for using it has passed; then the valve should be allowed to close. With the later valve, which is in the form of a plug cock, it is only necessary to open it, and it will remain so; it will be necessary, however, to close it by hand when ready to do so.

TEST OF BRAKES.

A terminal test of the brakes means a car to car inspection as described in chapter on "Terminal Test of Brakes," and it should always be made before leaving a terminal or at other points where trains are picked up. Opening the angle cock on rear of trains is not a test of the brakes, because they are not operated in that manner; nor is it desirable to so operate them. Engineers should always be advised of the number of operative brakes in a train, and when the test is conducted by inspectors they should so advise both conductor and engineer. The signal to release the brakes on a passenger train should be given by the car discharge valve in the rear car, and when

leaving terminals the usual signal to the engineer should be given by the car discharge valve.

When inspecting brakes for piston travel and cylinder leakage, in addition to noting the piston travel, try the brake beam. Using a "brake club" between the brake hanger and the wheel flange, if moderate force will slightly move the shoe or if it can be moved by a push with one's foot on the end of the beam the brake is of little value. So consider it and card for "Brake leaks off."

ANGLE AND CUT-OUT COCKS.

In addition to the proper pressure being maintained, it is also very important that each car in a train should do its share of the work in stopping; to insure this, a careful examination should be made of the train to see if all angle and cut-out cocks are open from the engine to the last air car so as to permit of charging the auxiliary reservoirs, where the braking power is stored. When the angle cocks are open, the handles stand straight (parallel) with the pipe, and when closed the handles stand crosswise (at right-angles) with the pipe. The handles on cut-out cocks stand at right angles to the branch pipes when open and parallel with the pipes when closed. In case of doubt, examine the grooves in the end of plugs. These grooves stand parallel with pipes when the angle and cut-out cocks are open, regardless of the position of the handles, and at right angles to the pipes when they are closed.

Cars fitted with old style brakes have stop-cocks in the ends of train pipe, the handles of which stand at right angles to train pipe when the cocks are open and parallel to the pipe when closed. These stop cocks also have grooves in the ends of plugs. When it is desired to ascertain if the air is connected throughout the entire train, after setting out or picking up cars for instance. or after the train has stood at some point a long time, the test should be made by the engineer in the usual manner in which the brakes are operated.

HAND BRAKES AND RETAINING VALVES.

Before leaving a terminal or at points where cars are added to train, it should be known that the hand brakes are released on all cars. On all cars leaving terminals and picked up at way stations the retaining valves should be cut out (handles turned down), except when their use is necessitated. If necessary to use hand brakes to assist the air brakes in controlling a train, the retaining valves should also be used, as the braking power developed by the air brakes will thereby be increased and a saving in air effected.

PICKING UP AND SETTING OUT CARS.

When setting out cars at way stations the angle cocks on each end of cars to be set out should be closed and the air hose separated by hand before the cars are pulled apart. When hose couplings are pulled apart the coupling gaskets are distorted and forced out of the grooves in the couplings, causing

them to leak, and many times the air hose are torn off, branch pipe is broken and train pipe torn loose from the car, and the joints in latter caused to leak.

When cars are left on sidings, the air brakes should be released and hand brakes set. If the air brake on a freight car is set with any degree of force and the hand brake then applied, the latter, if the chain has not broken, will be very hard to release when the air brake leaks off. On a passenger car with the old arrangement of brake rigging, if the air brake is applied, the hand brake cannot be set. Never depend on the air brake to hold a car which has been set out on a siding, as the air brake may leak off in a short time, and surely will eventually.

When making couplings the angle cock nearest the engine should be opened first so as to fill both air hose; if the other angle cock is opened first and suddenly, the brakes on train, if charged, will apply quick action, and will be hard to release. Under any and all circumstances when engine or cars are charged with air, the angle cocks should be opened slowly to avoid an emergency application of the brakes.

BRAKE STICKING.

As a general rule the cause for brakes sticking is due to the failure to raise the train pipe pressure quickly above the auxiliary reservoir pressure, which must be done in order to move the triple valve parts to release position. In the operation of brakes on long freight trains, some trouble must be expected on account of brakes failing to release, and if a little consideration is given to this subject and the experience of every day practice is made use of, much of the trouble can be anticipated and prevented.

Always advise the engineer of brakes sticking, stating location of car, and if any particular triple valve shows a tendency to stick frequently when the others release promptly, cut it out and card the car. (For other causes of brakes sticking, see articles on triple valve defects, also general instructions to "Enginemen and Trainmen.")

BROKEN IN TWO OR BURST HOSE, ETC.

The angle cocks on each side of the separated or burst hose should be closed as soon as possible, and the necessary precautions taken in regard to protecting train and applying hand brakes if on a steep grade.

After the train pipe is again opened to the rear air car, if the engineer is able to release all brakes, no further test is required.

In replacing a burst or defective air hose, take care to have the faces of the couplings come together without twisting the hose. In addition to extra 1-inch and 1¼-inch air hose, extra hose coupling gaskets for the modern standard couplings should be carried by trainmen. In order to distinguish the proper coupling gaskets to carry, as the gaskets used in the old style coupling cannot be applied on the road, orders should read Hose Coupling Gasket, Plate G-43.

In applying a new gasket the groove in the coupling in which the gasket fits should be made as clean as possible, or else the new gasket may leak. A coupling groove cleaning tool is provided for use in applying new gaskets. The point of the tool and the end of the handle are especially shaped, the former for cleaning the groove in the coupling and the latter for forcing the gasket into the groove evenly all the way around. Old gaskets having the flange partially forced out of the groove by not uncoupling the hose before cars were separated, or by other causes, can often be expanded in the same manner to prevent leakage.

Paper should never be used between coupling gaskets, neither should nails or anything of a metallic nature be driven between the couplings to stop leakage. Paper has been known to entirely obstruct the passage of air through the train pipe, and it is quite likely to stop up the car drain cup strainer. Nails or any metallic substance driven in between the coupling shoulders will prevent the couplings from separating at point where such are used, in the event of train breaking in two. In that case either the hose or train pipe will be torn off.

Couplings must not be hammered together to stop leakage, as this will also cause the same trouble as above stated. In the absence of good gaskets to replace defective ones, leakage can in many cases be stopped by driving small wooden wedges between coupling shoulders. These will not interfere with hose uncoupling should the train break in two. A defective gasket in the old style hose coupling will necessitate the replacement of the hose.

The coupling gaskets are often distorted and their flanges forced out of the grooves, due to their being improperly coupled, thus causing leakage. In connecting hose place the couplings together with gaskets squarely over each other; then roll them to place as though they turned on a pivot, keeping the heads pressed firmly together endwise until they strike the stop pins.

In freezing weather much trouble is experienced with gaskets leaking on account of being frozen. Thaw such, but in doing so exercise care to avoid injuring the gaskets.

Frozen air hose will also cause gaskets to leak by failing to bend when the slack runs out, thus slightly separating the couplings. About the only thing that can be done when this trouble is serious is to change the hose, or drive small wooden wedges between the coupling shoulders. The latter will have a tendency to hold the couplings together.

DEFECT CARDS (FORM 684).

Defect cards will be supplied to all conductors upon order. These cards properly filled out are of great value in the maintenance of the air brakes. Report all brake defects existing on cars in trains, issuing a separate card for each car, and in every case furnish all information called for by the card. Attach

to needle beam nearest the triple valve. No card need be made out for defect already indicated by a card attached to car.

Trains departing from terminals should have all unrepaired defects carded by inspectors or conductors previously in charge. The conductor then in charge is expected to require this or to make out and attach such cards.

CABOOSE GAUGE.

Where cabooses are fitted with air gauges trainmen are required to use this device as an additional precaution against danger from low pressure or an unintentionally closed angle cock. It is not intended to render unnecessary any of the specified brake tests.

Note particularly whether it indicates ample air pressure at times when such is or may be needed and take prompt steps to locate the cause and render assistance where it does not. This is particularly important when descending grades.

Where the grade requires the frequent use of the air brakes to control the speed, following a stop the train must not be allowed to proceed until full pressure is restored. This implies using hand brakes to hold it while recharging. Also, in case of a heavy reduction in train pipe pressure without a corresponding decrease in speed, at once aid with the hand brakes without waiting for same to be called for. Report any such cases to the Supt. on arrival at terminal.

By observation trainmen can soon learn about how rapidly and how much it is possible, when brakes are being released, to raise the train pipe pressure at the rear end of trains of various lengths. As failure to obtain a sufficiently quick and considerable rise contributes to brakes sticking, engineers should be promptly advised when such failure is observed so they may take precautions to overcome the cause.

Trainmen will allow inspectors to observe the caboose gauge whenever they so desire in conjunction with testing air brakes.

If it is observed that with different locomotives the caboose gauge varies over five pounds from the standard 70 pounds pressure that should be shown with train fully charged, have the gauge tested and adjusted.

Every man in train service should feel interested in the condition and maintenance of air brakes, and if only a small part of the time is spent in studying the operation of the air brakes, that was required in setting hand brakes before the advent of the former, much improvement will follow in the air brake service and in the reduction of the number of slid flat wheels.

Rules and regulations: Numbers (168-a, b, f and i), (170-k), (172-e), (182), (207), (212-e and f), (214-a, b and n), (225), (226), (465), (473-b), (517), (554), (555,) (556), (557), and (559).

ENGINEMEN AND TRAINMEN.

The purpose of the air brakes is to hold cars and engines for a limited time when standing (see "Mountain Grade Service" for time limit), to keep the speed under control down grades and to make stops. All of these are accomplished by the friction between the brake shoes and wheels. This friction is the actual holding power so long as wheels do not slide, and is always far less than the shoe pressure which causes it. With the same shoe pressure the friction steadily increases as speed reduces, and is greatest when the stop is completed. This is one reason why the hand or air brake holds so little at a high speed, even though heavily applied, and why wheel sliding is more liable to take place and shocks from brake application are more likely to occur when speed is low.

It is easier to drag a car with all wheels sliding than it would be were the brake shoe pressure considerably below that necessary to cause sliding. It is similar to the effect when driving wheels slip. All have noticed how rapidly the train slows down when the engine slips on a hard pull.

The amount of work the brake will have to do to stop a car is measured by the car weight, the speed and the grade. While the brake holds alike with the same shoe pressure and speed, yet the effect of loading a car is to increase the distance required for stopping it and the use of more of the possible holding power to keep it from increasing in speed down a grade. The effect of this is just in proportion to the increase in weight. That is, the brake on a car weighing 30,000 pounds empty has twice as much work to do when the car has a load of 30,000 pounds and three times as much when the load is 60,000 pounds.

While the loss in the shoe friction or holding power is a serious item when the speed is raised considerably, the increase in the work the brake will have to do to stop the car is even more so. To illustrate the latter, with all else the same if the speed of a car was increased from 10 miles per hour to 20 miles per hour the brake would have to do *four* times as much work to stop it. At 30 as compared with 10 miles per hour the work would be *nine* times as great; while at 40 as compared with 10 miles per hour the work would be *sixteen* times as great.

On a level grade *all* of the holding power is available for stopping, but on a descending grade a portion of it is required *merely to prevent the speed from increasing,* thus leaving so much less for making a stop than would be had on the level.

The effect of speed in reducing the brake shoe friction or holding power and increasing the brake work required for stopping is shown in a general way for a passenger train in the first paragraph under "Westinghouse High Speed Brake."

While the effect of raising the speed any considerable amount not only enormously increases the work the brake will have to do to stop the car and, by

lessened shoe friction, decreases the amount of work it is able to do, it should also be remembered that brake cylinder leakage, always present to a greater or less degree, invariably results in some loss in holding power *while the stop is being made.* Consequently this loss becomes greater as the length of the stop is increased by reason of any one or more of the three important factors, speed, weight and grade.

Speed only, though the most important of the three, can be governed by the enginemen and trainmen. Hence, it is desired to impress upon their minds in the strongest possible manner the importance of absolutely so limiting the speed as will give a reasonable assurance of safety, grade, weight of train, number of good order brakes in use and ability to maintain the air pressure being considered.

From the knowledge required to anticipate before starting about how severe will be the duty imposed on the air brakes, it will be clear that the brake tests at terminals and before starting down steep grades are absolutely essential.

The brake safety of the train is measured by the distance that would be required for making an *unexpected stop.* For this reason a train is not safe if, when going down a grade, the full brake power is required to keep it from running away or to very gradually decrease the speed where conditions are most favorable.

Dividing the total train tonnage by the number of good brakes will give the number of tons each good brake will have to hold on a grade or stop there and on the level. When considered in connection with the grade and number of cars with the air coupled up, for the greater the number the more difficult it will be to recharge, a very good idea can be obtained of how hard it will be to control or stop the train.

TRAIN INSPECTION.

The main object in fitting railway rolling stock with air brakes is to obtain the greatest possible degree of safety in operation, and the ability to stop in the shortest distance must be the first consideration. With these ends in view all operative brakes should be coupled up and cut in, full pressure obtained as soon as possible and afterwards maintained and all necessary tests made. Therefore, defective brakes and train pipe leakage should be repaired or reported as soon as possible.

SHOCKS FROM APPLICATION AND RELEASE.

Shocks are caused by the difference in holding power and speed throughout the train, and draw-bar spring compression. The longer the train the greater may these differences become. This is largely due to the impossibility of causing the pressure to fall equally at the same time throughout the train pipe, variation in brake power and load, consequent draw-bar spring compression and to the considerable amount of slack between the cars. When draw-bar springs are compressed and then suddenly permitted to expand, as in releasing at low speed immediately after a reduction in train pipe pressure, they aid

materially in causing a shock to the train. Parts of the train being on different grades at the same time, with variation in piston travel and car loading are among the causes for one portion of a train slowing down more rapidly than another. These are conditions that have to be met, and the engineer and trainmen are expected to understand them and exercise such judgment as will prevent damaging shocks.

TEST AFTER SWITCHING, ETC.

Where the train pipe has been closed or separated for any reason, the subsequent brake test required (see transportation rule 551) will be made as follows, except at the summit of mountain grades, a terminal or other point where a train is picked up. The condition of brakes on cars picked up should be ascertained, but for the remainder of the train it is necessary only to determine that the rear brakes can be applied and released from the engine.

Trainmen should advise the engineer of brakes cut out, or other changes made that affect the holding power.

QUICK ACTION FROM SERVICE APPLICATION.

The triple valve defects which may cause brakes to apply quick action when service reduction has been made are fully explained in the instruction on the quick action triple valve.

BRAKES STICKING AND WHEELS SLIDING.

Whenever brakes are found to be sticking or wheels sliding, the engineer should be advised of the fact immediately and also in what portion of the train. He will then be in a position to know whether the brakes failed to release, due to a too light application and lack of excess pressure, or whether they crept on after release, due to overcharging the train line and auxiliary reservoirs.

When the brakes are applied, two forces are acting on the wheels; the friction exerted by the brake, which tends to prevent the wheels from turning or cause them to slide, and the friction exerted between the wheels and the rails, which resists this tendency to slide.

The causes for wheels sliding are numerous, and may be enumerated as follows:

Frosty or greasy rails which reduce friction between the wheels and the rails below that exerted by the brakes. By the judicious use of sand, wheels may be prevented from sliding when rails are slippery (see "Train Handling").

Defective rubber emergency valve seats and leaky triple valve main piston packing rings. (See "Quick Action Triple Valves.")

Bad leakage in train pipe, hose and couplings; leakage grooves in brake cylinders stopped up; retaining valve pipes and exhaust ports in valves stopped up; failure to release brakes from the engine on long trains, especially when light applications have been made (see "Train Handling"), liable to occur when pulling in and out of sidings, slowing up over bad track, and at meeting points when train does not stop; setting out on siding cars on which the air

brakes are applied and hand brakes are set "on top" of the air brakes; hauling cars on the road or about yards with hand brakes set; injudicious use of a club in setting hand brakes; very short piston travel; brake shoes frozen to the wheels; and an overcharged train pipe.

Bad leakage in train pipe, hose and couplings will cause the brakes to set if the leakage can not be supplied by the air pump. When the leakage grooves in brake cylinders are stopped up, the air entering the cylinders, due to unsupplied train pipe leakage, cannot escape, thus causing the brakes to apply. Stopped up retaining valve pipes or exhaust ports in the valves will prevent the air in the cylinders from exhausting, resulting in a very high pressure, and will be liable to cause the wheels to slide. The small port in the retaining valve may become stopped up, but will not interfere except when the valve is cut in (handle horizontal). When found stopped up it should be cleaned out with a pin as explained under "Thermal Brake Test."

With few exceptions the freight car hand and air brakes work together, and merely taking up the hand brake slack when the air is set will retain the same brake power when the air is released. However, with the air brake set, if any force is applied to the hand brake, the result on the brake shoes will be the combined effect of the two. As this latter method is almost sure to cause wheel sliding and damage to the brake rigging, it should never be employed, except in emergencies. Even the former method should be avoided whenever possible, as it is far more liable to result in wheel sliding than when the air brake alone does the holding. This is because the hand brake is rigid and makes the brake force momentarily higher around curves and over rough track, while the air brake provides a flexibility which largely avoids this.

In order to prevent wheels sliding, trainmen should watch for hand brakes left applied, or air brakes sticking, especially after cuts for crossings have been coupled, cars picked up or set out, stops made, after slow-ups in which brakes have been lightly applied and while pulling in and out of sidings.

Engineers must bear in mind the liability of brakes sticking, following light applications, or when making couplings, particularly if the brake valve is not handled properly, and avoid trouble through these causes.

BACK-UP HOSE.

The back-up hose provides for the application of brakes from the rear end of a passenger train. Opening its valve suddenly, as should be done only in case of an emergency, will cause quick action. For a service application the valve should be opened slowly, yet fast enough to drive the brake pistons past the leakage grooves, and the opening should be gradually increased until the desired holding power is obtained.

Maintaining the discharge will keep the brakes applied, and stopping it will result in the brakes releasing and recharging, owing to the handle of the engineer's valve being in running position.

When backing trains with which the brakes are to be applied by use of the back-up hose, the handle of the engineer's valve should be kept in running position except following a brake application where a stop is made or a signal is given to back up. At such times the brake valve handle should be moved to release and then back to running position, as in making the regular release of brakes.

Before attaching the back-up hose blow out the rear train hose, and after attaching and cutting in make a sufficient discharge to insure that the angle cock is open. Within two hundred feet after starting to back up make a sufficient application to insure that the brakes are working. If such an application is not felt by the engineer within this distance he should stop and ascertain the cause.

Rules and Regulations: Numbers (4), (182), (226), (298-j), (318), (490), (491), (500), (501), (507), (508), (509), (510), (511), (512), (513), (514), (515), (516), (550), (553), (555), (558), (560), (564), (565-a, b. and c) [redacted] GEN'L SUPT. CIRCULAR 1418

TERMINAL TEST OF BRAKES.

Trains, when turned over to the inspectors, will have the hose coupled and the train pipe cocks, adjacent thereto, open, except the one on the rear end of the train.

Air brake repairmen and inspectors will have full charge of trains while testing and will use blue signal as per Operating Department Rules 182 and 226. Trains will not, under any circumstances, be disturbed while in their charge without obtaining their permission. They will furnish a report for each train tested as per Form No. 637.

When a yard brake testing plant is available trains will, where practicable, be so placed, when made up, as to permit of its use, and inspectors will use it for charging and testing trains. Where it is not practicable to so place a train or where no yard plant is available the test will be made from the locomotive. When necessary to use the locomotive for this work the engineer and trainmen will see that it is coupled to the train in ample season for compliance with Operating Department Rules 168-a, 182, 184-b and 551.

During the time the train is being charged, inspectors will examine closely for defects, noting carefully whether air hose are coupled properly, angle and stop cocks are open, except on rear end of last car, brakes cut in, and condition of pressure retaining valves and their pipe connections, these valves to be cut out (handles down) when not being tested. During this examination they will note and stop all leaks, the

train pipe and auxiliary reservoirs being charged to as near seventy pounds as possible. A close inspection should be made for spongy or defective air hose. If serious train pipe leakage exists that can not be located by the ordinary inspection the air hose should be tested with soap suds, as instructed under "INSPECTORS."

After the brakes have been charged to seventy pounds, a fifteen pound service reduction should be made and, with the brakes held applied, the train should be carefully examined for defects. Incorrect piston travel, more than 8 inches or less than 4 inches, should be adjusted to between 5 inches and 6 inches. Where short piston travel is noted it should be ascertained if brake has not partially leaked off, testing this by the brake beam.

In every case of a defective brake that can not at once be repaired, a defect card (form No. 684) should be filled out and attached to the needle beam nearest to triple valve. If necessary cut out the brake. Brakes that leak off need not be cut out, but should be carded for "Brake Leaks Off."

After making a thorough inspection of the train and completing all necessary repairs, the brakes should be released and a further examination made to note whether or not all have released. With passenger trains the signal to release brakes should be given by the air signal operated from the rear car, using the car discharge valve.

When circumstances will permit, the brakes should be kept charged until the road engine couples on. To see if train pipe is all cut in a further test should then be made by ascertaining whether the rear brakes can be applied and released from the engine.

When the train is ready to start the train men should give a signal to pull up slowly, so stationing themselves that all cars will be inspected, and note if all hand and air brakes are fully released and whether there are any flat wheels. (See Operating Department Rule 172-e.) Signal to depart should not be given until this inspection has been completed.

In addition to what has been said relative to terminal testing, whenever cars have been set out or added to a train, the brakes should be tested before the train starts, as covered under "ENGINEMEN AND TRAINMEN." When an additional engine is coupled to the train, it should be ascertained by test that all of the brakes can be operated from the head engine, as per Circular No. 1418 replacing Operating Department Rule 566.

TRAIN HANDLING.

EXCESS PRESSURE AND RELEASING BRAKES.

Excess pressure is the amount in pounds in the main reservoir over that in the train pipe and auxiliary reservoirs and is required to charge and release brakes. It is indicated with brakes off or on by the difference between the two hands of the gauge, provided, if brakes are applied, the train pipe reduction does not exceed that necessary to fully apply any one or more brakes. The amount to be carried in any service will be determined by those in authority.

It follows from the foregoing that the nearer brakes are applied to full service application the more promptly will they commence to release. Also, that as a light reduction results in less excess, it is more liable to be followed by brakes failing to release. Where made from standard pressure it is also likely to be followed by overcharging in the attempt to insure release. This becomes more pronounced the longer the train. Therefore, it is undersirable as a general rule to attempt a release following a light reduction from standard pressure.

Should a light reduction be necessary to accomplish the desired results, increase it before attempting to release. Straight air can usually be employed, if available, where otherwise a light application of automatic would be required, as in slowing down for the brakeman who closes the switch.

The proper length of time to leave the brake valve in full release to effect a release of all brakes, and yet avoid overcharging, depends to such an extent on the conditions just explained, the length of the train pipe and on the main reservoir volume, that no fixed rule can be established. Tests have demonstrated that following a full service application with a fifty-car train it often takes from six to ten seconds for the release wave of air to pass from the engineer's valve to the rear car.

The most common fault by far is in not leaving the brake valve handle in release position long enough. Another one is moving it back and forth between release and running positions several times, this breaking up the strong flow of air and preventing the quick and considerable rise in pressure desired at the rear end. The right way is to move the handle quickly to full release, leave it there the proper length of time, then return it to running position. With very long trains it is best within eight to twelve seconds, to again move to full release and back at once to running position, in order to "kick off" any head brakes which released with the others, but slightly overcharged and then reapplied. Do not practice returning to release again when the signal is given to start or when approaching a hard pull as this results in overcharging and is very liable to be followed by brakes sticking.

To release the brakes on a train of fifty cars the brake valve handle should ordinarily be left in full release for about twenty seconds, assuming a reasonable amount of excess pressure is available. With the

information given and a knowledge of the conditions surrounding each case, it requires merely the exercise of judgment on the part of the engineer to insure a prompt release and avoid overcharging. The time for releasing as given does not cover recharging. For it see "Mountain Grade Work."

With a fifty-car train a full service application will cause the pressure near the head end of train pipe to reduce about 5 pounds faster than that at the rear end. This results in the head brakes applying in advance of the rear ones, which tends to bunch the train and compress the coupler springs. In releasing with a train of this length the head brakes commence so much before those at the rear that they are practically off, so far as holding power is concerned, before the rear ones start to release, this causing the slack to run out rapidly. How serious the results may be is largely dependent on how heavily the brakes were applied, the amount the coupler springs were compressed and how slow the train is moving. The latter is very important because of the rapid increase in holding power at low speed (see "Enginemen and Trainmen.") At low speed it is almost sure to break the train in two unless there is retained at the head end some powerful holding power, such as is possible with the straight-air acting on the driver and tender brakes. Without it, release at low speed should not be attempted on long trains. Under no circumstances should the engine throttle be opened until ample time has been allowed for the rear brakes to release and even then steam should be used with care. Nor, without straight-air, should the brakes be released before the train pipe pressure has equalized after an application has been made on a moving train.

With passenger trains the foregoing does not apply, as there is no danger of damaging the train by releasing at a low speed, and holding the brakes applied to a stop will cause a disagreeable shock if the application is at all heavy. Therefore, as a general rule they should be released just before the stop. The exceptions are on a heavy descending grade or following a light application in making water tank, coal chute and other close stops, or, in some cases, with a very long train having cars ahead with much slack and weak draft gear.

SERVICE APPLICATION.

Service braking must be governed by the condition of rails, relation of brake power to weight of train, speed and grade, bearing in mind that safety is of the first importance. Always endeavor to maintain the auxiliary reservoir pressure as close to the maximum as possible for use in case of emergency, liable to occur at stations, as well as other points on the road.

In freight service the engineer should shut off steam gradually and allow the engine to drift some little distance in order to permit the slack to run in before the brakes are applied. The first reduction should not be less than 5 pounds in any case; with 40 or more cars of air reduce not less than 7 pounds. To insure applying the brakes on the rear end of a long train, the reduction must be heavy enough to cause the

brake pistons to travel past the leakage grooves in the cylinders. After the first reduction has equalized, follow in due time with moderate reductions at proper intervals to increase the braking power sufficiently for the purpose intended.

To reduce the liability of breaking in two, freight train stops should be made with one application, unless the engine is fitted with straight-air, but may consist of any required number of reductions. However, it is generally undesirable to make a heavy reduction at a low speed. This is mainly due to the high brake shoe friction at such speed and to the more rapid application of the head than the rear brakes which latter occurs under all conditions with long trains.

With passenger trains it is necessary to make quicker stops than with freight trains, and there is greater liability of wheel sliding because of the heavy applications and the fact that passenger cars are braked higher than freight cars.

To make the quickest stop with the least liability of wheel sliding, so far as the braking power is concerned, and to avoid disagreeable shocks, the two application method should be followed with passenger trains. This consists of making a heavy application when the speed is high, so as to rapidly reduce it. The low shoe friction at the high speed gives no more holding power with the heavy application than would result from a moderate application made at a low speed. When the speed has reduced to about 15 miles per hour, previous to which wheel sliding is not liable to commence, release all brakes, equalize the pressures in the brake valve reservoir, train pipe and auxiliary reservoirs, in the manner later explained, and then complete the stop with a moderate application.

In switching with a few freight cars and in any passenger service, when it is necessary to quickly follow a release with a reapplication, a prompt response of the brakes in the latter can be assured, and the temptation to use the emergency can be avoided in the following manner: Hold the brake valve in release only long enough to *start all* brakes to releasing; follow this immediately with short and successive preliminary exhausts until an answering discharge is heard from the equalizing discharge piston, then leave the valve on lap until the reapplication is desired. When the equalizing piston responds it indicates that the pressures in chamber D (above the piston), in the train pipe and in the auxiliary reservoirs are practically equal. This is the most favorable condition for a prompt application of the brakes under any circumstances, but particularly in service application position.

Failure to follow this plan is largely responsible for the severe shocks occasionally experinced at the rear end of passenger trains when they are being stopped at water tanks and coal chutes. Such shocks are inexcusable.

Engineers should study the conditions and notice the gauge frequently, particularly after the last reduction has been made previous to stopping, and a few seconds after release; if this is done and the brakes are operated in accordance with the conditions shown

by the air gauge, the trouble from brakes failing to release, and creeping on after release, due to overcharging, will be reduced to a minimum.

When it has been necessary to temporarily place the brake valve handle on lap position, be particularly careful not to forget and leave it there as such is even more dangerous than an unintentionally closed angle cock at the rear of the tender.

EMERGENCY APPLICATION.

An emergency application should never be made with or without a train, except when necessary to save life or property, in which event there is but one thing to do so far as the brakes are concerned; that is to place the brake valve in the emergency position and leave it there until the train stops or the need for its use has passed. With a freight train the brakes should be held applied until the train has stopped. No time should be lost in getting the sand running after the emergency has been used.

USE OF SAND.

It is well known that the use of sand will cause the wheels to grip the rails better, and thereby reduce the liability of drivers slipping or wheels sliding. It will also cause the brakes to hold better by increasing the friction between the shoes and wheels.

Where there is liability of wheel sliding, the entire train should be got on sand before the speed is low or the brake application is at all heavy and the rails should be kept sanded to the stop. Failure to accomplish this is liable to cause rather than prevent wheel sliding, as when wheels are once sliding, sand will not start them revolving, but will rapidly cause large flat spots.

REVERSING THE ENGINE.

An engine should not be reversed when the driver brake is set. With the latter properly proportioned and maintained it offers far more efficient means of stopping than does the engine reversed. Exhaustive tests have demonstrated that with a good driver brake and the engine reversed, the stop will be lengthened and the drivers flattened, due to the latter sliding. Even with a poor driver brake the wheels are almost sure to slide. It is because of this fact that the driver brake should not be used with the water brake.

USE OF STRAIGHT-AIR.

With engines equipped with straight-air, engineers are expected to make the following uses of it and to conform to the instructions governing its operation:

1. To quicken switching and reduce the incident damage to lading and equipment.

2. To permit of brake release on long trains without danger of slack running out suddenly and breaking train in two.

3. To prevent change of grade (sags or humps) or curvature from running the slack in or out so suddenly as to do damage.

4. To slow or stop trains where the brake work required is neither heavy nor prolonged.

5. To prevent the slack from running out and to aid the car brake retaining valves in controlling the speed while recharging on heavy descending grades.

6. To hold the train (with hand brake aid where needed) or locomotive and keep the automatic brakes recharged when standing on grades.

7. To control speed while weighing cars.

Frequent and intelligent use will increase the possible mileage between tire turnings, decrease the damage done to frogs and switches by badly worn tires, reduce the repairs to and improve the average condition of the automatic brake valve through the emergency applications avoided, and improve the service of locomotive valves and cylinders by eliminating the need of reversing when in motion.

INSTRUCTIONS FOR OPERATING.

1. Always keep both brakes cut in and ready for operation unless failure of some part requires cutting out. (See 6, 11 and 13, following, for exceptions.)

2. Always carry an excess pressure of 10 lbs. or more in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

3. When using automatic keep the straight-air brake valve in release position, and when using straight-air keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking. (See 5 and 8, following, for exceptions.)

4. Automatic *must not* be used while straight-air is applied; if automatic is then wanted, first release the straight-air.

5. Though the use of straight-air while automatic is applied will not increase the driver and the tender brake cylinder pressures above 45 lbs., yet release of either cannot be assured while the other brake valve is on lap or application position.

6. Bear in mind that the straight-air on the driver and tender brakes is almost as powerful as is the automatic on same, and that each should be used with care to avoid rough handling of train, or, in holding down a long grade, loosening of tires on drivers. When the straight-air is used to aid in recharging trains in motion down steep grades the automatic should be kept inoperative by having open the one-half-inch cocks shown by C and D, in Plate 26.

7. The straight-air reducing valve should be kept adjusted at 45 lbs. and the driver and tender safety valves at 53 lbs. Where a full application of the straight-air causes either or both safety valves to operate, it indicates too high adjustment of the reducing valve, too low adjustment of safety valves or leakage at either. Have them tested and adjusted.

The following additional directions cover details not given in the previous general instructions.

8. To release train brakes at low speed, apply the straight-air either *immediately before or after* moving the automatic brake valve handle to release position and *maintain* a strong straight-air holding power until *all* train brakes are released; then, if no stop is to be made, gradually release the straight-air and use steam carefully, if needed, until the train slack is all out.

9. In using the straight-air in switching, to slow a train from ordinary speeds, stop it from same on an ascending grade or on the level at low speeds, first gradually run the slack in or out, depending on the direction of movement, remembering that the slower the speed the more holding power the same cylinder pressure will give because the shoe friction is better. For the same reason, partially release the straight-air just before stopping so as to relieve the coupler spring tension and reduce the liability of wheel sliding.

If on an ascending grade, fully release the straight-air as soon as the stop is made, reapplying lightly *after* the train starts back, in case this occurs. Train men should hold up the slack with the caboose brake.

10. For quick work and economy in air, as with automatic, keep the piston travel well maintained and avoid cylinder leakage. Piston travel increases more rapidly with straight-air, because of greater use, than with automatic alone, and requires more frequent adjustment.

When doing "short" switching with an engine having long piston travel, release only until the brakes do not hold. This will save air and quicken the following application. But be *sure* to keep the straight-air brake valve in *release* position at all other times when holding power is not wanted.

11. To hold a standing train on a grade, if ascending take the slack out with steam, then apply the straight-air. If descending and cocks C and D, Plate 26, are open, run the slack in with straight-air just as the stop is being completed; or, if already stopped,

reverse, move the automatic brake valve handle to release and at once shove in all slack by full use of steam; then apply the straight-air and shut off steam. Keep the automatic brakes recharged when holding with straight-air, this being the main object sought.

In holding with straight-air, leave its brake valve in full application position. This is assuming that the reducing and safety valves are correctly adjusted and that there is no serious cylinder leakage to waste air.

12. If a burst hose or other *automatic* application causes driving wheels to slide, at once release their brake, where the provision is made, by opening the cut-out cock D, Plate 26.

13. To use the straight-air to aid in recharging the train brakes when descending a grade, on passing the summit open the cut-out cocks C and D, Plate 26, which will prevent the automatic from acting on the driver and tender brakes, but their auxiliary reservoirs will be recharged with those of the train. Therefore, under this condition the straight-air may be used irrespective of the automatic, the only restriction being to avoid rough handling or overheating of driver tires. Close cut-out cocks C and D at the foot of the grade.

The straight-air should be used not only to aid in holding the train while recharging its brakes, but as well to avoid a possible jerk from slack running out when the speed is brought very low just before recharging.

To insure against the engine moving when oiling, taking water or when leaving it for a time, let the

straight-air brake valve remain in application position. As before, it is assumed that the condition of the apparatus will avoid any undue waste of air.

Remember at all times that it is possible to cause very disagreeable shocks at the caboose which will not be felt at all on the head end. Avoid such rough handling. To aid in this, having run the slack either in or out by the use of straight-air, hold it so by not *fully* releasing until the need for holding power is past or the stop is completed.

MOUNTAIN GRADE SERVICE.

Some of the most important facts relating to mountain grade service, comprehended in chapter to "Enginemen and Trainmen," may be summed up as follows:

1. The brake work required for a stop increases much more rapidly than the speed.

2. On a level grade the entire holding power is available for stopping.

3. On a descending grade a certain portion of the holding power is required to prevent a gain in speed.

4. On a descending grade the work required of each brake to prevent a gain in speed increases with the weight of the load per good brake.

5. The holding power available for stopping on a grade is that in excess of what is necessary to prevent a gain in speed.

6. The holding power obtained from a certain shoe pressure always decreases as the speed increases.

7. The longer the distance, and consequently time, required for a stop, the more will it be lengthened by brake cylinder leakage.

Although standing brake tests with knowledge of results, tons per good brake and number of cars having the air connected, are necessary before starting, yet the ability to control or stop a train as indicated by this must be, for the sake of safety, confirmed by the first few applications after passing the summit. Speed should be kept very low until this is determined, and the speed later should be governed accordingly.

With ample pump capacity, implying at least one 9½-inch pump in good order, a train should not be difficult to control with air brakes alone if the tonnage per good brake is not over 50. However, with the same number of tons per good brake, a short train is easier controlled than is a long one, there being fewer brakes to recharge.

Another very important factor and one which can not be determined by the ordinary brake test, is the condition of triple valve feed grooves. These can not all be clean and if many are considerably choked with dirt, a longer time will be required to recharge their auxiliary reservoirs, it will make the train more difficult to control and require greater care. This is another reason for extreme care and low speed on beginning the descent.

It is impossible to maintain a perfectly uniform speed in using air brakes to control a train down a steep grade, but with fair handling the average variation should not exceed nine miles per hour and five miles per hour is easily possible, particularly where the water brake is used.

Where other conditions are alike, the ability to obtain the maximum holding power possible is dependent on auxiliary reservoirs being charged to the predetermined pressure and the intelligent use of same.

The greater the main reservoir pressure and volume, the more rapidly can recharging be accomplished, but to insure this the brake valve handle must be held in full release until the train pipe hand has raised to and remains a few pounds above the auxiliary reservoir pressure desired. (It should be understood that this method of handling brake valve applies only when descending heavy grades.)

The liability of a shock following release at low speed is much reduced when retaining valves are in operation, but, without use of the straight-air, it is possible with long trains, particularly if the forward portion is on straight track and the rear end on a curve. As a rule, the desirability of reducing to a very low speed before recharging occurs only with trains difficult to hold, and with such the straight-air or the water brake should be in use. If so, the holding power of either of these will prevent any undesirable results following release. Under other circumstances the driver brake should be cut in and its retaining valve turned up just before recharging, but it must be distinctly understood that the driver brake retaining valve must be turned down as soon as the liability of a shock has passed, this covering less than thirty seconds of its use.

Under no circumstances should the driver brake, either automatic or straight-air, be used continuously down long, heavy grades to an extent at all likely to overheat and loosen tires.

While it is desired to accomplish a given amount of work with the least possible expenditure of air, train safety is of the greatest importance; therefore, air or pump labor, up to the capacity of pump, should not be saved at the expence of a lessened train safety.

The shorter the time required for recharging and

reapplying the brakes, the greater will be the value of the retaining valves.

Although a driver brake may not, at its maximum efficiency and at any considerable speed, be used continuously down a long, heavy grade without excessive tire heating, it may be used occasionally at the most difficult parts or at all times at a lower speed, but never when the water brake is being employed.

Where a stop of more than 10 minutes is to be made on a heavy grade, release the air brakes and hold the train with the hand brakes. The objects are to guard against the train starting from the air brakes leaking off, and where engine remains attached to train, to have latter fully recharged when it is desired to start.

Before detaching the engine, release the air brakes in order to better determine whether the hand brakes set will hold the train. Even then it is not assured if retaining valves are in use. Hence, the train should be watched.

Where the air pressure has leaked rather low by reason of the engine having been away from the train, do not release the hand brakes until the train has been thoroughly recharged, the engineer to indicate this by whistling off brakes. With the driver brake cut out and the train standing, the engine of a descending train can be reversed and by the combined use of steam and the retaining valves or with the straight-air a very heavy train can be held long enough to complete recharging if trainmen have released the hand brakes before they should. However, this will not excuse trainmen for wrong practice. This plan can also be used to advantage where a very short stop is made, as to pick up a flagman of a preceding train.

Summing up many important features in the foregoing: (a) The relation between the number of good brakes and tonnage of train, with number of cars in the latter, should be known before beginning the descent; (b) the indicated ability to control train should be tested by the first running application; (c) this is especially important when commencing the descent of a steep grade (it should be done while speed is low, a sufficiently strong reduction should be made to insure all pistons passing the leakage grooves, and the average speed down the grade should be determined by the result of these tests); (d) the maximum and average maximum speeds should be held as near the average as practicable; (e) auxiliary reservoirs should be kept as near the maximum pressure as possible, this necessitating recharging whenever the grade, curvature and main reservoir pressure offer an opportunity; (where these conditions are not favorable it should be assured by slowing down sufficiently or stopping if necessary. This means, as a rule, short holds, slightly heavier initial reductions, but a lighter total application between recharges than in holding longer distances, a quicker recharge and application and more uniform speed); (f) keep the driver and tender brakes in good condition; use latter always and the former as much as practicable, testing their condition whenever possible, after they have been used for any distance down a grade, by ascertaining the wheel tread temperature, this indicating the amount of work done by each brake.

When full application will merely keep the train from increasing in speed or will very gradually slow it down where curves or lesser grade assist, some additional holding power must at once be obtained by the use of the straight-air, the water brake or by assistance from hand brakes. These precautions must be taken while the speed is yet low.

Where a train is difficult to control on a heavy descending grade, sand should be used to increase the holding power of the brakes. As the hand sander assures a better supply for this purpose and leaves all the air pressure for braking, it should be kept in working order and used at such times where the engine is so fitted.

Engineers of helping engines will cut in their brake valves to aid in charging the train *only* when requested to do so by the engineer using the brakes, and must not fail to cut out again before the train starts. Under no circumstances should they cut in when the train is running. When there is any apparent difficulty in controlling the speed of a train, and this is farther indicated by the head engineer using the water brake, the water brake must be applied on the helper engine if there be such near the head end of the train.

Trainmen must not use the conductor's valve or rear angle cock except as required by operating department rules and regulations.

For use of the straight-air see "Instructions For Operating" under "TRAIN HANDLING."

PASSENGER TRAINS.

While the lesser proportional load and better braked condition of passenger than freight trains renders the former the much easier controlled of the two, yet all precautions in the way of tests, speed, etc., should be taken to assure safety.

As stated in instructions for "TRAINMEN," some passenger car hand brakes cannot be set while the air brake is applied. This is because they work against each other. However, if the air brake leaks off or is being released the hand brake can be applied just as the air piston rod moves back into its cylinder. In fact, the hand brake application will aid in forcing the piston rod back, but must be followed up until the air brake is entirely released; else when the latter is fully released, the hand brake power will be lessened. This must not be overlooked when it is necessary to apply hand brakes on a grade. If the engine is detached, release the air brake on one car and apply the hand brake before releasing the air brake on another car. Should there be but one car detached, the application of the hand brake should be made while the air brake is being released.

The retaining valves are more efficient on passenger cars than on freight cars. This is due to the better maintenance and to the additional fact that the cylinders being larger will not permit of as rapid a fall in their pressure while recharging. Engineers should bear

this in mind, and, to avoid slowing down too much, must release earlier than would be proper with freight trains.

Where possible to do so, all available retaining valves should be used down mountain grades. When necessary to turn down any to avoid delay in starting, turn down those on the rear, again turning them up if the grade continues.

RULE NO. 515.

When complying with requirements of rule 515 in Operating Department Rules and Regulations, the conductor will advise the engineer or engineers of the total number of cars in train, the number with good order brakes and the number of tons per good brake. This information is needed in determining the probable ease or difficulty of controlling the train by air brakes alone, thus better enabling a decision as to whether any hand brake aid will be required and, if so, about how much.

THE WATER BRAKE.

When a moving engine is reversed the cylinders act as compressors. This is what gives the holding power of the water brake. Without the water, the suction into the cylinders would be from the smoke arch which would draw into the cylinders cinders and hot gases. These gases would be further heated by the following compression and all lubrication would be burned off from the bearing surfaces of the cylinders and valves, thus causing damage if the engine was run reversed for any considerable distance. To prevent this trouble, water from the boiler is let into the exhaust cavities, where it turns into wet steam just as it does when discharged at the blow-off cock. This wet steam prevents cinders and hot gases from being drawn in and acts as a lubricant to aid in preventing the valves and cylinders from being cut.

The apparatus for supplying the steam chests and cylinders with wet steam consists of one or two globe valves and some piping. If only one pipe is used to supply wet steam to both cylinders one globe valve is provided, and if two pipes are used, one for each cylinder, two valves are provided.

The globe valves are attached to the boiler below the water level and within convenient reach of the engineer. The pipes lead from the globe valves to the exhaust passages in the cylinder saddles.

In operating the water brake it should first be known that the cylinder cocks are open and free and

the throttle valve closed. The water valve or valves should then be opened about one-quarter of a turn, after which the reverse lever should be placed two or three notches back of the center of the quadrant. The color of the discharge from the cylinder cocks should be carefully noted; if it is a dense white the water valve is open sufficiently, but if it has a bluish color the water valve should be opened wider until a dense white appearance is noted.

If the engine throws water from the stack the water valve should be closed sufficiently to prevent this trouble.

The amount of braking power developed by the water brake depends upon the position of the reverse lever, the braking power increasing as the lever is moved back from the center.

As the water brake acts to stop the rotation of the drivers, the driver brake must not be used at the same time, because the braking force acting on the drivers would be too great and cause them to slide.

When it is desired to discontinue the use of the water brake, the water valve should first be closed, and the reverse lever moved ahead slowly to avoid throwing water from the stack and jerking the train.

Engineers on all freight engines which pass over mountain grades and which are equipped with water brake apparatus, must use the water brake a short distance, at least once per trip, and continuously in all cases where the train cannot be easily controlled by the air brake alone. This applies as well to helper engines when located near the head end of train.

When using the water brake on two cylinder compound engines the separate exhaust valve should be in compound position, but before discontinuing its use the separate exhaust valve should be opened to release the air in the steam chests and receiver before moving the reverse lever; otherwise much difficulty will be experienced in moving the latter, and there will be danger of breaking the train in two.

The speed of mountain helpers and heavy consolidation engines with driving wheels less than 60 inches diameter should never be permitted to exceed sixteen miles per hour while using the water brake, and the speed of engines with driving wheels 60 inches or over diameter should not exceed eighteen miles per hour. The water brake is most efficient within such limits.

Oil should be fed to the cylinders and valves continuously during the operation of the water brake. When the water brake is used on two cylinder compound engines which have only one water pipe and valve, it is generally necessary to increase the rate of feed of oil to both cylinders slightly above that required when the engine is working steam, but when in use on two cylinder compounds fitted with two water pipes, one for each cylinder, the rate of feed of oil to the low pressure cylinder only need be increased.

THERMAL BRAKE TEST.

The thermal or wheel temperature brake test is the most accurate yet simplest of all brake tests. It should be made regularly by inspectors located at or near the foot of such grades as result in the brake action heating the wheels to some extent. Similarly, engineers should employ it whenever practicable so as to ascertain the condition of tender and driver brakes and in order that any excessive heating of driving wheel tires may be learned in season to prevent damage.

As will be readily understood, the application of brakes heats the treads of wheels. Also, the greater the pressure applied to the brake shoe, the longer it is held on and the higher the speed the hotter will the wheel treads become. Therefore, after a train has descended a grade requiring the use of brakes the relative amount of holding done by any car or even any pair of wheels will be accurately shown by a comparison of the temperature of wheel treads in the train.

As the brake power applied to any pair of wheels with a correctly designed brake is proportioned to the empty weight on these wheels at the rails, it follows that with all brakes in proper condition, after a train has descended a grade the wheels of the cars having the greatest empty weight should be somewhat higher in temperature than the others of the train. However, the difference should not be considerable and an understanding of the fact will enable a correct conclusion as to whether any brake or brakes have done their share of the holding.

The test is made by touching the tread of at least one wheel of each car. The object is to detect and remedy as early as possible, any defects causing the brakes of any cars to do either considerably more or less than their share of the work, thus increasing the safety of trains and decreasing the number of slid and cracked wheels, as well as of sticking brakes.

The temperature of the wheels, when the thermal brake test is being made, divides the conditions of brakes into the following four grades: *Normal*, being the wheel temperature of cars with good order brakes, usually the majority in the train; *Cold*, being the temperature of the iron in the truck frame and indicating no braking was done; *Hot*, having a temperature very much above the normal showing excessive braking; and *Warm*, being a temperature a little above the cold wheels, yet materially below the normal, and showing the brake did very little work.

It is equally important that all inspectors understand these causes in order that they may be able to locate the defects whether indicated by the wheel temperature or by attached defect cards. It is not intended that moderate differences be noted, but where ever the wheel temperature is either far above or far below the average of the train, ascertain and remedy the cause or where time is inadequate, indicate it by a defect card stating either "Hot Wheels"

or "Cold Wheels," as found. Fill out the remaining information required and attach the card in the proper place.

Where the wheel temperature indicates that either too little or too much braking was done the cause or causes will be found among the following:

Wheels Too Cool (below the average of train) is caused by (1) brake cylinder leakage; (2) retaining valve or pipe leaking (do not confuse with leak at exhaust port caused by defective emergency valve or seat) or valve not cut in; (3) brake cut out; (4) [redacted] FEED age groove in triple valve either partially or entirely choked up; (5) auxiliary reservoir leakage, including that from the release valve (bleeder), past the slide valve or the triple valve gasket and, with freight cars, the tube through the auxiliary reservoir, the latter being very rare; (6) full piston travel (striking cylinder head); (7) piston travel too short to pass the leakage groove *when moderate train pipe reductions are made;* (8) the brake rigging striking so as to destroy the power before it reaches the brake shoes; and (9) check valve leakage with the New York triple valve.

Wheels Too Hot (above the average of train) is caused by (1) choked or entirely closed retaining position exhaust port in the pressure retaining valve; (2) leaky emergency valve or check valve case gasket in the quick action triple valve; (3) brake sticking, due generally to a poorly fitting main piston packing ring and too slow rise in train pipe pressure in recharging; (4) hand brake applied heavily where the air brake does no braking, or the hand brake applied even moderately where the air brake is holding; and (5) brake rigging so defective as to deliver an undue amount of brake force to some wheels.

The last mentioned fault is rarely met with except on cars having the piston push rod connected to the middle of a short equalizing lever. By the slack being taken up unequally on such cars this lever will strike in the rod jaw and deliver too much power to one truck and proportionately less to the other. When either too high or too low wheel temperature is noted on a car with this rigging, test the wheels in the other truck and, if the temperature is found far different, adjust the slack so as to correct the faulty distribution. Applying the hand brakes, in the absence of air pressure, will show how the levers stand.

All inspectors are required to give the same attention to defect cards reporting either "Cold" or "Hot" wheels as they should where the actual defect is reported.

Where a trainman observes that the wheels under any certain car or cars are heating unduly when descending a steep grade he should note whether an exhaust takes place at the small port in the pressure retaining valve while the train is being recharged. If not, it is probably choked up, retaining all the pressure. He should insert the pointed end of a pin as this will usually remove the obstruction.

If, when descending a grade, anything occurs which is liable to render it desirable that the condition of the brakes be known, such as a derailment, difficulty in controlling speed, temporary loss of control, etc., the conductor and engineer are required to together and in person make the thermal or wheel temperature brake test on all cars, the engine, tender and, if had, the caboose, and report the number and initials of those having wheel temperatures either far below or far above the average of the train.

Trainmen are expected to be particularly watchful for brakes that do not hold or for those that hold too much and to use every opportunity to note and report such.

INSPECTORS.

The object of these instructions is to insure proper care of the air brakes, so as to obtain the greatest efficiency in their use, and to aid in keeping train detentions as small as possible.

TESTING TRAINS.

Inspection of brakes should be made as soon as practicable after arrival of trains, and existing defects should be repaired where time and facilities permit; otherwise they should be properly carded for. To hasten the work of inspecting and testing *outgoing trains*, the brakes should be cut in and charged as soon as possible. When the test is being made from a yard testing plant the testing plant gauge should be consulted to ascertain the pressure, and when being made from the engine the engine gauge should be consulted. The conductor and the engineer should be advised of the number of cars having train pipe cut in and the number of good brakes on these. (For additional instruction see "Terminal Brake Test.")

REPAIR TRACK AND SHOP BRAKE TEST.

Do not test over five cars at one time. Couple up, cut in and charge to 80 pounds, or as near that as possible, and then examine train pipe, hose and couplings, triple valves and auxiliary reservoirs for leakage. When leakage exists repair at once or cut out the brake on car affected and repair it later.

Make a twenty-pound service reduction and quickly measure and note piston travel; in about three minutes remeasure the travel and if found one quarter inch less than the first measurement, ascertain the cause, and make repairs. Next open the rear angle cock, leave it so and, after two minutes, remeasure the piston travel; any loss in travel not existing before is due to leaky check valve.

While recharging after making the check valve test, turn up the retaining valve handles; when recharged make a twenty-pound reduction, release and, after one minute, note if retaining valve holds, testing this by pushing on end of brake beam. If brake shoe can be moved sidewise on wheel the retaining valve is of little value. The same condition is indicated if a weak exhaust follows when the retaining valve handle is turned down. In such cases the brake should be recharged, fully applied, released and a quick examination made of the pipe from triple valve to retaining valve, including the latter. If the leak is caused by the valve not seating properly it can often be made to seat by tapping the pipe lightly; otherwise clean or replace the valve, depending on the cause of the leakage. The leak will generally be found at the retaining valve pipe union. Retaining valves to be of value should hold the brake shoes firmly against the wheels, at least one minute after exhaust ceases. Be sure that the retaining position exhaust port is not stopped up and that the valve is in a perpendicular position. The triple valve end of retaining valve pipe should have sufficient flexibility to prevent causing leakage in the pipe if the auxiliary reservoir and brake cylinder become loose. The retaining valve pipe must be so clamped as to guard against vibration when the car is running.

Handle a detached retaining valve with care as a jolt will often bend the stem of the valve and cause leakage.

In applying a retaining valve, avoid so placing it as to obstruct the removal of the case or cover, introduce no unnecessary joints in its pipe and place the union near the triple valve.

To test the triple valve main piston packing ring make a service reduction of ten pounds, place the brake valve in running position and allow the pressure to feed into the train pipe just fast enough to cause a slow, steady rise.

The speed of rise for this test should be 10 pounds per minute. Where the automatic controlling valve is used, make the release through it. Otherwise, the brake valve used will have to be especially fitted up so as to permit of carefully regulating the rate of feed, and the air gauge must be kept in good order so as to promptly indicate any slight change in pressure.

If, after cleaning and oiling the triple valve, insuring that the packing ring is free in its groove and the slide valve spring is not too strong, release will not follow a slow rise to original pressure, the valve should be replaced by one in good condition.

The causes for a triple valve leaking at the exhaust are stated under head of "Defects" in the chapters

on the quick action triple valves. The method of testing to locate these will be found under same head.

When replacing defective rubber emergency valve seats use those with three-eighths-inch holes for the old style valves, and those with five-eighths-inch holes for the modern valves. Before applying any new gaskets or rubber seats, thoroughly clean the bearings to insure a fit.

Before replacing check valve case see that emergency valve seat is free in its recess in check valve case and that it enters flush; that the emergency valve stem is not bent; that the rubber seat for latter makes a good joint; that emergency and check valves do not stick when forced together; that check valve has a true bearing on its seat; that the emergency piston is free in its cylinder and the emergency valve seat; and that all of these parts are clean and free from oil, being put up perfectly dry.

Before replacing triple valve main piston and its parts see that the ring is free in the groove; that a full and accurate bearing is shown between the ring and the cylinder; (packing rings must not be removed from their grooves unless they are to be destroyed, and should be turned to the position found when piston was removed. Do not press on ends of ring to turn it as bending will result); that the knob on piston is not bruised; that the piston runs true on centers; that the graduating valve is tight, and its pin is in place and secure; that the slide valve spring has a moderate but not strong tension; that the graduating spring is standard and free from corrosion; that the main piston makes a good joint on the drain cup gasket, and that the latter lies true so as to prevent bending of piston stem; (another cause for bent main piston stems is loosening drain cup bolts while there is air in the auxiliary reservoir, which should never be done); that the slide valve face and main piston are properly lubricated; and, which is of the utmost importance, that these parts are absolutely free from grit, threads of waste or other foreign substances. In applying a triple valve, place its gasket *on the valve and not on the reservoir,* and use the standard gasket.

Always remove the graduating spring, clean it and, if the plating is gone or the spring is corroded, put in a new one.

The proper condition of a brake cylinder is that the cylinder wall, leakage groove and packing leather are free from gum and grit; that the leather has the flesh side outward, is free from cuts and punctures, and is placed true on the piston; that the follower bolt nuts are drawn firmly; that the cylinder wall and both sides of the free portion of the packing leather are properly lubricated; that the expander ring is true and has the right tension (regulated by making it fit the bore of the cylinder a very little loose), and that it is in proper position when the piston is in place. This last can be determined by lowering the end of the rod, just after the piston is replaced, until by one's fingers it can be felt whether the expander is in place. Then after again raising the rod to a central position rotate it slightly. Should the ring be partially out of place the rod cannot be rotated freely.

The standard piston travel is 6 inches, and it should be adjusted as nearly as possible to this amount with maximum pressure and a 20-pound service reduction.

When the temperature will permit, test with soap suds all hose on cars passing the repair tracks and shops. Close the opening of the uncoupled hose, using a standard hose coupling with the nipple end plugged, so that both the hose and the coupling gasket may be tested. Apply the soapy water with a brush and replace all hose where leakage is shown by the resultant bubbles.

Test for leakage through the angle cocks by listening at the hose coupling when unconnected and the train pipe is charged, or by covering the gasket opening with the hand for a few seconds to note whether pressure accumulates. Absolute freedom from leakage is not to be expected, but where considerable, replace the angle cock.

The foregoing instructions apply, in so far as practicable, to cars laying in yards where such cars are adjacent to yard testing plant connections and workmen can protect themselves as per Operating Department Rule 226, without interfering with necessary switching.

WORK COVERED BY STENCIL MARKS.

The work covered by stencil marks embraces not only that done to the triple valve, brake cylinder and retaining valve, but in addition the following is included: Brake cylinder and auxiliary reservoir firmly secured to supporting blocks; application of missing pipe clamps and tightening up of any loose ones; replacing, when needed, coupling packing rings (gaskets) or hose; turning latter and angle cocks to the proper position; making tight all air joints; removing the cap from the retaining valve, wiping out all dirt and seeing that the valve and its seat are in good condition (use no oil); that the retaining position exhaust port is free and that the valve proper is well secured to the car in a vertical position. Inspectors should at other times attend to any of these details as the needs and opportunities arise.

TRIPLE VALVE REPAIRS.

Triple valve repairs other than replacing bolts, gaskets and emergency valves, together with cleaning and oiling, are to be made only at designated repair points. Merely the parts just mentioned and complete triple valves are to be carried elsewhere.

DEFECT CARDS.

Inspectors should see that inspected trains leaving a terminal have none but defective brakes cut out and that all such are carded. Each arriving freight train should have all brake defects carded. Inspectors should report to Master Mechanic all failures to card cut out or defective brakes and will repair such defects or, in absence of time, card for them. They will be held responsible for departing trains having all defects repaired or carded for.

SLID FLAT WHEEL REPORTS.

Slid flat wheel reports should be correctly and fully made out and promptly forwarded, including defect card. In all cases of slid flat wheels the roundhouse foreman should be promptly advised of the fact, giving him the number of train, number of car, date, number of engine and name of engineer.

AUTOMATIC SLACK ADJUSTER.

The construction and operation of the automatic slack adjuster is fully explained in a previous chapter. The slack adjuster should be cleaned and lubricated at the same time this work is done on the brake cylinder and triple valve.

Testing, cleaning and oiling the adjusters should be done at main terminals when cars lay over at these points. Otherwise it should be done at the most convenient points.

Adjusters should so regulate the piston travel that ordinarily between 6 and 7 inches will be shown in a standing test with full service reduction from an original pressure of about 80 pounds. Where less than this is noted, first see that all hand brake slack is let out (each hand brake rod end against the stop). Then, if too short, let out the exact amount of slack on the adjuster that it is desired to increase the piston travel. Do not alter dead levers, bottom rods, etc., unless with all adjuster slack out the piston travel is less than 5½ inches, or, where the adjuster has taken up to its limit and travel is too long, and not then in the latter case if any brake shoes need renewing. In case of a broken adjuster pipe, and no facilities for making repairs are at hand, plug the brake cylinder end, regulate piston travel with the ratchet-nut and card for defect. (See "Automatic Slack Adjuster" for further instructions.)

BRAKE RIGGING.

With brakes applied see that none of the brake levers come near the ends of their guides or other obstructions which would interfere with delivering the braking power to the brake shoes. This is particularly important with passenger cars, especially those having six-wheel trucks and all wheels braked. Remember that the levers travel further with the train running than they do with the brake applied when standing; also, that the travel is later increased by the brake shoe wear.

With brakes applied there should be ample clearance between brake beams and their safety hangers to guard against striking then or after shoe wear has occurred. Also, with six-wheel trucks the short, equalizing levers should stand vertical or nearly so in order that they may equally distribute the braking power to the middle and outside pairs of wheels. Where not so the error should be at once corrected.

When necessary to temporarily remove cylinder or other levers be particular to replace them properly. Otherwise wheel sliding is very likely to result. Blue prints showing correct dimensions of levers and rods will be furnished upon application.

It is almost equally important that rods be of the correct length. The length of rods must not be changed from the standard without authority from Supt. of Motive Power.

Where absence of the needed material requires temporarily replacing a broken rod with one of incorrect length the fact should be indicated by a defect card attached to the car.

PASSENGER CAR PRESSURE RETAINING VALVES.

The pressure retaining valves on passenger cars should be tested and repaired with the remainder of the brake equipment at terminals where such cars lay over.

Rules and Regulations: Numbers (4), (182), (226), (551) and (559).

PNEUMATIC WATER DISTRIBUTING SYSTEM.

Where air pressure is used for water distribution in passenger cars the air supply is taken from the brake auxiliary reservoir, but a special governor valve, adjusted at 60 pounds, prevents any air from passing to the water system until the auxiliary reservoir has been charged above 60 pounds.

The water system has an air reservoir which eventually charges to the same pressure as that in the brake auxiliary reservoir. From the former the pressure is reduced to 25 pounds before it passes into the top of the water tanks. The water outlets being at the bottom of the water tanks allow the air pressure to drive the water up into the car.

From the foregoing it will be seen that when the air brake is cut out and bled, on such a car no further supply of air can reach the water distributing system. Where this results in failure to supply water the brake should be cut in for at least ten or fifteen minutes while the train pipe is kept charged if the cause for cutting out the brake is of a character which will permit. Once well supplied, the water distributing system will usually retain its air pressure for several hours.

Failure to supply water when the brake is cut in and fully charged may indicate an obstructed air pipe, governor valve or reducing valve, the latter set too low or a governor valve set too high.

Where the water is driven into the basins with too great force it indicates faulty regulation of the reducing valve, due either to dirt or wrong adjustment.

The adjustments of the governor and reducing valves must not be altered except by authorized parties having facilities for making correct adjustments.

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