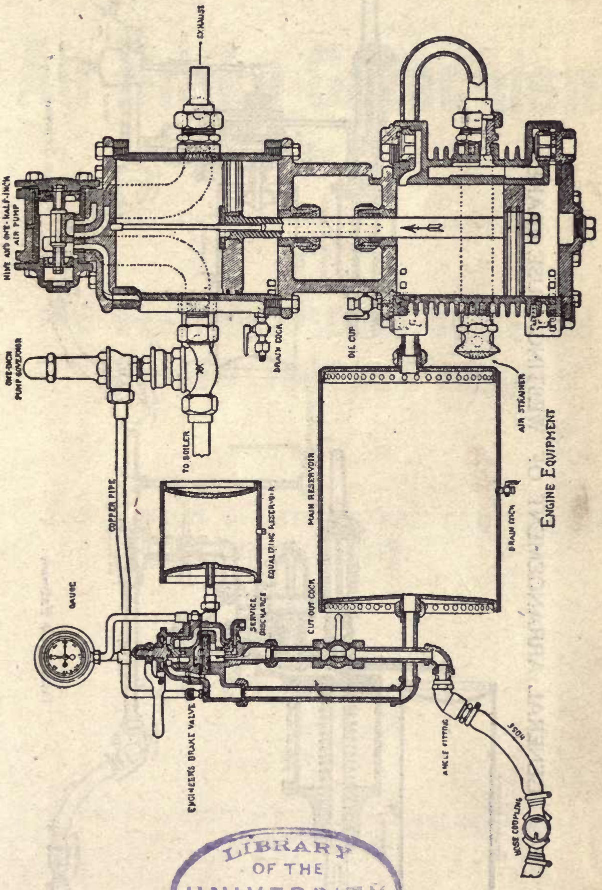
GENERAL ARRANGEMENT OF WESTINGHOUSE BRAKE



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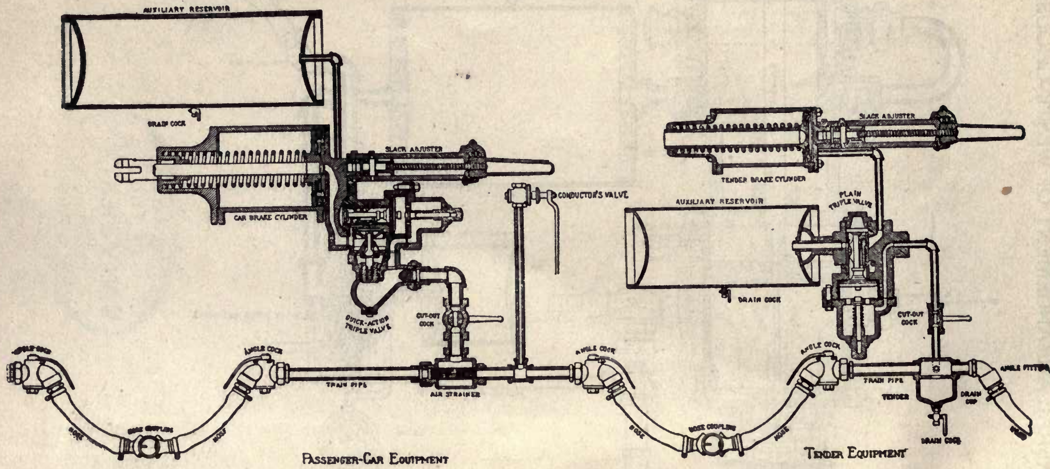


THE

Air Brake Catechism

AND

INSTRUCTION BOOK ON THE CONSTRUCTION
AND OPERATION OF

THE WESTINGHOUSE AIR BRAKE and THE NEW YORK AIR BRAKE

WITH A LIST OF

EXAMINATION QUESTIONS FOR ENGINEMEN
AND TRAINMEN

BY

C. B. Conger

DEAN-HICKS PRINTING CO., GRAND RAPIDS, MICH.

PREFACE.

In this enlarged edition of the Air Brake Catechism considerable new matter has been added which will prove of interest not only to those who are learning about the operation of the brake equipment from their own observation and experience, but to those who have the advantage of an instruction car with a regular instructor. This subject of self-instruction in all its details is so large that only a small part of it can be taken up in this little book, but the principal points are brought to notice.

The construction and operation of the air pump, as far as it interests enginemen, is explained, the matter of repairs is not taken up.

The construction and operation of the New York Air Brake Company's equipment is explained in addition to that of the Westinghouse Air Brake Company.

At the present day every one connected with the working of the air brake is expected to pass regular examinations, and these examinations are getting more strict each year. The work done by the air brake operator in handling trains is becoming more skillful every year; he who wishes to keep up with the best practice must continually try to improve his work. This can only be done by learning and practising the best methods.

The list of examination questions will call attention to points in the construction and handling of the brake which you should know if you wish to pass. Bear in mind that good judgment is the first requisite for a successful air brakeman, the addition of knowledge of the construction so as to locate defects and their remedies, and correct methods of handling, to good judgment, will make a skillful man under all conditions.

INTRODUCTION.

At the present day so much depends on the proper handling of the Automatic Brake that a definite knowledge is required from all men in train service of its operation when in good order, and how to locate defects or breakdowns, as well as how to avoid the difficulties arising from them.

This applies to the veteran as well as to the beginner. The changes in the mechanism, caused by the new and improved devices brought into service to take care of longer freight trains and faster passenger trains, call for study on the part of the men who have handled the brake for years, for a passenger train of moderate length equipped with ordinary triple valves and a long train with all high speed brakes are two widely different propositions, and the veteran looks for information on them. As for the beginner, he can not learn it all from experience, as no one is allowed to handle important trains until he has shown, either by an examination or by handling a moving train under the supervision of some man who can judge, that he has the necessary knowledge to properly operate the brake under all ordinary conditions.

This has brought about a demand for a clear and practical form of instruction in air brake practice, not so much to instruct the beginner on all the points as to put him in the way of learning them himself; and this introductory chapter is intended to help those who set out to learn the theory and have a chance to operate the brake or see it operated. This can best be done by learning the foundation principles first, studying the action of the important primary parts of the machine; the secondary parts will then work their way in so you understand the whole properly.

Much time may be wasted by beginning at the wrong end to unravel air brake operations. If you are too hasty and jump at conclusions, you may be wrong; better not know anything about it than know it wrong. Therefore, take time enough at first to learn it right; you will never regret it.

There is nothing mysterious about the operation of the air brake. Each part has its own duty to perform. Take each part by itself and study it up, then get an idea of its relation to the other parts, and you will find out that it is easy. You cannot learn it all at once, or by once reading over an instruction book. In studying the construction and principle on which it operates, it is an advantage to have help from some one who can instruct you. When you come to operate it, the machinery in actual operation is the best instructor.

When you see the air brake working every day, sometimes making a good stop, at others not controlling the train as you think it should, the operation may seem mysterious, but it is governed by fixed laws of mechanics and forces. If you take pains to learn these laws and about the forces, and examine each part of the mechanism, it will be clear to you.

Attention is called to explanations of some of these operations in the succeeding pages of the Air Brake Catechism. Many of these operations are explained in more than one manner in connection with the movements of other parts of the apparatus.

In the first place, all the parts of the brake which are named in question 1 of the Catechism, are charged with compressed air, which comes from the air pump to the main reservoir, then through the ports in the brake valve into the train pipe and triple valve, from there it passes through the feed port in the triple valve into the auxiliary reservoir provided for each complete brake. When the brake is ready to operate, the pressure is equal in the train pipe, in the triple valve on both sides of the triple piston, and in the auxiliary reservoir. When you change the relation of these pressures in different parts of the equipment, the effort the compressed air makes to equalize, by the high pressure air pushing against the low pressure air, moves the different parts of the air brake that can be moved in this manner away from the high pressures.

When it is once fixed in your mind what pressure you have in each place, and that any change of pressure will cause the movable parts of the valves to change their positions, closing some of the openings through which the air can pass and opening others, it is plain that the next step is to find out just what openings the air must pass through at each operation, whether applying or releasing the brake.

When studying the equalizing processes in the operation of compressed air equipment, remember that it is *air* that flows from one part of the equipment to another and *not pressure.* Pressure is only a condition, air is a substance or material. A substance can flow from one cavity or receptacle to another, but a condition can not flow through an opening. When compressed air flows from any part of the equipment to another, as from the auxiliary to the brake cylinder, it will change the conditions or pressure in these places, but the pressure does not flow either way. It will take away much of the mystery of equalization if you will bear these facts in mind.

We will take up the plain triple valve first, as the process of equalization is best explained with it. You will notice in the cut on next page of the plain triple valve in the position for charging the auxiliary reservoir and exhausting the air from brake cylinder, that the triple piston 5 is the dividing line when the pressures are unequal; that the train pipe pressure is against the lower side of this piston and auxiliary pressure on top. There is a small passage cut in the side of the cylinder around the piston, called a feed port, at *m*, through which air can pass from the train pipe around the piston 5, and up beside the slide valve 6 into the auxiliary at *Y*, when triple piston is clear up in release position; this is the opening through which air can equalize in train pipe and auxiliary. The piston acts as a valve to open and close this feed port. This port *m* is very small, and equalization takes place slowly through it. A brief explanation of the reasons for its small size is found farther along in the book.

As the auxiliary stores the compressed air used for applying its own brake, it must first be charged with a full

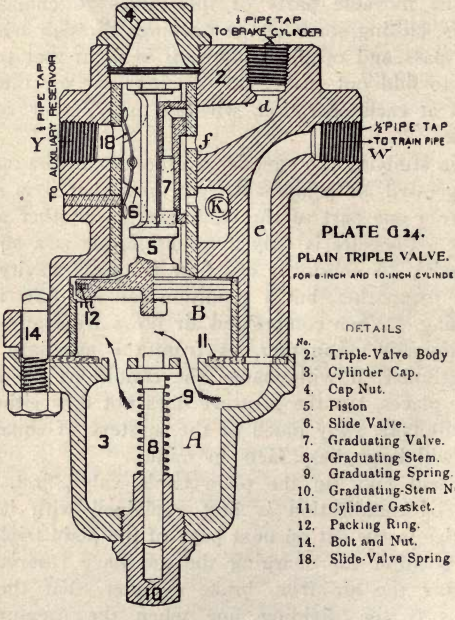


PLATE G 24.

PLAIN TRIPLE VALVE.

FOR 8-INCH AND 10-INCH CYLINDERS.

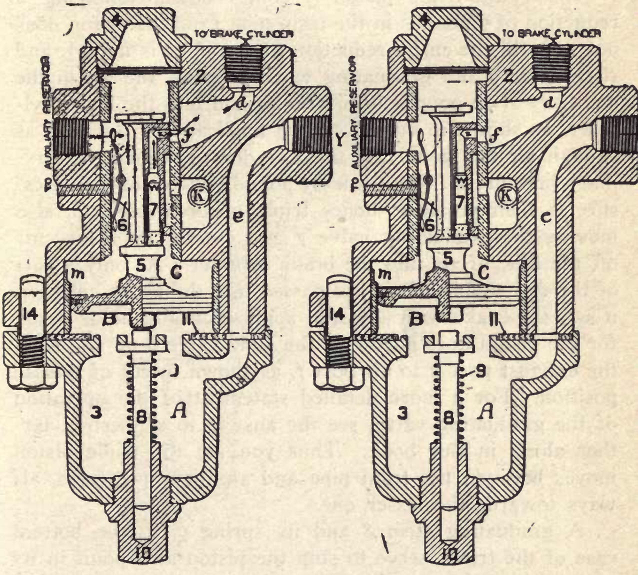
DETAILS

No.	
2.	Triple-Valve Body
3.	Cylinder Cap.
4.	Cap Nut.
5.	Piston
6.	Slide Valve.
7.	Graduating Valve.
8.	Graduating Stem.
9.	Graduating Spring.
10.	Graduating-Stem Nut.
11.	Cylinder Gasket.
12.	Packing Ring.
14.	Bolt and Nut.
18.	Slide-Valve Spring

RELEASE AND EXHAUST POSITION.

supply of air; which will raise its pressure to the standard —usually 70 pounds—and it takes about a minute and 10 seconds for air enough to flow around the piston to equalize the pressure at 70 pounds. To apply the brake with a triple valve the train pipe pressure must be reduced. As soon as any reduction of pressure is made in the train pipe, the auxiliary pressure will be greater and force the triple piston down, following the decrease of pressure in train pipe end of triple.

This first movement of the piston does not set the brake. There is some slack between the collar on the piston rod and the top of slide valve *6*—about five thirty-seconds of an inch—a very slight reduction of pressure under the piston moves it down the amount of this slack, closing feed



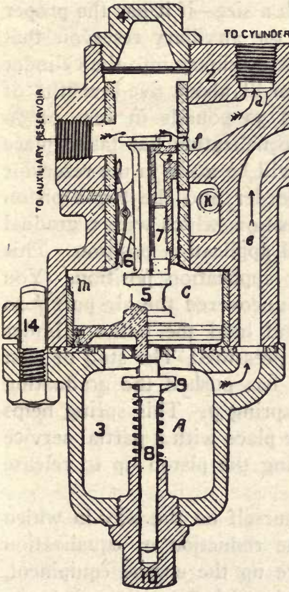
SERVICE APPLICATION—LAP POSITION.

port *m* and pulling graduating valve *7* off its seat in slide valve. As the slide valve has the auxiliary pressure holding it on its seat, more change of pressure under the piston is needed to move the slide valve—a point to remember when you move the triple valve to release position. When the piston comes down, bringing with it the slide valve, a port *z*, leading from the seat of graduating valve *7*, is opened to *f*, allowing the auxiliary air to pass from the graduating valve into the brake cylinder. This also has a movable piston that pushes against levers which are so coupled up that the brake shoes are forced against the wheels. The operation of this triple piston with a moderate reduction of train pipe pressure, say from 70 pounds down to 63, will show the exactness of this equalization principle.

When the triple piston 5 comes down, following a reduction of 7 pounds in the train pipe (and the piston does not wait till the entire reduction of 7 pounds is made), and slide valve *6* and graduating valve *7* opens, the air in the auxiliary at 70 pounds begins to expand into the brake cylinder, as shown in cut of service application. As soon as enough air has gone into the cylinder to reduce the auxiliary pressure a little below 63 pounds, the train pipe pressure is then greatest; hence triple piston moves up, also moving the graduating valve *7* and closing it. This cuts off the flow of air into the brake cylinder. As only a part of the full supply of air has passed into the brake cylinder, it sets the brake with a partial application and holds it set, for the piston does not move the slide valve *6* up and open the exhaust port *k* to air port *f*, as shown in cut of release position. For a more detailed statement of the operation of the graduating valve, see the answer to a question farther along in this book. Thus you see the triple piston moves between the train pipe and auxiliary pressures, always towards the lesser one.

A graduating stem *8* and its spring *9*, in the bottom case of the triple, serve to stop the piston at a point in its travel where port *z* will be exactly opposite port *f*. This stem and spring are not moved in a *partial service* application, because when these ports are wide open the air will pass from the auxiliary to the cylinder as fast as it is going out of the train pipe, this will reduce the auxiliary pressure as fast as the train pipe pressure reduces.

If the relations between the pressures on either side of triple piston are changed, it will move toward the lower pressure until the limit of its travel is reached, or until the relation between the pressures is changed the other way; this will stop its movement if pressures are equalized, or move it the other way if pressure is increased. Increasing the pressure in train pipe side of triple over the auxiliary moves the triple piston clear up, moves the slide valve *6*, opens exhaust port *k* to air port *f*, allows the air to escape



The plain triple valve moves to this position when the train pipe pressure is lower than the equalizing pressure of the cylinder and auxiliary either with a quick or a slow reduction.

EMERGENCY APPLICATION.

from brake cylinder and releases the brake; so you see, charging up the train pipe to standard pressure releases the brake. As the feed port *m* is also opened when the piston *5* is clear up, the air flows into auxiliary, equalizing its pressure with the train pipe. To change the relations between the pressures in any other way is done by letting out some of the air—the train man releases the brake by bleeding out the auxiliary pressure until it is lower than train pipe pressure.

If a reduction of the train pipe pressure of more than 20 pounds is made, as from 70 to below 50, the auxiliary pressure must also be reduced 20 pounds or more before it will allow the piston *5* to move up and close the graduating valve.

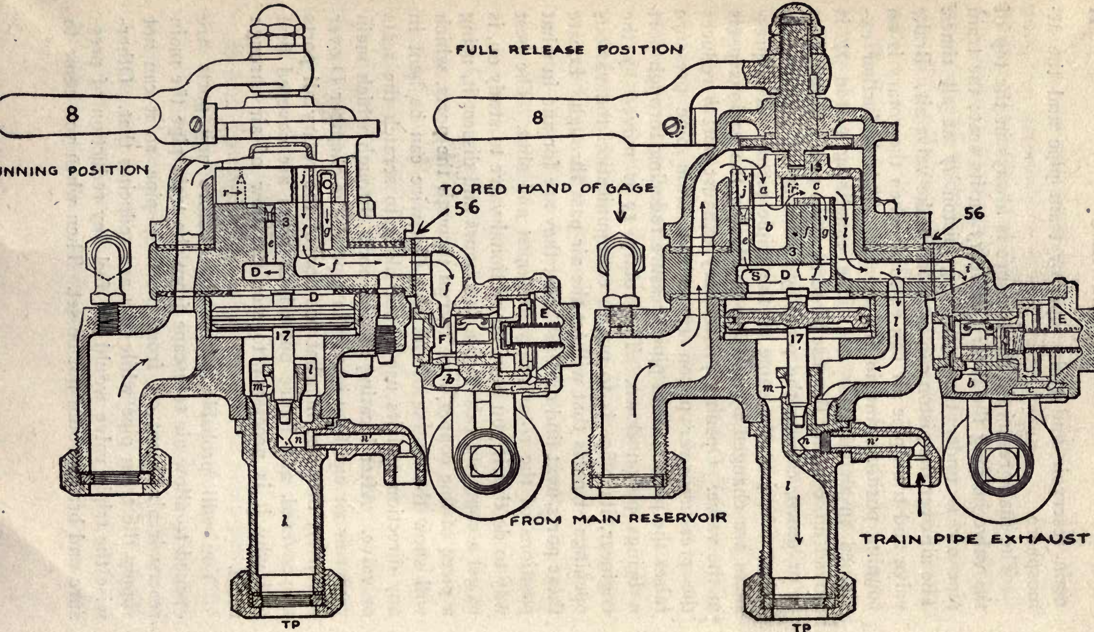
The brake cylinder is of such a size—if it has the proper piston travel—in proportion to the auxiliary reservoir that if air is allowed to flow from the auxiliary into the cylinder it will equalize in both of them at about five-sevenths of the original pressure, which is 50 pounds in case of 70 pounds originally. After this equalization has taken place no more reduction of pressure will be made in the reservoir except by a leak or at the bleeder and the triple piston will move clear down to the position, which with a gradual service application is called full application position. This is the same as the emergency application position. You will notice the slide valve has uncovered the air port *f* so air can pass through freely and hold the brake cylinder pressure equal to the auxiliary pressure. The stud or post on the bottom of triple piston has pushed the graduating stem *8* down, compressing its spring *9*. This spring helps to stop the piston *5* at the proper place with a partial service application and assists in starting the piston up to release after a full application.

After thoroughly posting yourself on the way in which the plain triple operates by the reduction or equalization of pressures, you can then take up the engine equipment. It is a good plan to know just how the pump operates, its care and management, but that can be left till later; it is treated of farther along in this book. The pump generally goes ahead with its work from beginning to end of the trip without much attention from the engineer; the rest of the equipment depends on the skill and knowledge of the engineer for its successful operation, as it responds directly to his manipulation.

The brake valve controls the passage of air between the main reservoir and train pipe, or train pipe and the atmosphere.

The main reservoir air pressure is always in the top of the valve holding the rotary valve *13* on its seat; the train pipe air is under the equalizing piston *17* at all times. The air over the piston can be called brake-valve air. Brake valve and train pipe air can equalize when the rotary is on running position, and in full release. This is further explained in detail later on. The equalizing piston *17* is moved up, opening the discharge or train pipe exhaust port *n*, or down, closing the port, by a change of pressure on either side, just the same as the triple piston. The pressures are changed by opening or closing the various ports in the valve. Opening preliminary exhaust port *h* reduces the pressure over piston *17* so that train pipe pressure raises the piston; train pipe pressure reducing through port *n* brings piston down. The rotary *13* is moved by the engineer, its office is to put in communication the various openings or ports that will let the air pass through. Locate these ports, next find out just what they are for and in what positions of the rotary they are open and shut. The best way to do this, if you have no sectional valve to study on, is to get a complete valve for a few hours and dissect it, using a piece of fine copper wire to run through the ports, which will show the course of the air; this wire can be bent in any direction and its use is not likely to scratch the seats or valve. After locating all the ports through which main reservoir air can flow into train pipe or the chamber D over piston *17*, then see in what position of the rotary all ports are covered, and figure out which ports are covered first and why it is necessary to stop the flow of air through them.

You will probably notice that before any ports are opened to allow air to escape from the train pipe the main reservoir air is cut off from the train pipe, so it can not supply the train pipe while you are reducing that. Otherwise the triple valve would not feel any reduction of pressure and brake would not be set. Then when you come to


FULL RELEASE POSITION
NNING POSITION
TO RED HAND OF GAGE
56
56
FROM MAIN RESERVOIR
TRAIN PIPE EXHAUST
8
8
TP
TP

locate the ports that are opened to reduce the train pipe pressure and actuate the triple, it will be necessary to know just exactly the principle of operation of the equalizing discharge valve.

On a long train the reduction of train pipe pressure must be the same at each triple if we expect each brake to be set at the same time and with the same relative power. To make this reduction of pressure alike for all the triples, or what is the same, for all the cars in the train, we must allow the air to escape from the train pipe gradually so the reduction will not be any more violent from the first car than from the last one, nor should the escape of air be closed till the same reduction has been made in each car. The discharge should not be stopped suddenly before the pressure in the last cars has equalized with the first ones, or the momentum of air flowing from rear cars, as well as equalizing pressures in all cars, will raise the train pipe pressure in the cars nearest the brake valve and tend to release their brakes. This gradual closing of the train pipe exhaust, the brake valve is intended to do automatically. Its principle of operation is, the engineer makes the proper reduction of pressure *in* the brake valve *over* the equalizing piston *17*, and the action of the piston *17* reduces the train pipe pressure to an equal amount in all the cars, whether few or many.

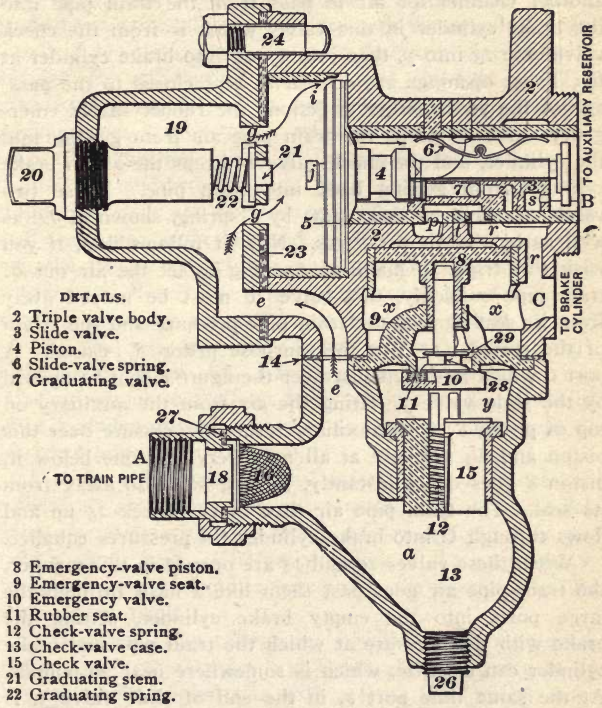
Before you move the rotary far enough to open the preliminary exhaust port *h*, the equalizing port *g*, which allows train pipe air to pass from train pipe to chamber D, over piston *17*, is closed; this cuts off chamber D from any other pressure; you can then make a reduction on top of piston *17*, so train pipe pressure will raise it up and hold discharge *n* open till the pressure below is a little less than it is above, when piston is moved down by the chamber D pressure, closing train pipe discharge

With the equalizing discharge valve, the black hand of the double gage is connected with chamber D at all times; if the rotary is in either full release or running position the equalizing port *g* connects it to the train pipe air, so it shows that pressure also. When the brake is set with a service application, the pressures equalize so nearly on each side of piston at the instant train pipe exhaust closes that the black hand is expected to show train pipe pressure then also. In the emergency position the black hand does not at once show the amount of the reduction. You will find this further explained later.

If the packing ring in piston *17* leaks very much, the black hand will show train pipe pressure when rotary is on lap, as the air pressures can equalize past this leaky packing ring; all of them leak a little. Look out for this defect when operating the brake. The brake valve reservoir is connected with the valve for the purpose of giving a larger volume of air to chamber D in order to insure a gradual reduction of pressure there.

Up to this point we will assume that the student has followed the action of the brake in a service or graduated application. There is what we call the emergency or quick action, which is produced by a different set of operations and is peculiar to the quick action triple valve only. We will go to the beginning and inquire why this action is necessary.

On a long train of air braked cars, to avoid a severe shock to the rear part of train when brakes are applied from the head end of train very suddenly, as by bursting a hose or breaking apart of the train, or in case of danger when it is necessary to set the brake brom the engine very hard so as to stop as quickly as possible, the brakes should set on the rear cars quickly enough so the slack will not run up against head cars and damage cars or draft gear. Then, in case of danger, every second after the brake is applied at the engine before it begins to set on last cars and hold them, the train is getting nearer the danger; so a brake that can be set instantly on the whole train will stop the train quicker than one which sets slowly from car to car. With the plain triples the air in train pipe will be exhausted at one place only, either where an opening is made in train pipe or at brake valve; this takes several seconds to affect the farthest car. If an opening can be made to exhaust this air at each car and reduce the train pipe pressure, the action of the brakes on a long train can be made nearly simultaneous, so nearly so that the brakes are all set before the slack can run out. The quick action



QUICK-ACTION TRIPLE VALVE—RELEASE POSITION.

triple is designed to exhaust a portion of the train pipe air at each triple, so as to set the next brake suddenly. To thoroughly understand how the quick action triple can exhaust some of the air from the train pipe suddenly and reduce the pressure so as to affect the next triple in the same manner, it will be necessary to study the construction of the quick action valve. This triple has the same openings to admit air from the train pipe to the auxiliary that we find in the plain triple. In the quick action triple they are shown at *e* through *g* and feed port *i*. But there is another channel for air to pass from the train pipe into the brake cylinder in this valve, which is from the check valve case *13* into *y*, then into *x* and into brake cylinder at C. These openings are ordinarily kept closed to the passage of the air in either direction; the rubber seated emergency valve *10* keeps the train pipe air from getting into the cylinder, and the check valve *15* keeps the air in brake cylinder from getting back into train pipe. These two valves are held on their seats by a spring, shown at *12*, as well as by the air pressures. Now it follows that, if you wish this triple to make an opening to let the air out of train pipe suddenly, this valve *10* must be moved away from its seat against the train pipe pressure and the strain of the spring *12*. For this purpose piston *8* is used. A port *t*, which is shown just over the figure *8*, can be opened by the slide valve *3*, letting the air from the auxiliary on top of piston *8*; with auxiliary reservoir pressure over this piston and no pressure at all or a very low one below it, piston *8* goes down instantly, forcing valve *10* away from its seat. The train pipe air then moves check *15* up and flows through C into brake cylinder till pressures equalize.

When these valves *10* and *15* are opened in this manner, the train pipe air goes past them like a flash through the large ports into the empty brake cylinder, setting the brake with the pressure at which the train pipe and brake cylinder can equalize, which is somewhere near 20 pounds. At the same time port *s*, in the end of slide valve *3*, is open, air from auxiliary flows through *r* and piles in on top of train pipe air in cylinder, raising the cylinder pressure at full equalization to 60 pounds. The train pipe air equalizes *first* with cylinder, through large ports, and auxiliary pressure *last*, through small ports. Considerable air passes around piston *8* which is not an air tight fit in its bushing.

Now for the means employed to let the auxiliary reservoir pressure on top of piston *8* at one time to produce "quick action" and keep it out at another to preserve the graduated application. As long as this triple is used with a graduated application, the slide valve *3* does not move over far enough to uncover emergency port *t*, as with a gradual reduction of train pipe pressure the auxiliary pressure will be reduced equally with the train pipe pressure through the graduating valve *7* and its port z. The graduating stem *21* and its spring *22* ordinarily stop the movement of the piston *4* when it reaches the service application position. But if the train pipe pressure is reduced so suddenly and to such an amount that the graduating valve can not reduce auxiliary pressure equally with train pipe reduction, and graduating spring does not stop the piston, the greater auxiliary pressure will move piston *4* and slide valve *3* far enough so port *t* will be uncovered, auxiliary air will move piston *8*, valves *10* and *15* will move at once and "quick action" is the result. The Westinghouse Co. have put a quick-action triple valve in service that allows train pipe air to flow into the brake cylinder during a service application. This will be described later on in this book.

A sticky triple valve or any defect in valve *7* that will prevent air getting past it will sometimes cause the quick action operation with a moderate service application if you have a *short* train. The equalization of the pressures is the foundation principle to look for in the operation of the quick action triple.

It is necessary to restrict the flow of air through some of the openings in triples and brake valve in order to be sure to handle a long train with safety. This refers more particularly to the "feed ports" in the triples for recharging auxiliaries, the "preliminary exhaust port" *h*, train pipe exhaust *n* and exhaust ports in triple valves. The proper size of these ports has been determined by the experience of many years.

Perhaps it would be well to study on the matter of equalization of different pressures of air in the equipment, as if this is well understood you can solve other problems in air brake operations more easily. It is the law that where compressed air in a certain sized vessel expands into an empty one, the pressure is reduced in the full one in proportion to the increased volume the air has to occupy. From this you can see that in the case of the brake cylinder and auxiliary the auxiliary pressure will be reduced more if the brake cylinder is large in proportion to the auxiliary than if it is small. Apply this law to the cylinders having different piston travels; a cylinder having a long piston travel holds a greater volume of air than the one with short travel, so we can expect the one with long travel to reduce the auxiliary pressure to a lower point than the short travel, and it is found that a travel of 11 inches of the freight brake piston gives a final equalized pressure of close to 45 pounds, while a short travel of 4 inches gives a final pressure of 57 pounds; a travel of 8 inches, which is between 4 and 11 inches, will give a final equalization of about 50 pounds. The difference of pressures with long and short piston travels is more marked with partial applications than with full equalization. A 5 pound reduction of auxiliary pressure will give about 18 pounds per inch on a piston with 4 inches travel; while with the 11 inch travel piston, the pressure will not show anything. This will give different brake powers on different cars in the train, although it should be equally proportioned to the weights of the cars; unequal brake power makes some cars hold less than others, so the strain is not equally distributed throughout the train, a point in equalization worth studying on.

The final point at which auxiliaries and their cylinders equalize cuts quite a figure in operating the triples to release the brakes. A variation in piston travel of the different brakes changes this point of final equalization and will be explained later. As was stated in explaining the operation of the triple piston, the train pipe pressure must be greater than the auxiliary pressure to move the triple piston up so slide valve will open exhaust port and let air in brake cylinder equalize with the atmosphere; then the brake piston will have no air pressure on either side of it. This relieves the strain on brake levers and shoes.

If auxiliary pressures on this final equalization are unequal and train pipe pressure is not raised at once higher than the highest auxiliary pressure, all the brakes will not release at once. This leads us to consider the question of equalization of the train pipe and main reservoir pressures when you desire to release the brakes.

If the train pipe is long it will take more air from main reservoir to equalize at a certain stated pressure than if it is short, for a long train pipe holds more air than a short one. Then, again, if the train pipe has considerable compressed air left in it after setting the brake, it will equalize at a higher point than if it is empty. This emphasizes the fact that it will be hard work to release the brakes on a long train if you exhaust all the air in making an application.

Another place where equalization is important is on the second application shortly after releasing brakes. It takes time for the train pipe and auxiliary pressures to equalize. If you do not wait this proper time the auxiliary will not have charged to standard pressure, and, of course, when brake is set it will not reach as high a final pressure on brake piston, which reduces the braking power.

Equalization between train pipe and auxiliary on making the reduction for a second application is very important, because if train pipe has a high pressure which the auxiliary has not reached, the triple piston cannot move till the train pipe pressure has been drawn down a trifle lower than the auxiliary. If one is 80 and the other 60, it means a reduction of 20 pounds before brake begins to set, and about 20 more to set all brakes tight. This affects the work of the brake on a short train more than a long one. With a large main reservoir and a short train it is easily done.

This defective handling of the brake is called "overcharging the train pipe," and can be avoided by returning the brake valve to lap from full release as soon as the train pipe has had time to charge up its whole length, which will move all triples to exhaust position and quickly equalize the train pipe and auxiliary pressures. When these pressures are equalized, a very slight reduction in the train pipe pressure sets all the triples to work at once. In stopping a short passenger train for baggage or at a water plug, if the stop is being made too soon, go to a full release for an instant to move *all* the triples to release, then back to service application, making a service reduction of 6 or 8 pounds which will probably set the triples before all the air has passed out of brake cylinders, and in addition to holding the brake set at a low pressure will have all of them ready for a further application at an instant's notice so that you can stop at the exact spot required. Never try this with a long train of any kind at slow speed, as you are liable to break the train in two.

A few hints on getting ready to make a good stop and knowing whether you can depend on the brake to operate properly may be of service here.

When operating the brake valve, you should listen to the sound of the train pipe air discharging from it, because that sound tells how many cars you have in your train with train pipe connected and how the valve is doing its work, just as the exhaust of the locomotive tells whether the valve motion is in order; any unusual sound notifies you that something is wrong.

When you make a test of the train brake before starting out, make the same kind of an application as when stopping at a station, by successive reductions; a 5 to 7 pound reduction for the first one, lighter ones afterwards; then you will know how the brake will work when making station stops. It should be full application to get the full piston travel.

Never make an emergency application when testing brakes unless specially called for, and then not till *after* the first test has been finished.

If the brake leverage on the train is adjusted for 70 pounds train pressure, it is not safe to carry either more or less. If you carry less, you cannot top quickly when you have to; if you carry more and skid the wheels, you will slide by and will spoil a lot of wheels.

Have your air gage properly placed and well lighted, so that it can be seen without taking your eyes too far off the track and signals. Consult it often till you learn the air brake business. If it does not register correctly or sticks when the pressure is changing, call the attention of the proper party to it.

It pays to inspect and test your engine equipment carefully before leaving the engine house; it may save you a failure on the road.

Drain the main reservoir daily; the tender triple should be drained regularly in cold weather. It is a good plan to open the cocks at rear of tender and blow out the train pipes for both brake and signal line before coupling to the train.

Too much oil used in the air end of the pump does more harm than not enough, as it chokes up all the small openings in the engine equipment. The piston rod packing needs more oil than the air piston; the air valves do not need any.

Use good valve oil always.

WHEN OPERATING THE AUTOMATIC BRAKE REMEMBER

That the compressed air stored in the main reservoir is used to charge up the train line and auxiliary reservoirs, and that it is used to release the brake. Do not have any water in any reservoir, as it takes up the room needed for air.

That the compressed air stored in auxiliary reservoir is used to set the brake. There is an independent supply for each brake. Keep a full supply in each auxiliary.

That the brake is set by any reduction of pressure in the train pipe, no matter how it is made, if it is sufficient to move the triple piston and valve.

That the train pipe pressure must be reduced 5 to 7 pounds at first application, or brake pistons will not travel over leakage grooves, allowing brake to leak off.

That the train pipe pressure must be raised above the auxiliary pressure, or the auxiliary pressure reduced by bleeding, before the brake will release.

That you cannot recharge an auxiliary reservoir until the exhaust port in triple is wide open, unless air leaks past triple piston, as the feed port does not open until after the exhaust port is open.

That a second application after release does not set the brake as tight as the first full application, unless the auxiliaries have had time to recharge to standard pressure. This takes from 25 to 45 seconds.

That the small reservoir attached to brake valve is put there to give a larger supply of air for the preliminary exhaust of brake valve so you can make a gradual reduction.

That if your driver brake does not work quickly and hold well with service application, in 99 times out of 100 it is on account of a leak.

That the distributing valve used with the locomotive brake must be kept clean and all pipe joints tight if you expect to get good service from it.

That the position of the straight air brake valve and the independent brake valve has all to do with the application and release by the automatic brake valve of the locomotive brake.

That in all these questions and answers it is understood, unless otherwise stated, that 70 pounds is the standard train pipe and auxiliary pressure; 90 pounds main reservoir pressure; and 8 inches the standard piston travel for all passenger, freight and tender brake pistons. The brake piston travels an inch or more farther when train is running than with a standing test, so travel should be adjusted to less than 8 inches.

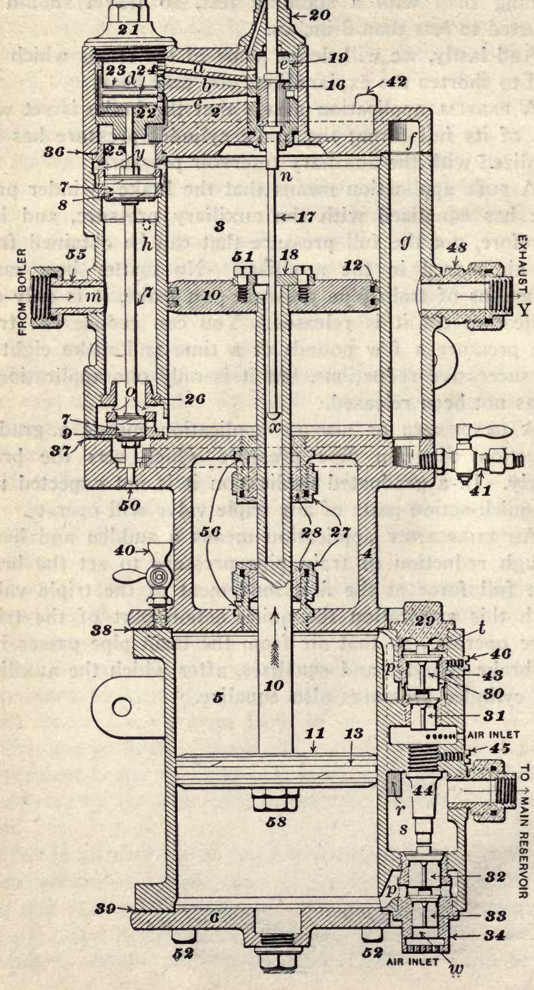
And lastly, we will define some of the terms which are used to shorten the explanations you may hear.

A PARTIAL application means that the brake is set with part of its full force; the brake cylinder pressure has not equalized with the auxiliary reservoir pressure.

A FULL application means that the brake cylinder pressure has equalized with the auxiliary pressure, and has, therefore, got the full pressure that can be obtained from the air stored in the auxiliary. No matter how many reductions of train pipe pressure you make, it is only one application till it is released. You can reduce the train pipe pressure a few pounds at a time and make eight or ten successive reductions, but it is only one application if it has not been released.

A GRADUATED or SERVICE application means a gradual reduction of train pipe pressure which sets the brake slowly. In a graduated application it is not expected that the quick action parts of any triple valve will operate.

An EMERGENCY application means a sudden and heavy enough reduction of train pipe pressure to set the brake with full force at the first movement of the triple valve. With this application the quick action part of the triple valve operates, so that air from the train pipe passes into the brake cylinder and equalizes, after which the auxiliary and cylinder pressures also equalize.



FROM BOILER
EXHAUST
Y
AIR INLET
TO MAIN RESERVOIR
AIR INLET
21
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THE 8-INCH AIR PUMP.

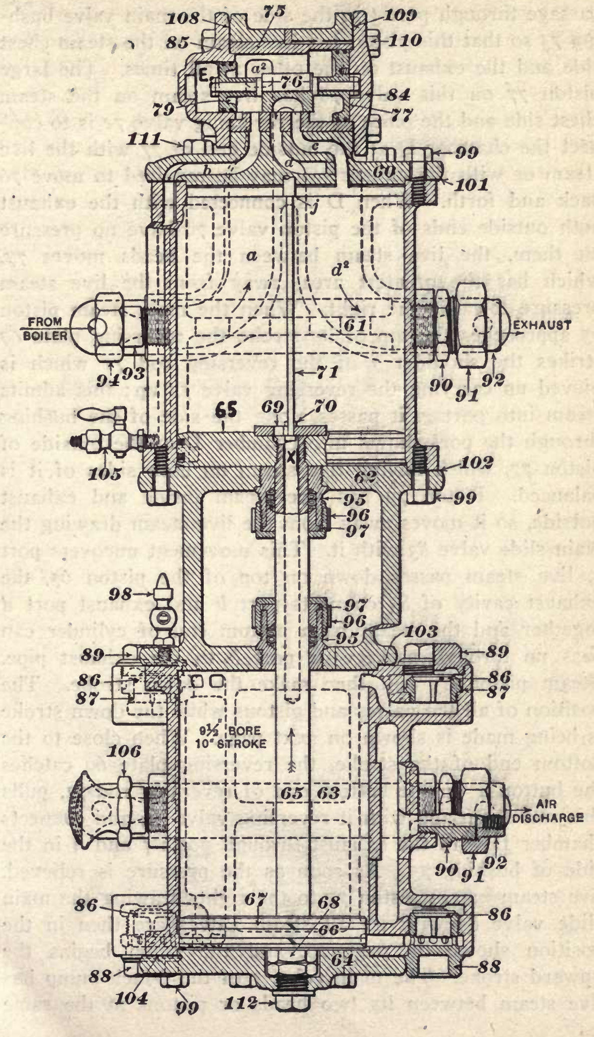
The sectional view of this pump shows the steam and air pistons 10 and 11 and and all the steam valves in their positions when the steam piston is making its stroke upward.

The live steam comes from the boiler through the governor and passage *m* into the chamber between the heads of the main steam valve *7*. It also goes into port *h* and through a passage in the wall of the steam cylinder and in the top head, which is not shown as this port is in the section cut away. This passage from *h* leads live steam constantly into the steam chest *e* of the reversing valve *16*; it can pass through port *a* into the cylinder and over the reversing piston *23*, pushing it down; for the combined area of the piston *23* and the small one *7* is greater than that of the top one *7*. This opens the steam port in the bushing *26*; steam then passes under steam piston *10*.

At the same time the exhaust ports in bushing *25* are open so any steam in the top end of the cylinder escapes at *y* through *f* and *g* to the exhaust pipe. This moves the steam piston up, bringing up the air piston *11*. As the air piston moves up, any air above it escapes through port *p* by raising discharge valve *30* and passes into the main reservoir. At the same time the lower end of the air cylinder is filled with air from the atmosphere; when the piston *11* raises, a partial vacuum is formed under it and the pressure of the outside air forces up inlet valve *33* and air passes into cylinder. On the arrival of the piston at the top of its stroke, both these air valves, *30* and *33*, drop into their seats, remaining there during the return or down stroke. The other set of air valves open on the down stroke, *31* to admit air above the piston *32* to discharge air from the lower end of the air cylinder to the main reservoir.

When the steam piston reaches the top of its stroke, the reversing plate *18* strikes the shoulder *n* of the reversing rod *17*, moving it up; this in turn moves the reversing valve *16* up also. Reversing valve *16* being moved up in chamber *e* covers port *a* so live steam can no longer pass on top of reversing piston *23*; ports *b* and *c* are connected by the cavity in valve *16* so that the steam in cavity *d* over piston *23* exhausts through *c* and balances the pressure on each side of piston *23*. The top piston of main steam valve *7*, which has live steam under it, being larger than the bottom one and piston *23* being balanced, the main steam valve *7* is raised up, also moving up *23*; this movement of *7* opens the upper steam ports and the lower exhaust ports to that live steam pushes the piston *10* down to the bottom of the cylinder. When the piston reaches the bottom of the stroke, the reversing plate *18* catches on the button *x* at the bottom end of reversing rod *17* and moves the reversing valve back to the position shown in the cut; the live steam then moves the piston valves *23* and *7* to the positions shown there, and the pump is ready for the up stroke.

The first sectional view of the 9½-inch pump is shown with the main piston *65* and all the valves in the steam end as they stand when the pump is making the upward stroke. The live steam which comes up through passage *a* at the back of the pump into steam chest A is always on top of the main slide valve *83*. This valve is shown at the right hand end of its stroke, in which position it uncovers port *b* so steam can pass down to the bottom end of steam cylinder under the piston *65* and push it upward. At the same time the exhaust cavity of this slide valve *83* connects the port *c*, which opens into the top end of the steam cylinder, with exhaust port *d*, which passes down around the back of cylinder to the exhaust pipe; the steam above the piston can then pass into the exhaust. This slide valve *83* is moved by the differential piston valve *76*, with the large piston *77* on one end and the small piston *79* on the other. Chamber E is always connected to the exhaust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75
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85
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E
a²
76
84
79
77
111
99
b
c
d
60
101
j
a
d²
FROM BOILER
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EXHAUST
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93
71
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70
105
X
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95
103
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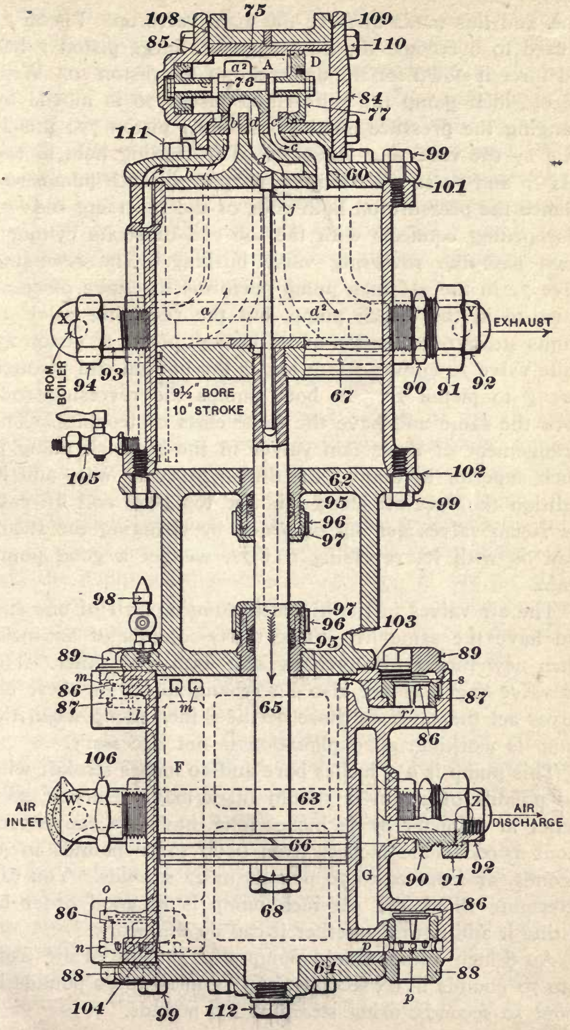
89
86
86
87
87
9½" BORE
10" STROKE
106
65
63
AIR DISCHARGE
90
91
92
86
67
68
86
66
64
88
88
104
99
112

passage through port *t* in the side of the main valve bushing *75* so that this piston has live steam on the steam chest side and the exhaust on the other at all times. The large piston *77* on this valve *76* has live steam on the steam chest side and the office of the reversing valve *72* is to connect the chamber D at the outside end of *77* with the live steam or with the exhaust as may be required to move *76* back and forth. When D is connected with the exhaust both outside ends of the piston valve *76* have no pressure on them, the live steam between the heads moves *77*, which has the greatest area, away from the live steam pressure towards the right. When the main steam piston *65* approaches the top of its stroke the reversing plate *69* strikes the shoulder *j* of the reversing rod *71* which is moved up carrying the reversing valve *72* up; this admits steam into port *g*, it passes along the side of the bushing through the port shown into chamber D at the outside of piston *77*, which having live steam on both sides of it is balanced. Piston *79* has live steam inside and exhaust outside, so it moves away from the live steam drawing the main slide valve *83* with it. This movement uncovers port *c*, live steam passes down on top of the piston *65*, the exhaust cavity of *83* connects port *b* and exhaust port *d* together and the steam from bottom end of cylinder can pass up through passage or port *b* to the exhaust pipe. Steam piston *65* will then make the down stroke. The position of all the valves and pistons while the down stroke is being made is shown on next page. When close to the bottom end of the stroke, the reversing plate *69* catches the button *x* on the bottom end of reversing rod *71*, pulls this rod down and with it reversing valve *72*, and connects chamber D with the exhaust through ports *f* and *h* in the side of bushing *75*. As soon as the pressure is relieved, live steam moves piston *77* to the right, drawing the main slide valve *83* with it; all steam valves are then in the position shown on page 26, and the pump begins the upward stroke. The main valve *7* of the 8-inch pump has live steam between its two heads or pistons at the same


108
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X
Y
EXHAUST
FROM BOILER
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9½" BORE
10" STROKE
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86
87
65
F
106
W
AIR INLET
63
Z
AIR DISCHARGE
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G
68
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112
64

time. and this tends to force the main valve up. Piston *23* is used to overcome the advantage the large piston *7* has and force it down for the up stroke of the piston *10*. With the 9½-inch pump the differential piston 76 is moved by changing the pressure on the outside of piston 77; this is done by the reversing valve *72*. The angling hole in cap nuts *20* and *74* serves the same purpose in both pumps—to balance the pressure on both ends of the reversing rods—; this opening connects with the top end of steam cylinder, down past the reversing valve bushing. The reversing valve *72* in the 9½-inch pump performs the same office as valve *16* in the 8-inch pump, but the reversing valve *16* admits steam over the top of *16* through port *a* to piston *23*, while valve *72* admits steam *under* the bottom end through port *g* to piston *77*. In both pumps the reversing rods work the same and have the same class of troubles. The arrangement of the steam valves in the 9½-inch pump is much superior to that of the 8-inch in every way, and in addition they are all located in the top head *60*. In case the steam valves get out of order, by changing the steam head *60* with its reversing rod *71*, we get a good pump again.

The air valves in the 9½-inch pump are all of one size and have the same lift—three thirty-seconds of an inch; when new they are interchangeable with each other. The air valve cages *88* are also interchangeable. As these air valves act the same as those of the 8-inch pump when the pump is working, an explanation is not necessary.

This pump is 9½ inches bore and 10 inches stroke; with 140 pounds of steam it should fill a main reservoir 26½ inches in diameter by 34 inches long, having a capacity of about 15,000 cubic inches, from 0 up to 70 pounds in 38 seconds, or from 20 to 70 pounds in 27 seconds. You can determine whether a 9½-inch pump is in good order by testing it and noting whether it can do this work.

An 8-inch pump should pump this amount of air from 0 to 70 pounds in 68 seconds, and from 20 to 70 pounds in about 50 seconds, using steam at 140 pounds.

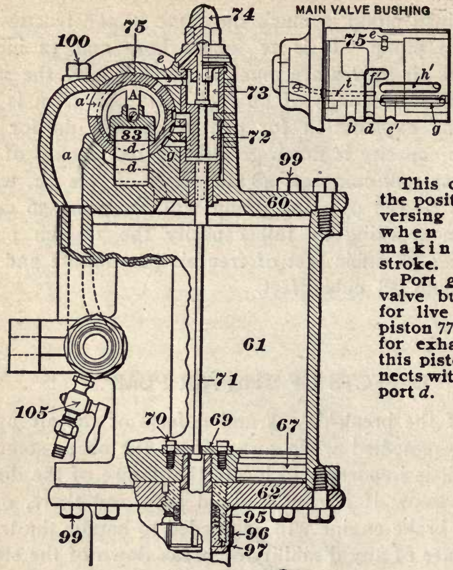
The 11-inch pump is much the same in construction as the 9½-inch pump. It is 11 inches bore and 12 inches stroke. The air valves are much larger but have the same lift, three thirty-seconds of an inch. Its operation is the same, so the explanation for one pump will do for the other. The capacity is much greater, as 100 strokes of the 11-inch pump will compress 48 cubic feet of free air, while 100 strokes of the 9½-inch pump will compress 36 cubic feet. When working at full capacity the 11-inch pump will compress 58 cubic feet of free air per minute and the 9½-inch pump 38 cubic feet.

DEFECTS OF THE AIR PUMP.

Many of the break-downs and defects of the air pump can not be remedied when away from the shop, some of them can; it is important to locate the nature of the defect at once to know if it can be fixed then and there, or if another air brake engine will be needed to handle the train.

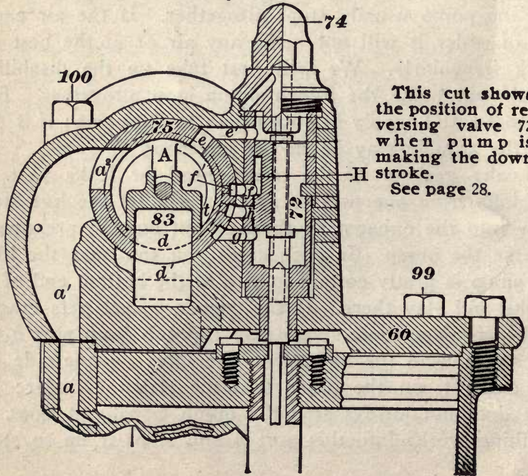
In the case of any disability or break down of the steam end the pump usually stops altogether. If the air end is out of order it will not make any air or at the best will work irregularly. We will first take up the disabilities which will make the 8-inch pump stop altogether. First see that a full supply of steam goes to the pump; if it does not the trouble may be in the governor.

Leaky gaskets in the steam head or leaks past the bushings from one port to another will let the live steam blow into the exhaust so there is not enough pressure to reverse the pump. In such cases you can hear the blow, the pump is pretty certain to stop at the bottom end of the stroke and stay there. If the copper gasket gets cracked at the opening where steam goes through from port *h* into the steam head the live steam can blow on one side into the exhaust, on the other into the steam cylinder; this leak does not always stop the pump, usually it does. If anything works into this port *h* and stops it up so steam



This cut shows the position of reversing valve 72 when pump is making the up stroke.

Port *g* in main valve bushing is for live steam to piston 77; *h* is port for exhaust from this piston; *f* connects with exhaust port *d*.



This cut shows the position of reversing valve 72 when pump is making the down stroke.

See page 28.

can not pass through in sufficient volume to hold proper pressure for the reversing piston it will stop.

Leaks past the bushings are not unusual; when once they start, the steam soon finds a way to get to the exhaust without doing its work.

When the packing rings and valves in the steam end become worn the oil will blow into the exhaust before it has oiled all the moving parts. This will leave reversing piston 23 so dry that it will not move and reverse the position of main steam valve 7. This is a case where increasing the feed of oil and jarring the steam head with a block of wood will usually start the pump.

A piston rod broken where it joins piston 23 will act much the same way; this rod has been known to get stuck in the bottom hole in the bushing and hold the piston down. The small hole starting in the side of this bushing running down and to the side of this piston rod is to oil this rod; if it gets stopped up it should be opened. Sometimes the top of reversing piston *23* will wear to a steam tight fit against the cap nut 21; this keeps the steam off the top of piston 23, it can not then push it and main steam valve 7 down. An examination of these surfaces, and if necessary nicking the smooth surfaces so the steam can get in, will remedy this.

When the reversing plate 18 gets loose, or the button *x* on the reversing valve rod 17 breaks off, the pump will reverse at the top end of its stroke but not at the bottom and will stop at the bottom end of its stroke. If the steam is now shut off and the reversing valve allowed to settle down by gravity when the steam is turned on, the pump will make another double stroke and stop again. Taking off the cap nut 20 and raising up the reversing rod will show whether this is the trouble. In this case a spare rod 17 comes handy. If the plate 18 is loose the steam head will have to come off to get at the plate. If one of the nuts 58 holding the air piston on the piston rod works off, or a piece of it breaks off—these nuts split sometimes—and gets under the air piston so that it can not come clear down to move the reversing rod and valve properly, that will stop the pump. Take out the plug 59 in the bottom head of the air cylinder or the entire head, and this trouble can be located. If the nuts work off either end of main steam valve 7 the pump is liable to stop at once. If the stop pin 50 below the small piston 7 breaks off so the small piston gets below the bushing 26 and sticks, the pump will stop until this valve can be moved up.

Stoppage of the pump may be caused by an obstruction working into some of the small steam ports, closing them up, especially port *h*. Taking off the cap nut 21 after steam has been shut off and all the valves settled down will locate this difficulty, as when all the passages are free the steam will come out through port *a* over the reversing piston 23. This same test will show whether governor is open for steam but is not as reliable as breaking the joint between the governor and pump. We will speak of the governor later on.

As the reversing rods, plates and valves are of the same pattern in the 11-inch, 8-inch and 9½-inch pumps, the failures of any of these parts affect all these pumps alike. With this exception the steam end of the 9½-inch pump gives very little trouble if the joints and gaskets are in good order.

Nearly all the blows of steam when the pump is at work take place when the steam piston is making the upward stroke. At that time the steam can blow past the steam piston packing rings for when on the down stroke the condensed water laying on top of this piston will prevent much steam getting by the rings; on the up stroke there is nothing of the kind to hold the steam back. On the up stroke live steam is on top of reversing piston 23 so it can blow into the exhaust, on the down stroke it is exhaust on both sides. With the differential piston 76 of the 9½-inch exhaust steam is on both ends on up stroke.

A blow past these main valves of either pump is so nearly like a blow past the steam piston that an examination is necessary to determine its location. A bad blow coming all at once is a good indication of a broken packing ring or a leak started through one of the copper gaskets.

If the top end of the reversing rod is not a steam tight fit in its cap nut 20 in the 8-inch or 74 in the 9½ and 11-inch pump, steam will blow past there steadily on the up stroke; passing through the small hole drilled obliquely through the cap nut, then down past the reversing valve bushing and into the upper end of steam cylinder which on the up stroke is connected to the exhaust. It can not blow on the down stroke, as at that time live steam is in the top end of cylinder. Very few of these reversing rods are steam tight in the cap nuts. This opening between the steam space above the piston and top of cap nut is necessary to balance the pressures on the reversing rod so it will not move while the pump is making its stroke.

If the reversing rod gets bent so it catches on the reversing plate or the button catches on the side of the hole in the piston rod, the pump will reverse before it completes its stroke. A pump that reverses too soon in its stroke will pump very little air into the main reservoir.

A difficulty in the air end of the pump will usually give notice at once by a quick stroke one way and a slow stroke the other, which may be caused by several defects. If air from main reservoir leaks past a discharge valve it will fill that end of the cylinder with high pressure air so the air piston will move away from it quickly and towards it slowly. In such a case the inlet valve cannot lift—no air will be drawn in at that end. If the inlet valve leaks an examination will disclose it with the 8-inch pump. With the 9½ and 11-inch pumps it is not so easy, as the air passing out of one inlet valve will pass to the other and give it the signs of a poor suction there. Improper lift of valves will make a pump move faster one way than the other. If the lift of an inlet valve is too small, that end of the cylinder may not fill with air so the piston will not meet with so much resistance in compressing the air. If the lift of a delivery valve is too small the piston will move very slowly at the last part of the stroke; it has to wait for the compressed air to pass through the small discharge opening.

It will show more difference in relative speed when the air pressure is low.

The lift of the receiving valves 31 and 33 of the 8-inch pump should be one-eighth of an inch, of the discharge valves 30 and 32 three thirty-seconds of an inch. This lift is very soon changed by the wear of the valves and the seats; too much lift of discharge valves will make the pump pound, as well as wasting main reservoir air by allowing some of it to flow back into the cylinder before the valves can seat. To test for a leak in the bottom discharge valve, pump up full pressure, stop the pump, take out the plug in the bottom head—air will blow out there steadily from a leak. To test for a leak in top discharge valve leave this bottom plug out and open the oil cup on top end of cylinder; see if air blows out there steady; if so, it comes from top valve. You should have both ends open as the air might leak past piston packing and appear to come from the wrong end.

Leaky packing rings, leaky valves, choked air passages, all tend to make the pump run hot. Running the pump at too high a speed is generally the trouble in the first instance. When once it has been very hot the packing rings contract and do not fill the cylinder; the valve bushings leak and the oil burns on the inside of passages and make a bad matter worse.

The Westinghouse Company are now making a cross-compound air pump in which the high pressure steam piston operates the low pressure air piston; the steam when exhausted from this cylinder then passes across to the other end of the low pressure steam cylinder and operates the low pressure steam piston and the high pressure air piston. A diagrammatic view of this pump is shown; as by this means the steam and air passages can be more clearly traced. The reversing rod 21 and valve 22 are operated by the reversing plate 18 at the end of the stroke of the high pressure steam piston 7 in the same maner as the 9½-inch pump. The differential pistons 26 and 28 and valve 72 performs the same functions as the pistons and valve in the 9½-inch pump, except that there are additional ports in valve 72 so as to distribute the steam to two cylinders. Live steam comes in over the main valve through port *a*, passes through opening *k* and port *g* under piston 7 forcing it up. If the pump has made a complete stroke of both pistons the exhaust steam from above piston 7 passes out through port *c* and the passage *h* in the valve down into the top end of the low pressure cylinder at *d*, forcing that piston down. Exhaust steam from the lower side of piston 8 is passing out through port *f* and exhaust cavity *i* to the final exhaust *e* and then to the atmosphere. Port *n* is the live steam port from the reversing valve seat to the end of piston 26 and serves the same purpose as port *g* in the 9½-inch pump. Port *m* is the exhaust port from the chamber at the outside of piston 26 and corresponds to port *h* in the 9½-inch pump. *l* is the exhaust port from the reversing valve seat and corresponds to ports *f* and *t* in the 9½ pump. By following the arrows shown in the passages a good idea of the flow of the steam can be learned. With this pump there is but one set of valves and reversing gear in the steam end and that connected to the high pressure piston. The movements of the pistons are at the same time, but in opposite directions. The high pressure steam piston 7 moves up, its exhaust steam moves the low pressure steam piston 8 down and vice versa. Air compressed above the low pressure air piston 9 flows past intermediate discharge valve 39 and port *u* in over piston 10. Free air enters through the lower air inlet and port *r* past inlet valve 38 and then into the lower end of the cylinder as piston 9 moves up. High pressure air piston 10 on its down stroke compresses the air below it out at port *v'* past lower discharge valve 42 and through passage *w* to the main reservoir. During the stroke of the pistons the intermediate pressure, being that between the low and high pressure air pistons, reaches about 40 pounds. On the opposite strokes of these pistons free air comes in at inlet valve 37, the intermediate pressure air goes out at valve 40 and high pressure air past discharge valve 41. The high pressure steam piston 7 has a diameter of 8½ inches, the low pressure steam piston 8 is 14½ inches.

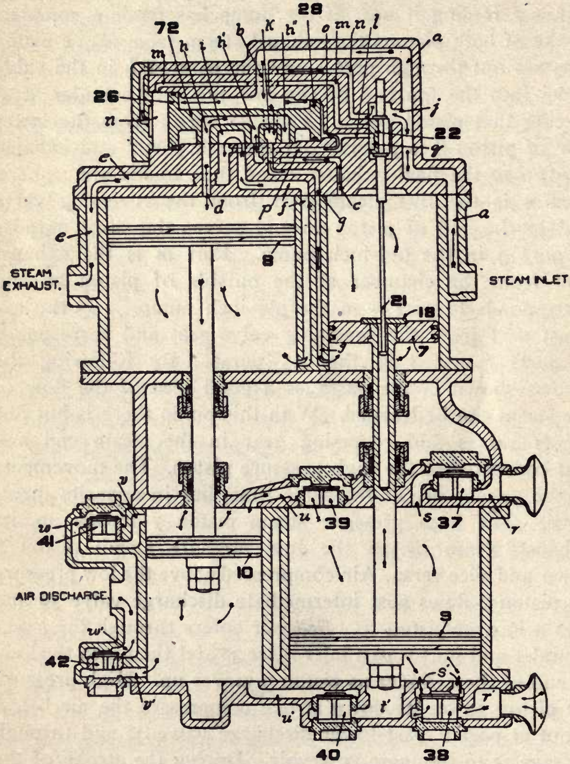


DIAGRAM OF THE CROSS COMPOUND PUMP
UP-STROKE, HIGH-PRESSURE-STEAM SIDE

All pistons have a stroke of 12 inches. The low pressure air piston is 14½ inches and the high pressure air piston is 9 inches in diameter. The capacity of this pump is 131 cubic feet of free air per minute, as against 58 for the 11-inch pump working under the same conditions.

Cross-compound pumps are now being built of a smaller size than given above, to correspond in capacity to the 9½ and 11-inch pumps.

THE PUMP GOVERNOR.

The duty of the pump governor is to shut off the steam from the air pump when the air pressure has reached the standard desired. Where only one pressure is to be controlled, the single governor is used; if more than one pressure, the duplex governor is used. The steam valve and its air piston are the same with both the duplex and single governors, but one or two air tops are used, according to the number of air pressures controlled.

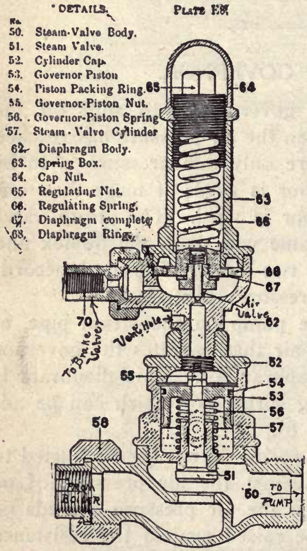
It is located close to the pump on the steam pipe, at the union connection 70 the air that operates the governor enters, and is under the diaphram 67. This diaphram is held down by the regulating spring 66, which can be adjusted by the regulating nut 65.

We will suppose that the spring 66 has been adjusted to hold the diaphram down against the air pressure of 90 pounds and no more. When the air pressure exceeds 90 pounds the diaphram will be raised against the resistance of the spring; this will raise the air valve, air will flow in on top of the air piston 53 and force it down, moving steam valve down to its seat and closing the steam supply to the pump, which will stop it.

As soon as the air pressure falls so the regulating spring 66 can move the diaphram down and close the air valve the air pressure above the piston drops, and the steam valve is opened allowing the pump to take steam again. With the duplex governor the regulating spring of one air top can be adjusted for one pressure and the other spring for another pressure. Thus the pressure carried depends on which side of the governor is in operation.

There are several causes which will prevent the governor from shutting off the steam from the pump when the maximum air pressure is obtained. If the regulating spring is screwed down too tight it will not allow the diaphram to raise and lift the air valve off its seat. If too much oil is used in air end of pump the air valve gets gummed up where it rests on its seat so air can not get through after air valve raises. This is the most common cause of the pressure getting higher than the governor is set for. To cure this trouble take out diaphram and clean off air valve and its seat so air can get through freely when air valve raises. If the air leaks past piston as fast as it comes through air valve, the piston will not be moved down as there will be no pressure above piston. Putting in a tight packing ring cures this unless the cylinder is worn out of true.

PUMP GOVERNOR



If the governor piston sticks so air pressure will not force it down, steam will not be shut off. If the waste pipe in the side of steam end of governor is stopped up so steam or air is confined below piston, the governor will not shut off at any pressure. This waste pipe may be smashed out flat so nothing can pass through it, in cold weather it will freeze solid full at the bottom end which will keep the air piston held up. If anything gets in over diaphram so it cannot raise, that will hold air valve shut so air cannot get on piston to shut off steam valve. If valves and seats are kept clean, and all parts allowed to move as they should, governor will work accurately. In case the governor shuts off the steam with less than the standard pressure you are likely to find there is dirt or a scale holding the air valve off its seat so air can get through on top of piston steadily, in which case the governor will shut off steam as soon as air pressure on the top of governor piston will more than balance steam pressure on steam valve. If this air valve seat is injured so it leaks, or a new valve has been put in that is too short to make a good joint, a very low air pressure, less than forty pounds, will shut off the steam. A broken regulating spring will also do this.

Sometimes the pump will not start up soon after the air pressure in the governor has been reduced below that the governor diaphram is set at. This is because when the air valve closes, the air is shut up in cylinder over governor piston and must leak out before piston can raise and open steam valve. The old type of governor D-9 had this trouble, but the new style of governor E-8 has a small blow hole drilled in the side of 62, below air valve seat, which lets enough air escape after standard pressure is reached to keep pump running steadily. Another way is to cut a small crease through the threads, so the air over piston will leak out in about two seconds and let pump go to work. If this crease gets stopped up with gum it should be cleaned out; after which the governor should let the pump go to work promptly.

To find if the trouble is in the governor when the pump will not start, open both drip cocks in the 9½-inch or 11-inch pumps, or break the joint between the governor and 8-inch pump; if live steam comes out freely the governor is not at fault. In such a case shut off steam at the boiler, wait a few seconds till steam is out of pump and turn it on again, if the live team blows out freely, the trouble is in the pump.

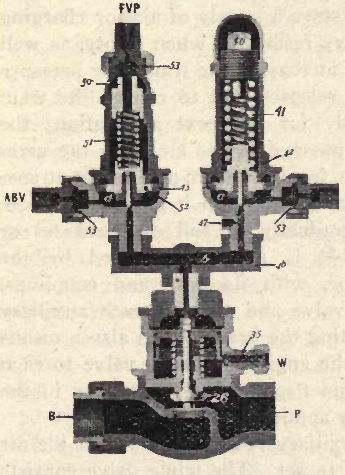
PIPING THE GOVERNOR.

With the single top governor and a brake valve using a feed valve to regulate the train pipe pressure, main reservoir air is used to operate the governor, with some types of brake valves like the old D-8, train pipe pressure operates the governor. With the duplex governor one side is usually piped to the main reservoir direct, the other side, in some cases, uses train pipe air. With the high speed brake, one side is set for 90 pounds, the main reservoir pressure used with the ordinary train pipe pressure of 70 pounds; the other side for the higher pressure needed to release brakes, using 110 pounds. In such cases there is a stop cock in the 90 pound side air pipe, which is to be closed to cut out that side when the higher pressure is used.

There is also a method of piping which allows of two main reservoir pressures being used, one on release and running position of the F-6 brake valve and a higher one with the valve on lap and application positions. The 90 pound side is piped to the port *f* in the 1892 model brake valve at a point just above the figure 62—see the cut of this valve farther on. When the rotary is in full release or running position, main reservoir air can come freely into this port and operate the governor at a pressure of 90 pounds. During a brake application this port *f* is closed by the rotary and the air pressure there soon equalizes with the train pipe.

The 90 pound side of the governor does not then control the pump and the high pressure side which is connected directly to the main reservoir and adjusted for a pressure higher than 90 pounds, usually 110 pounds, allows the pump to run and raise the main reservoir pressure so as to have a good stiff excess to release brakes.

There is also a method of piping the duplex governor to control the amount of excess pressure regardless of what the train pipe pressure may be. One side is piped to the main reservoir direct at MR, and set 120 or 130 pounds, according to what the maximum main reservoir pressure is to be. The other side has a light spring 51 over the diaphram that has the proper tension to hold the diaphram 52 down for the excess desired. At A B V main reservoir air from the brake valve comes in under the diaphram at *d*. At FVP train pipe air at the reduced pressure comes in above the diaphram, and its pressure is added to that of the spring 51, so that we have 70 pounds train pipe plus that of the spring—say 20 pounds—so that when the main reservoir air in *d* can overbalance the pressure of 70+20 above the diaphram, the diaphram will raise the pin valve and admit air over the governor piston and close the steam valve 26. This will operate the same at any other train pipe pressure; so there will be the same excess, depending on the adjustment of the spring 51. Air passes in at ABV only in release, running and holding positions of the H-5 brake valve. When the brake valve is moved to lap or beyond the air is cut off from under the diaphram at *d* and the pressure at *a* and spring 41 control the pump.



PUMP GOVERNOR

AIR BRAKE CATECHISM.

1. Q. what are the essential parts of the automatic brake and what service does each part perform?

A. The air pump, the main reservoir, the engineer's brake valve, the train pipe with its hose and couplings, the auxiliary reservoir, the triple valve, the brake cylinder, the gage and the pump governor. The air pump compresses the air for setting and releasing the brake; the main reservoir is used to store a supply of air for charging the train pipe and auxiliary reservoirs when empty, as well as to hold the supply for increasing the train pipe pressure when the brake is to be released and to charge the train pipe and auxiliaries ready for the next application; the brake valve governs the passage of the air from the main reservoir to the train pipe, from the train pipe to the atmosphere, or stops the flow of air through it in any direction. The brake can be set gradually or full on, held set or released, when this valve is properly handled by the engineer. The train pipe, with its hose and couplings, extends from the brake valve and supplies each auxiliary reservoir with air for setting the brake. It is also a means of communication from the engineer's brake valve to each triple valve, and from one triple valve to another in the quick action or emergency application.

Each brake has an auxiliary reservoir in which the air is stored for operating it to set. The triple valve consists of three separate valves and is connected to the train pipe, auxiliary and brake cylinder; it is used to control the charging of the auxiliary with air and regulate the time in which this is done, to open a valve to admit air from auxiliary to brake cylinder to set the brake, or by another movement to close this valve and open the exhaust port so air can get out of brake cylinder to the atmosphere and release the brake. Thus the functions of the triple valve are three-fold, to charge the auxiliary, set the brake and release it. The triple valve is operated by a variation of pressures between the train pipe and auxiliary; this variation is controlled by the brake valve. The brake cylinder, with its piston connected to the brake levers, beams and shoes, sets the brake when the triple valve lets air into it. The gage shows with the red hand the main reservoir pressure, with the black hand the pressure in the brake valve above the equalizing piston and in the brake valve reservoir; when brake valve is in full release or running position it also shows the train pipe pressure. The pump governor is located in the steam pipe to the pump; it is operated by the air pressure and shuts off steam from the pump when the air pressure reaches the standard amount carried.

In addition to these essential parts there is the pressure retaining valve that is attached to the exhaust outlet of the triple valve and controls the flow of air away from the brake cylinder when the triple valve is in release position; the conductor's valve that when opened reduces the train pipe pressure and applies the brake, the release valve or bleeder connected to the auxiliary reservoir used to reduce the auxiliary pressure and release a single brake. A separate valve and its reservoir called the distributing valve is used on locomotives and performs the duties of the triple valve by applying and releasing the locomotive brake. A high speed reducing valve is used on coaches.

2. Q. What are the duties of an engineer as to his air brake equipment when leaving the roundhouse?

A. To start his pump slowly and increase its speed after 15 or 20 pounds of air have picked up; to be sure that pump is in good order and will pump a full supply of air promptly; to know that governor shuts off the pump when the proper pressure is reached and allows it to start promptly; to see that lubricator has oil enough in it for the trip; to know that there is no water in the main reservoir, drain cup, triple valves or auxiliary reservoirs; to test all the joints in piping, also brake valve and triple valves for leaks, and have leaks made tight; to see that tender and driver brake pistons have the proper travel and do not leak off when set; to test the air signal if one is used.

3. Q. Why must the pump be started slowly, oil used cautiously, triple valves, reservoirs and tender strainers be drained, and how often?

A. The pump must be started slowly to allow the condensed water to get out of steam end, and run slowly till the air pressure rises, or the piston will strike the heads of air cylinder. The triple valves, reservoirs and strainers, or drain cups, should be drained every day in cold weather, once a week in warm weather. Oil should be used sparingly in air end of pump. It should never be put in through the air inlets of the pump, as it soon collects dirt and chokes up the air passages, which helps to make the pump run hot.

4. Q. How do you test for leaks in the engine equipment?

A. When full pressure is obtained—70 in train line, 90 in main reservoir—shut off pump, place valve on lap; if red hand drops and black hand is stationary, it is a sign of a leak somewhere in main reservoir line, which begins at valves in pump and ends at brake valve. It may be in joints of piping, in main reservoir drip plug, in the air signal line, in valves of pump or brake valve. If there is an air sander or air bell ringer on the engine their valves are liable to leak. If main reservoir pressure falls rapidly when you are sure it is not going into train pipe under rotary, examine each of the places mentioned. With the use of the cut-out cock under brake valve a leak under rotary is soon detected. Set the brake full on, place the valve on lap, shut the cut out cock; if rotary leaks into train pipe the black hand will soon show same pressure red one does; if rotary is tight and air leaks out of train pipe the black hand will drop. With a leak in train pipe of engine or tender and cut out cock shut, the brake will set; with valve on lap and cut out cock open the black hand will fall slowly. For a leak in signal line shut the cut out cock next the reducing valve; a leak here will make the whistle blow. Using a torch or putting soapsuds on a suspected leak will generally locate air blowing out there.

5. Q. Why must there be no leaks in your train pipes or any other part of your air brake supply?

A. If train pipe leaks, brake will continue to set tighter when brake valve is put on lap, and stop the train before you want it to, so that it is necessary to let it off and make another application for an ordinary stop. If cars are cut off from engine, they must be bled at once if their train pipe or angle cocks leak. Train pipes sometimes get worn through where they rest on or rub against something, so they are tight when standing still and leak when moving or shaken around. This leak sets the brake when train is in motion, and no leak can be heard when standing still. Jar the pipes a little when inspecting the engine to locate this leak. Sometimes the brake levers strike the end of plug in stop cock and push it in so it will leak when brake is applied.

6. Q. Why must all hose couplings be hung up properly when not in use? Why should they always be blown out at rear of tender before uniting to other couplings? What is the difference between an air brake and an air signal coupling?

A. So no dirt or foreign matter will get into the open coupling and work into the triple or brake valve or stop up strainers. So couplings and gaskets will not get injured or broken dragging over rails and crossings. If blown out each time, any water, sand or dirt in the tender piping will be blown out. Air brake and air signal couplings are of different sizes—made so purposely—so the brake line cannot be coupled to the signal line. The opening and lip of the lock in brake coupling is much wider than the signal coupling, so the brake coupling will not go into it. It is the practice to paint the signal couplings red so they are more easily distinguished when taking hold of them to couple up.

7. Q. If main reservoir has water in it, how will it affect the operation of the brake?

A. The water in main reservoir reduces the supply of air stored there in proportion to the amount of water contained. The brake will set the same, but on a long train will not release as readily, as there will not be enough air stored to recharge the train line quickly and you must wait to have it pumped. The main reservoir should be entirely clear of water, even if it is necessary to drain it each trip, so as to get a prompt release and recharging of train.

8. Q. How does this water get into the main reservoir?

A. The air from the atmosphere before compression contains more or less moisture in the shape of vapor. After compression the air can not hold all this vapor as it is compressed to a very much smaller volume, so nearly all the vapor falls to the bottom of the main reservoir as solid water as soon as the air cools off to the normal temperature of the outside air. If the pump runs hot so the air does not cool off in the main reservoir some of the water will be found in the triple valves and drain cups.

9. Q. Of what use is the extra main reservoir pressure, and does the size of the reservoir have anything to do with the amount of excess pressure you carry?

A. It recharges the train pipe and forces the triple pistons up into exhaust position quicker and surer, so that all brakes release about the same instant; recharges the auxiliary to full pressure in less time, ready for the next application. With a large main reservoir there is a greater volume of compressed air stored to draw from, so a less number of pounds of excess pressure will do the work than with a small reservoir. With a short train good work can be done with less excess than on a long train. Excess pressure, as well a a large volume of stored air, is needed on a long train, so the air will travel from the engine to the rear car more quickly and release the rear brakes at nearly the same instant the front ones release; this will avoid many break-in-twos. Excess is needed to release brakes and large volume to hold up the pressure in train pipe for recharging. The main reservoir should always be drained of water so it will be full sized.

10. Q. Could it release the brakes with an empty train pipe as readily as when the pressure in the train pipe had been reduced only 20 or 25 pounds? Why?

A. No. When the air from the main reservoir expands into an empty train pipe, it will not fill it up and equalize at as high a pressure as when the train pipe has some compressed air left in it. For instance, the train pipe line of 25 freight cars holds 16,000 cubic inches, about as many cubic inches of air as an ordinary main reservoir. If this train pipe is entirely empty and the main reservoir has 90 pounds, it will equalize into twice the space, and show half the pressure, or 45 pounds in each. The brake would be set at 50 pounds; with that pressure above triple piston, brakes could not release until the pump had raised the pressure over five pounds. Now, if the train line has been reduced 25 pounds, having 45 pounds still left in it, 90 in main reservoir and 45 in train pipe, would equalize at a little over 65, which would raise triple pistons so brakes would release promptly.

11. Q. Would you run your pump as fast to recharge an empty train pipe as one with 45 or 50 pounds in it? Is there any economy in retaining as much air as possible and keeping the pump cool?

A. The pump would have to run faster to recharge an empty train pipe than one with 45 or 50 pounds in it. When you empty the train pipe of 25 cars it wastes as much air as when you empty a small main reservoir; smaller trains in proportion. This would make some pumps hot to supply. Always save your air and keep the pump cool, no matter what length of train you handle.

12. Q. Please explain what excess pressure is.

A. Excess pressure is the difference between the main reservoir and train pipe pressures when the brake valve is in running position so that the excess valve or the feed valve can maintain a difference between the two pressures. In full release position these valves are cut out, but the air can pass through an open port from the main reservoir to the train pipe and equalize, so in release position there is no excess. If you carry excess you aim to prevent this equalization and thus have a greater amount of air in main reservoir to equalize into train pipe when necessary to release brakes. Of course it takes more excess to promptly release all the brakes on a long train than a short one. When releasing brake, it supplies the train pipe with a higher pressure than brake was first set at; this makes the movement of all triples to release position much quicker and surer. With a long train it is absolutely necessary for this purpose. On a long train excess is needed to force the air back through train pipe quickly and release brakes, with large volume to hold the pressure up. It recharges the auxiliaries quicker, ready for the next application of the brake. It charges empty cars quicker that are taken on the train. When brakes "creep on," they can be released at once by placing the brake valve on full release for a second or two, just long enough to raise the triple to exhaust position and not long enough to charge the reservoirs to a higher pressure, then returning it to running position.

13. Q. Have we more than one pattern of equalizing discharge brake valve?

A. Yes, we have three kinds of them in service, called E-6, or F-6, D-8 and H-5, from the number of the plate on which each is illustrated in the Westinghouse catalogue. The E-6 and F-6 valves are exactly alike and are now known as the "1892 model" or F-6 valve. Very few of the D-8 valves are now in service. The H-5 brake valve came next after the F-6 or 1892 model, and may be styled the 1906 model.

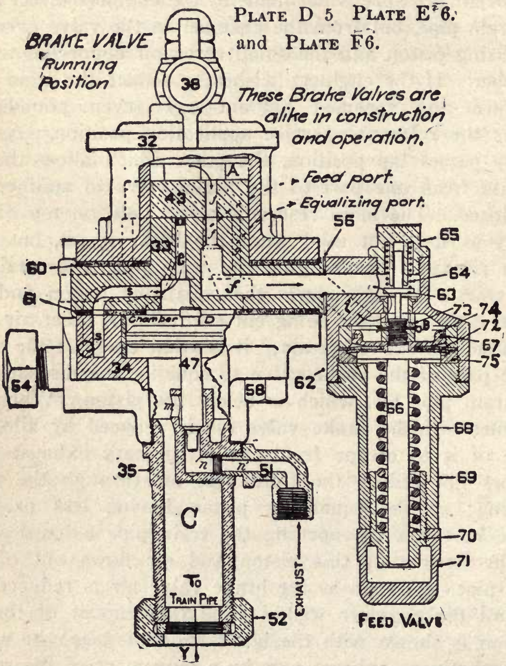
14. Q. Describe the principle on which it operates and what difference there is between the three patterns.

A. This brake valve has a rotary valve with various ports and cavities in it by which the air can pass to and from the various pipes and connections when the engineer moves the rotary. It also has a piston in it called the equalizing piston, with a train pipe exhaust valve on the bottom side of it which is designed to automatically reduce the train pipe pressure. When brake valve is not being operated this piston has an equal pressure on both sides of it, so it remains stationary, holding train pipe exhaust valve closed. When it is used to set the brake, the reduction of air pressure is not made by the engineer direct from the train pipe, but from the chamber in the valve over the equalizing piston and the small reservoir connected to the chamber. If the engineer wishes to reduce the train pipe pressure any specified amount—say seven pounds—he moves the rotary to service application position. As the rotary passes lap position, the ports which allow the air to pass from one part of the brake valve to another are all closed. The main reservoir air is held on top of the rotary as it is not used when the brake is set, but only when releasing or charging the train pipe and auxiliary reservoirs. The air above the equalizing piston and the brake valve reservoir being cut off from all other air may be called "brake valve air;" it is what operates the automatic part of the brake valve to equalize the discharge of the train pipe air, which is below the piston. When the pressure of the brake valve air is reduced by allowing some of it to escape from the preliminary exhaust port, it does not reduce the train pipe air through the same opening; so the equalizing piston having less pressure above it, raises up, opening the train pipe exhaust valve on the bottom of this piston and air flows out of the train pipe. As soon as the brake valve air is reduced the amount the engineer wishes (and the amount of the reduction is shown with the black hand of gage) he closes the preliminary exhaust port by a movement of the rotary to lap. The pressure of the brake valve air then remains stationary; while the train pipe air flows out through the train pipe exhaust till it is reduced a little lower than the brake valve air, which then moves the piston down gradually and closes the train pipe exhaust. It takes longer to reduce pressure in a long train pipe than in a short one through the small train pipe exhaust port because of the greater volume of air in the long pipe, so the train

EQUALIZING DISCHARGE VALVE

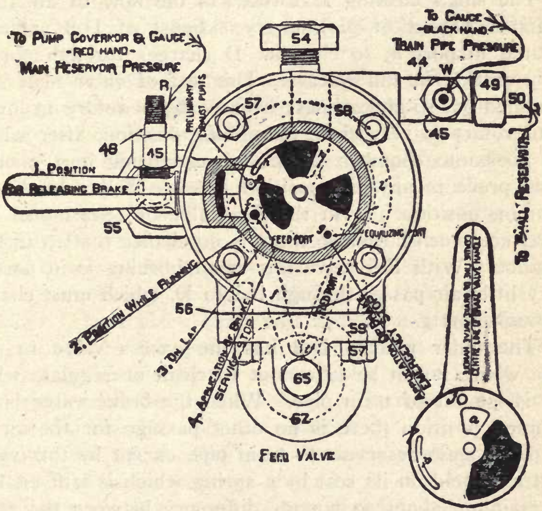
WITH FEED VALVE ATTACHMENT.

1892 MODEL.



pipe exhaust is held open by the train pipe air till the pressure is reduced the whole length, then closed automatically by the pressure of the brake valve air.

Each of these valves uses a double hand gage and has a small reservoir about 12 inches long connected to it by a small pipe; this equalizing reservoir is used to supply the cavity over equalizing piston with a larger volume of air, so a more gradual reduction of pressure can be made through the preliminary exhaust port from this cavity. The later size of this reservoir is 14½ inches long; it con-



tains a larger volume of air than those first used and thus makes the reduction of brake valve air more gradual.

In illustration on page 52 the main reservoir air is above the rotary 43 in A and feed port *f*. The train pipe air is in B over the feed valve piston 74 and in C under the equalizing piston 47. The brake valve air is in chamber D over piston 47 and in the equalizing reservoir connected to brake valve at port S. The brake valve air is connected with train pipe air through equalizing port *g*, which is drilled through the seat under rotary shown by dotted lines and more plainly on another page.

Either of these valves when placed on emergency position opens a large port which lets the air from the train pipe direct to the atmosphere, making a sudden reduction, which causes the brake to go on suddenly and with full force.

The small bushing that restricts the flow of air from chamber D out of preliminary exhaust of D-8 valve is located in port *h*, so chamber D charges through port *e* very quickly in full release. The seat of valve near *e* is is milled out so air can pass from port *j* in rotary 13 into *e* until rotary is very close to running position, after which air goes into chamber D through equalizing port *g* only. This prevents any lap position between full release and running position. With the F-6 valve or 1892 model the ports are much larger so there is no chance for lap in this position. With F-6 valve this small bushing is in port *e*, very little air passes through it into D, which must charge through port *g*.

The older pattern D-8 has the excess valve in one side where it can be taken out to clean or regulate when air is let out of train pipe. When the brake valve is on running position there is no other passage for the air to go from main reservoir to train pipe except by this valve and it is held on its seat by a spring which is stiff enough to maintain about 20 pounds difference between the pressure in train pipe and main reservoir and hold the excess in main reservoir. The pump governor is piped to train pipe and set at 70 pounds.

The F-6 has a reducing or feed valve attached in the place of the excess valve, which is set to regulate the train line pressure at not over seventy pounds, at which pressure it closes and no more air can pass to train pipe from main reservoir till the train pipe pressure falls below what the feed valve is set at, when it opens again; with this valve the governor is piped to main reservoir and set at ninety pounds.

There are some other differences in the construction of these valves which make their operation a little different. The preliminary exhaust cavity *p* in the rotary of D-8 valve is short, so that as soon as the valve is moved from service application to emergency position the preliminary exhaust port is lapped or covered, and the pressure over equalizing piston 17 can not be reduced while in this position, unless air leaks out past piston packing ring or through joints.

With F-6 the preliminary exhaust cavity in rotary is a long groove, so preliminary exhaust port is open from service application to full emergency. This can let all the air out of cavity over equalizing piston—which is named chamber D—and equalizing reservoir, so black hand will drop back to nothing as soon as air can escape.

With D-8 the running position feed port *j* through rotary comes over equalizing port *g* when at a certain place on emergency, so main reservoir pressure can get in chamber D and black hand will show the same pressure as red one. In this position there is no air in train pipe as direct application port is open. These ports do not connect with each other in the F-6, so main reservoir air can not get into chamber D in this position.

With D-8 set on the ledge between running position and lap, the main reservoir pressure is shut off by port *j* closing at *f*, so no air can pass through to train pipe; while equalizing port *g* remains partly open and train pipe pressure is still connected directly to the black hand of gage. This is a good position to test the pressure in the auxiliaries, for when the train pipe and auxiliaries have equalized, the black hand will become stationary, unless there are leaks that take air out of the train pipe.

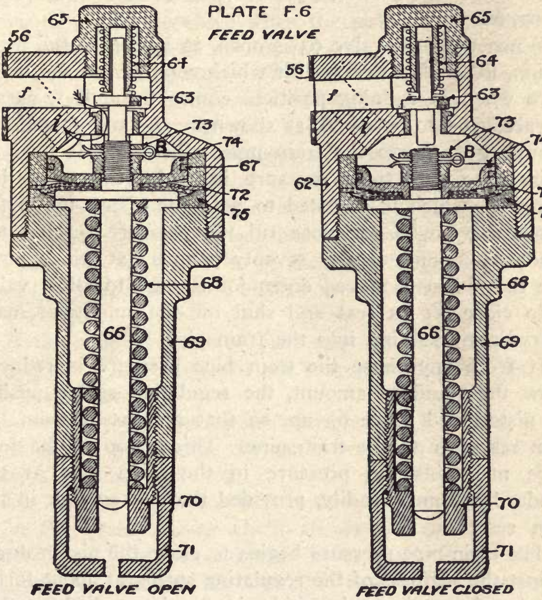
The F-6 valve will not show this way, as the ports *f* and *g* are both closed at the same time by the movement of rotary 43. If the air in the train pipe and chamber D can equalize past piston 47 the black hand will show train pipe pressure, and when auxiliaries have equalized with train pipe, it will show both pressures.

15. Q. Why is the pump governor operated by the main reservoir air pressure with the F-6 or 1892 model brake valve and by the train pipe air pressure with the D-8 or 1889 model?

A. Because the feed valve attachment or train pipe governor on the 1892 model valve regulates the flow of air into the train pipe while the valve is in running position and maintains its pressure very closely to the standard amount, so that the pump governor can be used to regulate the main reservoir pressure, therefore the pressure it regulates is used to operate the governor.

With the D-8 valve the excess valve 21 does not regulate the train pipe pressure, it can only be used to maintain a difference of pressure between the main reservoir and train pipe. With an engine and tender only, the spring and valve may be adjusted, so this difference may be twenty pounds exactly; while if a long train is attached it will be considerably more, the air will not pass this excess valve freely enough to hold up the pressure in a long train as easily as in a short one. Train pipe leaks affect this and the excess spring 19 gets stronger as it is compressed, so that it takes more difference in pressures to hold it open and supply leaks in a long train than in a short one, as there are usually more of them. If the governor was operated by main reservoir pressure from the D-8 valve and set at ninety pounds, the train pipe pressure for one train could be adjusted to seventy pounds by getting the excess spring just right. If this engine were attached to another train the train pipe pressure would likely be more or less than seventy. Now, seventy pounds is what we want for safe work with any train or engine, as the excess valve can not regulate the train pipe pressure properly and the pump governor can, the governor is operated by train pipe pressure and set at seventy pounds for all trains.

By the use of a Duplex governor, which consists of two complete diaphram bodies coupled with a tee connection to one steam valve body, having one air diaphram connected to the train pipe and set at seventy pounds, the other connected to the main reservoir and set for the desired main reservoir pressure; both train pipe and main



reservoir pressure can be regulated while the brake valve is on running position. On full release position the side of the governor set at the lowest pressure will stop the pump at that pressure. On service application the train pipe side of governor will be cut out and the one coupled to the main reservoir will stop the pump.

16. Q. Describe the feed valve of train pipe pressure

regulator. How many kinds are in use and what are the differences in their operation?

A. There are three forms of the feed valve in general use. The older one, called F-6, has a poppet valve, 63, which is opened and closed by the movement of a piston, 74, which piston is moved in one direction, *down*, by the pressure of the train pipe air, and *up* by a regulating spring, 68.

When the feed valve 63 is open, as shown in the illustration, the main reservoir air which comes from the brake valve when in running position, comes through *f*, passes by valve 63 into cavity *B*, as shown by the arrow, and out through port *i* into the train pipe. Piston 74 is held up against the train pipe pressure in *B* by the regulating spring 68, which is adjusted to hold the piston up so the supply valve will not close till the pressure reaches the standard amount, usually seventy pounds; at which pressure the piston is moved down for enough to allow valve 63 to close on its seat and shut off the supply of main reservoir air passing into the train pipe.

If from any cause the train pipe pressure is reduced below the standard amount, the regulating spring pushes the piston and valve 63 up, so that air passes from the main reservoir to the train pipe. This action of the feed valve maintains the pressure in the train pipe at the standard amount steadily, provided there is enough in the main reservoir.

The train pipe pressure begins to move the piston down against the stiffness of the regulating spring at about forty-five pounds, so that valve 63 begins to close a little at that pressure. As the pressure increases it compresses the spring more, until at seventy pounds piston 74 is down so the valve 63 has entirely closed. On account of this action of the F-6 feed valve the passage of air from the main reservoir to the train pipe was free up to forty-five or fifty pounds, and was then gradually restricted as the pressure raised, so that between sixty-five and seventy pounds the opening was so small that with a long train or much leakage it took a long time to feed up between those pressures.

To stop the piston in case the brake valve is in full release position, the lower part of the piston comes against the top part of the spring case 69, in the illustration the piston is shown in this position, in service it moves down only far enough to allow valve 63 to close. The small spring 64 closes the valve when the piston moves down.

The two gaskets 72 are intended to stop any train pipe air leaking by the piston. There is a recess in the bushing ring 75 deep enough to hold the smaller gasket when the piston is down. If this gasket is too thick for this recess it will hold up the piston and feed valve so that the train pipe pressure will get too high. If the spring case 69 is screwed up too far into the valve body 62, the edge of the larger gasket will be smashed out thin, the two gaskets will then fill the recess in 75 and hold the piston up and valve 63 open, which will allow train pipe pressure to feed up too high.

If the stem of valve 63 that runs up into the cap nut 65 gets bent, the valve will not seat squarely, and air will leak past it steadily.

A leak through the gasket 56 from port *f* to port *i* will allow air to pass from the main reservoir to train pipe without passing valve 63.

Do not confound this leak with a leak through gasket 61 in the brake valve, which allows the air from main reservoir to flow into chamber D in any position except full release. A leak through the feed valve affects the pressures in *running position only,* as that is the only position in which air can pass the rotary to the feed valve.

The feed valve attachment must be kept clean if it is expected to work correctly. If the valve 63 gets gummy so that it is not air tight on its seat, the main reservoir will tend to equalize with the train pipe at more than the standard amount.

The Slide Valve Feed Valve, G-6, which is a later type than the F-6, is shown in two positions, has a slide valve 55, to open and close the air supply port *b*, and allow air to pass from the main reservoir to the train pipe when the rotary is in running position. This supply valve is operated by a piston, 54, which is moved in one direction by the main reservoir air pressure, in the other by a spring, 58.

To aid the reader we have prepared two sketches of this feed valve in which the ports and passages are shown

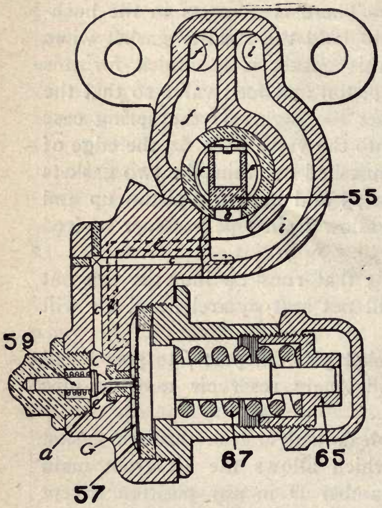


Fig. 1.

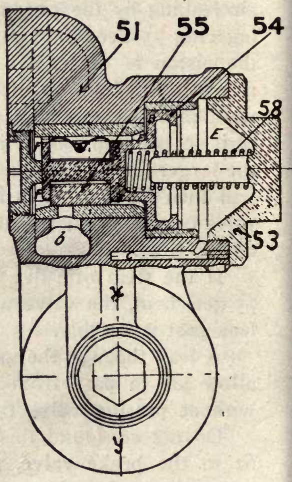


Fig. 2.

in such relations to each other that the flow of air through the complete valve may be more easily understood. Figs. 1 and 2 show the valve as it really is, in the normal position, with no main reservoir air in it, on the next page are shown the diagrammatic sketches spoken of.

With the G-6 feed valve the pressure of the main reservoir air against the piston, 54, must be sufficient to push it over against the strength of the spring 58, before the slide valve will be moved to uncover port *b*. With this valve at work feeding up the train pipe the main reservoir will show slight excess pressure at all times. This you do not see with the F-6 valve, as its feed valve is not held open by the main reservoir pressure.

Main reservoir air enters at *f*, passes into the slide valve chamber F on top of, around the ends and sides of

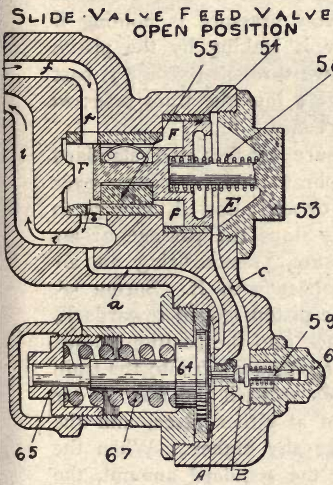


Fig. 3.

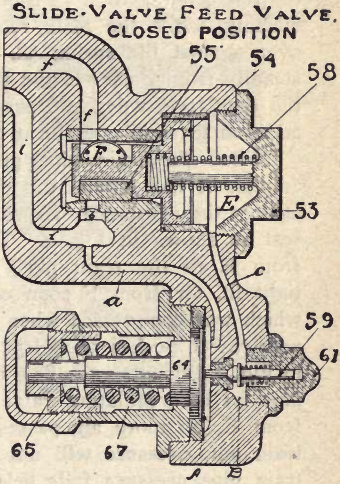


Fig. 4.

valve 55 and against piston 54. Chamber E, on the other side of the piston, is connected through passage *c* with the chamber around regulating valve 59, and if this valve is open, air from E will pass through *a* into the train pipe through *i*, so that air in E can equalize with that in the train pipe.

A diaphram, 57, which consists of two thin brass sheets similar to the governor diaphram, keeps the train pipe air from escaping to the atmosphere through the spring case, this diaphram rests on a piston, 64, which is held up by the regulating spring 67. The stem of the regulating valve 59, rests against this diaphram, when 57 moves over, the regulating valve moves with it. With reservoir pressure in F and train pipe pressure in E, the piston and slide valve moves from the position shown in Fig. 2 to that shown in Fig. 3, so that the port is open at *b*, allowing air to pass from *f* to *i*. Piston 54 is not a tight fit in its bushing, while the main reservoir pressure is holding it over against the spring 58, air is leaking by the piston steadily from F into E and thence through passage *c*, past the regulating valve and passage *a* into the train pipe; in addition to what goes in at port *b*.

When the train pipe pressure reaches the standard amount it has moved the diaphram and its piston over against the resistance of spring 67 and allowed valve 59 to seat as shown in Fig. 4. This stops the passage of air from E to the train pipe, piston 54 not being an air tight fit, air from F soon equalizes with E. Spring 58, which was compressed when the piston moved towards E, now reacts, pushes 54 and 55 back into the position shown in Fig. 4, this stops the flow of air through *b* into the train pipe, as the regulating valve has stopped the flow of air from E, no more air passes in at either place, and the train pipe pressure will not rise any higher.. When the train pipe pressure falls below the standard amount, the regulating spring will move the piston 64 and diaphram enough to unseat valve 59, air in E can then equalize with the train pipe, reservoir pressure in F at once moves the piston and slide valve as shown in Fig. 3 and air feeds into train pipe again.

If the regulating valve leaks, if either of the cap nuts 53 or 61 leak, or if the spring 58 is too weak, or gone, the piston will hold slide valve open so that train pipe pressure may get too high. If the opening by the seat of the regulating valve is stopped up, or the regulating spring is too weak, the slide valve will be closed. To clean valve 59 leave rotary in service position and take off cap nut 61. To clean piston 54 remove cap nut 53. Piston 54 has no packing rings, it should be clean and free from gum.

The B-4 feed valve is much the same as the G-6, but has a small port f drilled through the piston 8 and a packing ring 9, that regulates the supply of main reservoir air passing into the chamber G behind the piston. In all respects the operation of the piston with its supply valve, and the regulating valve is the same as the G-6 feed valve.

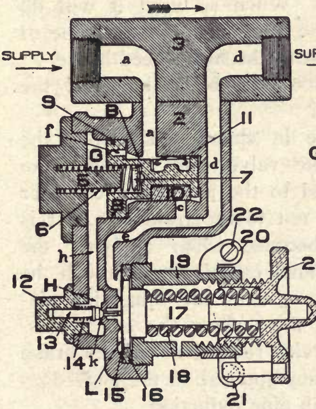


DIAGRAM OF FEED VALVE, CLOSED

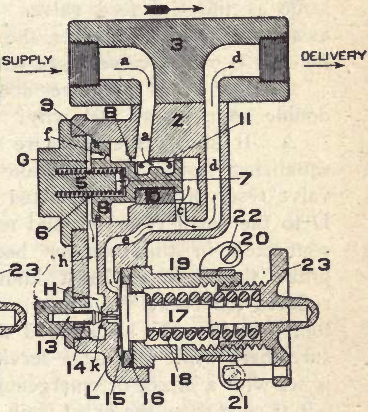


DIAGRAM OF FEED VALVE, OPEN

But there is a quick thread screw on the regulating nut 23 that allows a change to be made in the tension of the regulating spring 18 so that the pressure of the train pipe air can be changed from 70 to 110 pounds, or vice versa, by a partial revolution of the small hand wheel that is part of the regulating nut 23. Secured to the spring case 19 are two split rings, 20 and 21, a small screw 22 binds the ends of the split ring when once adjusted so it cannot slip around on the spring case 19. The feed valve is first adjusted to close at the lower pressure, say 70 pounds, and the split ring 21 brought against the pin fixed in the hand wheel 23. The wheel and adjusting nut 23 are now turned to increase the tension on the spring 18 till the valve will close at the higher pressure, say 110 pounds, and the split ring 22 is moved against the other side of the pin in 23. By turning 23 so the pin rests against one or the other of the stops on the rings 21 or 22, the tension of the spring is adjusted for the proper pressures. This type of feed valve is usually attached to a pipe bracket, as shown in the cut, but it can be attached to the 1892 model valve the same as the G-6 feed valve. When so used it will do away with the pipe bracket, the reversing cock and one of the two G-6 feed valves used with the high speed brake.

17. Q. What pressure does the black hand of the double gage show, and why?

A. It shows the pressure in chamber D above the equalizing piston in the brake valve, and in the brake valve reservoir, it is connected to the pipe from chamber D to the small reservoir and not to the train pipe. It is connected in this manner because when applying the brake the engineer must know exactly how much he reduces the brake valve pressure over the equalizing piston, therefore the black hand must show the exact pressure there while making a service reduction. If the brake is set with a direct or emergency application the gage does not at once show the exact train pipe reduction.

18. Q. In what position of brake valve does it also show the exact train pipe pressure?

A. Full release, running position, or anywhere between full release and lap. In these positions the equalizing port *g* which is the communication between the train pipe and the chamber D, is open. In any other position this port is shut to the train pipe pressure so it is not connected to the black hand direct.

19. Q. Then the black hand does not show the exact train pipe pressure when on lap or past lap towards the emergency position?

A. No, not immediately, and you can easily prove this by placing the valve on lap and opening the angle cock at rear end of tender; the train pipe pressure will drop to nothing at once, which the black hand will not do. Usually the equalizing piston packing ring leaks a little, and the black hand will drop back slowly as the air leaks out into the empty train pipe; if there are no leaks in the brake valve, or connections to gage or brake valve reservoir, it will not drop any. Unless the packing ring leaks considerable it does little harm. A very small leak is an advantage as it will show on the black hand the train pipe pressure as soon as the pressures can equalize past the piston, it can warn the engineer if valve is left on lap and train pipe pressure falls slowly without setting the brake.

20. Q. What difference between the D-8 and F-6 valves in regard to carrying excess pressure?

A. With D-8 valve or any brake valve using an excess valve to maintain the excess pressure, when placed in running position, you get the excess pressure before the train line begins to raise any, no matter at what pressure you start, as the main reservoir pressure must raise enough first to get by the excess valve before going into train pipe. With the 1892 model, both pressures raise together till train pipe stands at seventy pounds, then the feed valve shuts and excess begins to pick up in main reservoir. So you have excess first, with D-8 valve, and hold it while valve is in running position; with F-6, you get train pipe pressure first up to seventy pounds, then excess afterwards.

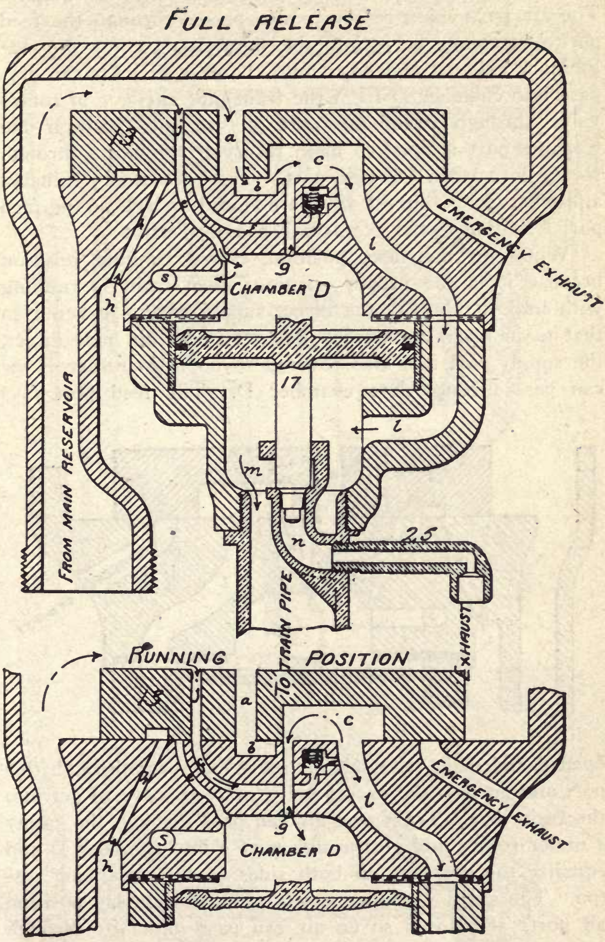
21. Q. When the D-8 valve has been left on release position till train line and main reservoir have equalized at seventy pounds, and is then placed on running position, are the brakes apt to creep on at once? Why is this?

A. When the D-8 valve is placed on running position, it shuts off the air from train line till the excess pressure is picked up in the main reservoir, before this excess is picked up if the train line leaks, the brake will set. In such a case, run your pump a little faster for a few minutes—not over five—so as to get the excess quicker. If train is under motion and you feel a brake dragging, put the brake valve in full release for a second only, then place it in running position; this may have to be done a second or third time until air begins to go through excess pressure valve, when it will hold brakes off. A short rule for this is: Keep your excss all the time by not using the full release position, except at the time of releasing the brakes, then running position will hold them off.

22. Q. Please state the different positions of the brake valve, the course the air takes passing through it, and what ports are covered in each position.

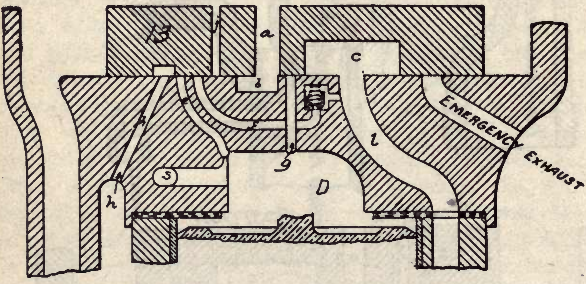
NOTE—To aid the student we have prepared some sketches of the D-8 brake valve in which the rotary 13 is shown as if it were a long valve sliding in a straight line back and forth over a valve seat instead of turning on a center as the actual rotary valve really does. In these sketches the rotary is shown as if cut between the preliminary exhaust cavity *p* and the emergency exhaust cavity and straightened out as a hoop is straightened out when cut across. The ports are shown in somewhat changed positions so they will be in proper communication with the ports and cavities in the sliding valve 13. Ports *a* and *g* are shown in the sketch as if they communicated with each other, in the actual rotary valve *a* is nearer the center than *g*, so in service they do not register with each other. In actual service port *j* registers with *f* in running position as shown, and with port *g* in emergency position; but for the purposes of explanation the sketch gives a very good idea of the course of the air in the various positions of the D-8 valve.

A. When on full release position, main reservoir air which comes in the brake valve on top of the rotary can pass through opening *a* in the rotary into a cavity in the rotary valve seat *b* and from there around the bridge in rotary and into the train pipe direct; in this position


FULL RELEASE
CHAMBER D
EMERGENCY EXHAUST
FROM MAIN RESERVOIR
TO TRAIN PIPE
EXHAUST
RUNNING POSITION
CHAMBER D
EMERGENCY EXHAUST

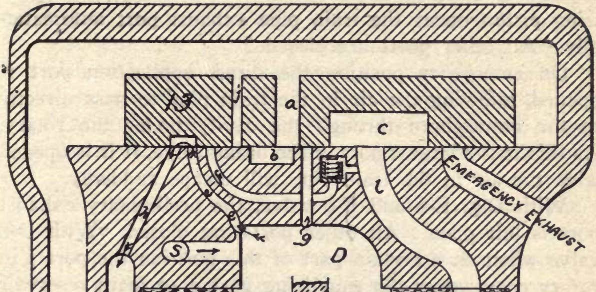
the main reservoir and train pipe pressures can equalize. The air from main reservoir also passes through the feed port *j* in rotary valve into the supply port *e* for the preliminary exhaust and down into chamber D. Air can also pass into chamber D from the train pipe cavity *c* in rotary valve through eqaulizing port *g*. In this position the warning port is open so main reservoir air blows through rotary into main exhaust port. The preliminary exhaust and emergency exhaust ports are closed as well as the feed port *f* leading to the excess valve or feed valve.

When on the next position, called running position because it is the proper position when train is running with brakes released, the direct supply port is covered so that main reservoir air can not get into train pipe direct, the supply port *e* is also covered so no main reservoir air can pass through into chamber D. The feed port *f* is

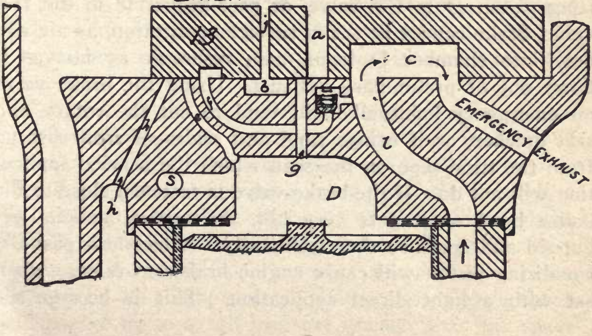


opened and main reservoir air must then pass through this port and go past the excess valve or feed valve to get into the train pipe. Train pipe air can pass through the cavity *c* under rotary and go through port *g* into chamber D and equalize the pressure on both sides of the equalizing piston. The small warning port is covered. On lap position all ports are closed so no air can pass under or through the rotary. On service application position the prelimin-

SERVICE APPLICATION POSITION.



EMERGENCY POSITION



ary exhaust port *h* is opened so air flows out of chamber D; this is done by a movement of the rotary, the equalizing piston opens the train pipe exhaust port automatically. All other ports are closed.

On emergency position the direct application port is opened, allowing the air in the train pipe to pass directly to the atmosphere through the cavity under the rotary. As this is the largest port in the brake valve, if it is opened wide the air in the train pipe will escape suddenly.

With D-5, E-6 and F-6 valve, the preliminary exhaust port is left open. All other ports are closed. With D-8 valve when on a certain part of this position the port *j* in rotary comes over the equalizing port *g* so main reservoir air passes into chamber D. This port does not open in the other brake valves. The port from brake valve to brake valve reservoir is open at all times.

23. Q. Do leaks in the brake valve interfere with its work?

A. Yes; if there is a leak under the rotary valve from the main reservoir to train pipe, the train pipe pressure will raise so that the brake will release when valve is on lap. A leak from train pipe under rotary valve, or through train pipe discharge valve to atmosphere, or a leak between equalizing reservoir and brake valve when valve is on lap, will set the brake tighter than you want it. If it leaks through gasket from main reservoir to cavity over equalizing piston 47 in F-6 valve, or past gasket 18 in the H-5 valve, brake cannot be set in service application, as air will flow into chamber D from main reservoir as fast as it flows out of preliminary exhaust. Using the brake valve on emergency habitually will tend to cut the rotary and seat quicker, as it brings sand and scales of iron rust up from the train pipe on the seat, which the service application will not do. If the brake valve is fastened close to the boiler head so it gets very hot, the leather gaskets get burned and crack so they leak badly. A bad leak past the equalizing piston will cause engine brakes to release when set with a light direct application. This is because air leaks from equalizing reservoir past piston and raises train pipe pressure in the short train pipe on engine and tender. This leak will also prevent the equalizing piston raising when making a service reduction if the air can come past the piston into chamber D as fast as it is discharged through preliminary exhaust port. It also makes the train pipe reduction less than the gage at first shows, on a long train.

24. Q. What is the effect if equalizing reservoir pipe is broken so a blind joint has to be made?

A. The brake cannot be set with a gradual application in service position; there is so little air above the equalizing piston, it escapes out of preliminary exhaust so quickly that the pressure above piston is reduced more than 20 pounds, equalizing piston stays up and the brake works with full application; some times emergency with a very short train.

25. Q. What should you do in such a case?

A. If joints cannot be made so as to use equalizing reservoir again, a blind joint should be made at its connection with brake valve; the elbow in train pipe exhaust should be plugged and valve used with direct application port, taking care to make a gradual reduction so brake will not go on with emergency, and closing valve slowly so the brakes on head end will not be kicked off. The elbow has a thread cut in it for plugging; if it is not threaded take it out and plug the hole with the plug in the equalizing reservoir. A ⅜ plug is used with the H-5 valve.

26. Q. With the equalizing discharge valve, why does the air blow out of the train pipe exhaust when brake is released, if working brake on engine and tender only?

A. Because the train pipe is charged up through a large hole in rotary valve; the cavity over equalizing piston and brake valve reservoir is charged from the main reseroir through the small supply port *e* for preliminary exhaust, and by equalizing port *g*. If the train pipe is short, it will charge up to a full pressure quicker than the space above piston; train pipe pressure will then raise piston and discharge valve, allowing air to blow out of train pipe exhaust elbow for a second or two. This flash of air is not as heavy with the D-8 valve as with the later patterns. The D-8 valve has a larger opening through supply port *e*. There is no flash of air from the H-5 brake valve when coupled to any cars.

27. Q. Can this action of the valve be of advantage to you?

A. Yes; if you hear this escape of air from train pipe exhaust when releasing brake on a train, it is a sign of a short train pipe; and is a notice to the engineer that an angle cock at the head end of train is closed, or something has got into the train pipe and stopped it up. You should see at once if an angle cock is not shut by some mistake or malicious intent. Check chains swinging against the handle will close it.

28. Q. Does the amount of air which blows out of train pipe exhaust when setting the brake with a service application give you any idea of the number of cars in your train working air?

A. Yes, with engine and tender only, the train pipe exhaust does not blow much, if any, longer than preliminary exhaust. With a long train it takes some seconds for the train pipe pressure to be reduced and equalize its whole length. You can, after some practice, tell whether you have a long or short train working air by listening to the amount of air escaping from train pipe exhaust. This test shows the length of train pipe cut in and filled with air, not the number of brakes that set. It takes considerable practice to tell how many cars are coupled on. By this test it gives the number of car lengths of train pipe in use; if the triple is cut out on any car it gives you no notice. When some of the cars are cut out by closing angle cocks, a less amount of air will come out than with all of them. It is important to know this, as some of the angle cocks may be closed, thus cutting off all the cars behind the closed one. In making a test for the length of train pipe connected to the brake valve, reduce your brake valve pressure exactly five pounds by the gage and then note the amount or air coming out of the train pipe exhaust. Always use the same amount of reduction as there is no sure way to compare the length of train pipe exhaust for different trains unless the same brake valve reduction is used as a measure each time. A partly opened angle cock can be detected by this test, for the air will flow with a strong, steady sound from the train pipe ahead of the partly opened cock, while the air from the pipe behind it will string out longer and weaker than it should. Look out for this, as the brakes can all be set, but as the air equalizes very slowly into the rear cars some of the triples in rear cars are liable to stick. With a full train of *quick-service* triples considerable train pipe air goes through these triples to the brake cylinder; so a less amount of air will come out of the brake valve from the train pipe than with the older form of triples.

29. Q. What is the stop cock under brake valve for? Will it assist you in locating leaks? How?

A. To cut out the train pipe from brake valve when "double heading," so only one engineer can control all the brakes. For this purpose it is absolutely necessary. Yes, it will assist in locating leaks. When shut, after charging train pipe and auxiliaries, if there is a leak in train pipe, brake will set at once; if the rotary leaks either into or out of the train pipe, it will show it very soon, as there is so short a train pipe to leak into or out of. A little observation will teach you many ways of using this cut-out cock in testing for leaks. With the H-5 valve and the distributing valve this stop cock controls the exhaust from the distributing valve.

30. Q. If you had an 1892 valve and the brake would not go on in service application, nor the black hand fall, nor the train pipe exhaust open, while air came readily from preliminary exhaust, what would be the matter?

A. I would look for a leak at the joint on lower gasket where a leak would allow air to get from main reservoir direct to cavity over equalizing piston No. 47. This would give main reservoir pressure to chamber D and show it on the black hand. A brake valve with this leak would show no excess pressure. No air could come out of train pipe exhaust, as the pressure could not be reduced over the piston so valve could be raised. To set the brake use direct application port, opening and closing it slowly.

31. Q. If you had a continual blow at the train pipe exhaust port of the brake valve and could hold no air, where would the difficulty be apt to be found?

A. Stuck or leaky equalizing piston, dirt on its valve seat, brake valve reservoir bleed cock open, or bad leak in pipe to brake valve reservoir or gage. Would put valve on lap, then on emergency for a moment and see if that would stop it, or close the stop cock under the valve and flash the valve to clean off the seat.

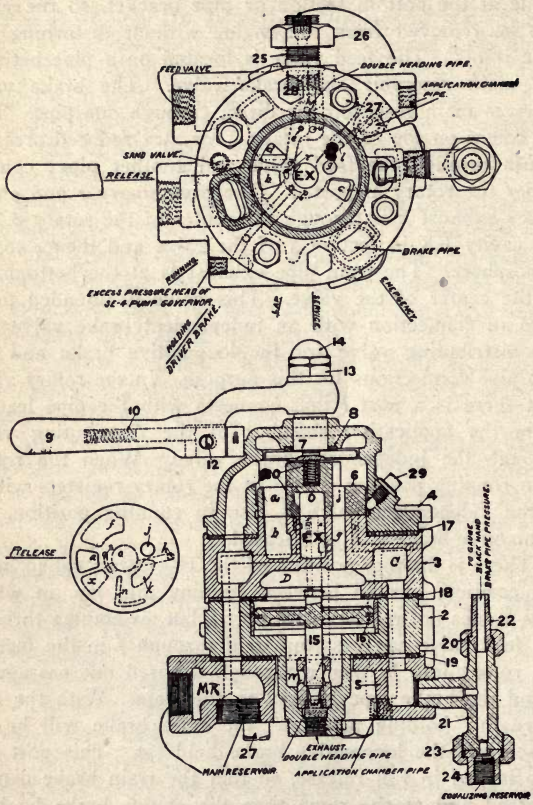
32. Q. How should the brake valve handle be placed when running or standing with brake released, unless auxiliaries are being charged? Why?

A. Always in running position. Because this is the only position in which you can carry excess pressure, which is needed to release brakes promptly. With 1892 valve on full release the train pipe pressure will run up as high as pump governor will allow; this high pressure is apt to slide the wheels. A small blow hole is put in the rotary valve to warn engineer that valve has been left in full release. All valves should have this warning port; if it gets stopped up, it is a sign that there is dirt on top of rotary valve, which should be taken out and cleaned at once. When on running position the opening through brake valve from main reservoir to train pipe is a smaller one than on full release. If the train breaks in two or conductor's valve is opened to stop the train in case of accident, the brakes will operate instantly as the train pipe pressure can be reduced from the train faster than the running position feed port can supply it. If the valve is on full release the brakes will not set tight till the main reservoir pressure is also reduced.

33. Q. What are the essential differences between the 1892 model and the 1906 or H-5 brake valve?

A. The H-5 brake valve has all the pipe connections made at the bottom section or pipe bracket, so the valve can be removed from the engine without disturbing any pipe joints. The feed valve is located on a pipe between the main reservoir and brake valve. The brake valve receives main reservoir air direct through one pipe. This air comes on top of the rotary. Air at a reduced pressure comes through the feed valve and another pipe; coming under the rotary at port *d*. The preliminary *e* and emergency exhaust *x* is through the center of the rotary *o* into the cavity EX in section 3 of the valve and thence to the atmosphere. The train pipe exhaust is at the bottom and in the center of the valve. This valve is intended to be used in connection with an independent brake valve and the distributing valve for the locomotive brake and has two pipe connections for this purpose. In the rotary valve seat there is a port *l* that connects with the pipe leading from the application chamber of the distributing valve through the independent brake valve. When the rotary is in running position port *h* in the rotary registers with *l*, if the independent valve is also in running position, the locomotive brake will be released.

There is another position of the H-5 valve, called holding position, located between running and lap, in which port *h* does not register with port *l*, but air coming through the feed valve can pass out of *d* through *f* in the face of the rotary into *b*, thence through a cored out passage to *c* and the brake pipe leading to the train. With the H-5 valve in "holding position" the train brake will be released and the locomotive brake held set. This port *l* is also lapped in full release, so that the train brake can be released and at the same time the engine brake be held set if required; this will hold the slack back in the head end of the train and make it safe to release the train brake at slow speeds, and not break in two. Another port *i* in the rotary seat connects with the double heading pipe, port



H-5 AUTOMATIC BRAKE VALVE

h registers with *i* in lap position. This pipe leads from the exhaust port of the distributing valve and is only used on the following engine of a double header. When the double header cut out cock under the brake valve is closed this pipe connection through the cock is open.

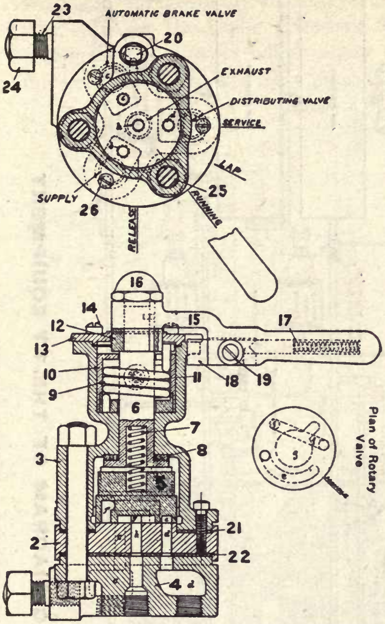
In the emergency position of the rotary, port *l* in the seat registers with port *g* through the groove *n* in the face of the rotary so that in emergency position air from the brake valve reservoir can flow into application chamber of distributing valve and apply the engine brake with greater force. Port *p* connects with the excess pressure head of the pump governor, when the rotary is in full release, running or holding positions; main reservoir air can pass through port *s* in the rotary and the small groove in its face and enter port *p*, thus controlling the excess pressure head of the governor in these positions. In full release main reservoir air from port *s* flows through the warning port *r* into EX and gives the warning that the valve is in full release position. In service position port *h* in the rotary registers with *e* in the seat, air from chamber D flows into *o* and EX, all other ports in the seat are closed. The action of the equalizing piston 15 has already been described. Cavity *k* in the face of the rotary connects ports *g* and *c* in running and holding positions, so that train pipe and chamber D charge up alike in these positions and there is no flash of air from the train pipe exhaust when releasing brakes with a short train.

Plug 29 can be taken out and some good oil poured in the cavity around the lower edge of the rotary to lubricate it. Spring 30 holds the rotary key 7 up against gasket 8 when there is no air pressure to do this. In full release position main reservoir air passes through ports *a* in the rotary and directly into port *b* and the train pipe, and port *j* registers with the equalizing port *g* so chamber D charges quickly. In running and holding positions cavity *f* in the face of the rotary connects ports *d* and *b* so the air that has been reduced in pressure at the feed valve can flow into the train pipe and charge it up to the pressure that the feed valve closes at, and no higher. To take the H-5 valve off its pipe bracket take out the through bolts. To take the valve apart take out the tap bolts that hold the valve sections together.

34. Q. Describe the independent brake valve.

A. This valve is used in connection with the distributing valve and allows air to flow into or out of the application chamber, and thus operate the supply valve piston, that in turn operates the valves which admit main reservoir air to the brake cylinder to set the engine brake or exhausts the cylinder air to release it. It does not admit main reservoir air direct to the brake cylinder as the Straight Air brake valve does. It has four positions, release, running, lap and service, that come the same as on the automatic brake valve. A stiff spring 9, in the top of the valve body 3 returns the handle from release to running position as soon as the engineer removes his hand.

In running position port *d* from the distributing valve is connected through port *f* in the rotary 5 with port *c* leading to the automatic valve, so that air can flow from the application chamber through the independent valve to the automatic brake valve, and this valve should always be in running position when the automatic valve is to operate the engine brake. In release position cavity *g* in the face of the rotary 5 connects port *d* with the exhaust port *h* in the center of the seat, so that the application chamber air can pass to the atmosphere without regard to the position of the automatic brake valve and release the engine brake independently of the train brake. In service position cavity *e* in the rotary connects the supply port *b* with *d* so that main reservoir air reduced to 45 pounds can flow direct to the application chamber and operate the distributing valve supply piston; this position applies the engine brake independently. Lap position blanks all ports and is to be used only when making a graduated application or release of the engine brake or when trying to

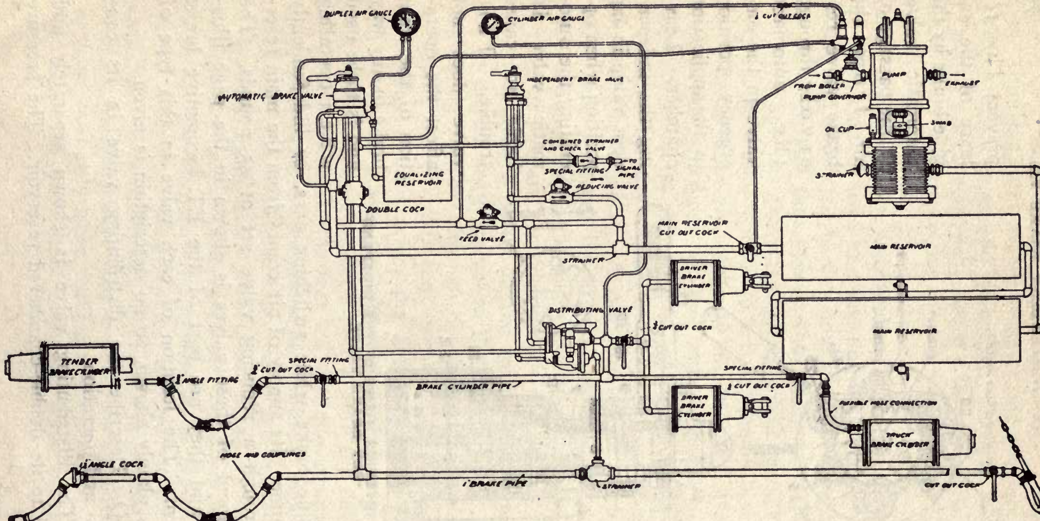


INTERIOR VIEWS OF THE INDEPENDENT BRAKE VALVE

prevent the release of the engine brake by the automatic valve, or the passage of air from the brake valve reservoir through the automatic valve in the emergency position to the application chamber. Leaving the independent valve in lap position when operating the automatic valve is liable to cause trouble. This valve does not affect the operation of the train brake in any way and is to be used when operating the engine brake while switching cars, or independently at any time. Its supply of air comes from the main reservoir through a reducing valve set at 45 pounds. The arrangement of these valves is shown in the page illustration and they are part of the ET locomotive brake equipment. The location of each valve in this type of brake is plainly shown, so no description is given.

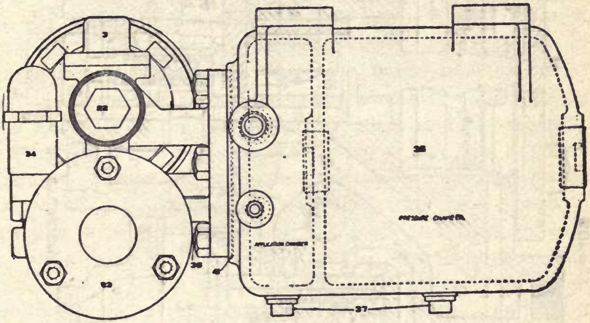
35. Q. Describe the distributing valve in its construction and operation.

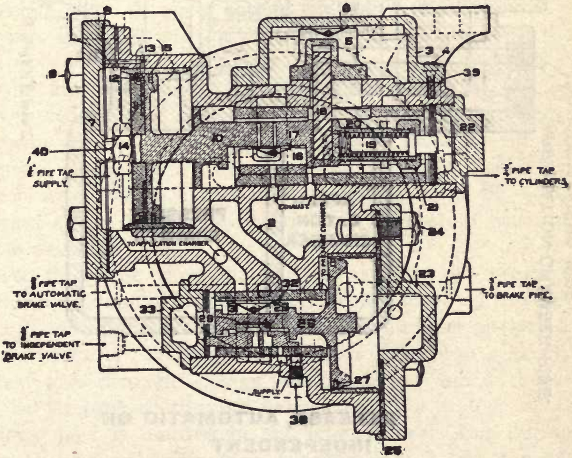
A. The distributing valve is shown separately and attached to its double-chambered reservoir. The pressure



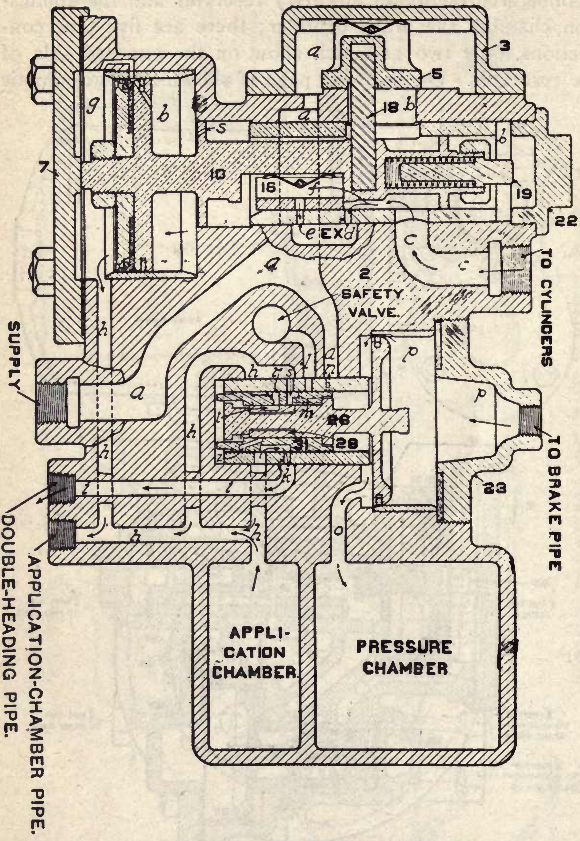
PIPING DIAGRAM OF THE ET EQUIPMENT

chamber represents an auxiliary reservoir and the application chamber the brake cylinder; there are five pipe connections, only two of which show on the exposed side of the reservoir. On the next page is shown a diagrammatic





view of the valve and reservoir, in which the valve is shown much larger in proportion to the size of the reservoir than it really is. We will use capital letters as abbreviations for the names of the five pipe connections made to the reservoir and from there to the various parts of the



RELEASE, AUTOMATIC OR INDEPENDENT

valve. In the diagrammatic view the slide valve 31 and graduating valve 28 are shown both above and below the piston stem 26, so the ports that are beside each other can be seen. Air from the main reservoir enters at supply, passes through port *a* up and around the application valve 5; also down to the seat of slide valve 31 and through port *n* to the pressure chamber when valve 31 is in emergency position. Air from the brake pipe enters at BP and is on the outside of equalizing piston 26. When this piston is in release, as shown, train pipe air can pass around the piston through the feed port into the pressure chamber. When the train pipe pressure is reduced piston 26 moves back towards the reducing train pipe pressure, bringing first the graduating valve 28 and then moving the slide valve 31 as soon as the lost motion between the shoulders on piston stem and valve 31 is taken up. This admits air from the pressure chamber to the application chamber through ports *o* and *h*, and in this respect is exactly like a triple valve when feeding air from the auxiliary to the brake cylinder. With a partial application of the automatic brake the equalizing piston 26 and its valves reduces the pressure in the pressure chamber by allowing air to pass into the application chamber till the pressure chamber is a trifle lower than the train pipe, when piston 26 moves back and laps graduating valve 28. This movement has been fully explained in connection with the triple valve.

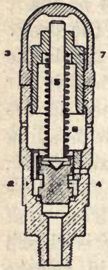
At the same time that air flows into the pressure chamber or dummy brake cylinder, it also flows up through port *h* into the space *g* behind the application piston 10. If the brake is "creeping on" and air flows into *g* slowly it may pass through leakage port between *g* and *b*, thence to the atmosphere through exhaust ports *e* and *d*. This leakage port is omitted in the later valves. But during a brake application air from *o* passes into *h* and *g* much faster than it can get through leakage port, so that the pressure in *g* will move piston 10 to the right. This moves application valve 5 and as soon as the lost motion is taken up, exhaust valve 16 covers the exhaust ports *e* and *d*. Valve 5 next opens the supply port from *a* into *b* and *c*, so main reservoir air can flow to the brake cylinder at BC and apply the brake. We will suppose a 7 pound reduction is made in the train pipe. As soon as it is felt on the piston 26 at *p* it will move towards BP, open valves 28 and 31 and closing exhaust port *k*. Air will flow into the application chamber and cavity *g* till the pressure chamber or dummy auxiliary is also reduced 7 pounds, when piston 26 will lap valve 28 over the port in valve 31. Air pressure in *g* will then move piston 10 and its valves 5 and 16, closing the exhaust ports *e* and *d* and opening supply port from *a* to *c*. To open port from *a* the graduating stem 19 must be moved back against the tension of its spring 20, when the stem 19 meets cap nut 22. As soon as the pressure in *b* and the engine brake cylinders is equal to that in *g* on the other side of piston 10; spring 20 and the stem 19 will move piston 10 and valve 5 back to lap, but does not move valve 16 to open the exhaust. This applies the brake and holds it applied as long as any pressure remains in *g* and *h*. If leaks in the brake cylinder packing or piping reduce the pressure in *b*; piston 10 will move towards this decreasing pressure and open the supply port till the pressure in the cylinder again equals that in *g*, when piston 10 will lap valve 5. When the air in the application chamber is either wholly or partly exhausted to the atmosphere piston 10 will be moved back towards *g* by the brake cylinder pressure and either wholly or partly exhaust the air from the cylinder.

In the independent application and release of the brake through the distributing valve the lower or equalizing piston 26 and its valves do not move. The air is fed into and out of the application chamber and chamber *g* by the independent brake valve at the pipe connection AC. This air comes from the main reservoir and is reduced to 45 pounds pressure before passing through the independent brake valve. When the independent valve is in service position air flows in at AC till the pressure in the application chamber and *g* is enough to apply the brake the desired amount. A partial or full application can be made depending on how much air is admitted through the brake valve, and a partial or full release by lapping the brake valve before all the air has escaped. To prevent the air passing out the exhaust port *k* of valve 31 when in release position port *i* is piped at DH to the double heading cock in the train pipe under the automatic brake valve. When this cock is open for the train pipe, as it should be when the automatic brake is being operated from that engine, the pipe leading from the exhaust port *k* is closed so no air can escape through valve 31 when in release position. But if this engine is not operating the train brake in a double header the exhaust port *k* is open through a pipe from DH through the cut-out cock and a port in the H-5 automatic brake valve when the rotary is in lap position.

There is a cut-out cock in the train pipe connection before reaching BP to cut out the distributing valve from operating automatically when necessary. Closing this cut-out cock does not prevent the brake being operated by the independent brake valve.

When the automatic brake valve is in the emergency position air from the brake valve reservoir can flow through the independent valve—if it is in running position—into the application chamber and *g*, so that the engine brake can be applied in that position of the automatic valve, even if cut out from the train pipe.

When piston 26 is moved its full travel to the emergency application position so it rests against gasket 25 in cap 23; ports *n* in the bushing and *m* in valve 31 will be open to each other so main reservoir air can flow slowly through the small port *n* into the pressure chamber and increase the pressure there. At the same time port *l* is open to the safety valve 34 and it will reduce the pressure there to about 60 pounds. This feature is intended to operate the brake the same as the high speed reducing valve. In the No. 5 distributing valve (the one here described), port *l* is only open to the pressure chamber and port *h* in applica-



14.—SAFETY VALVE

cation position; being closed in release and lap positions of valve 28 and 31. For this reason, when using the independent brake valve only with the equalizing piston 26 in release or lap the safety valve 34 will not reduce the pressure in the application chamber should the reducing valve for the independent valve be out of order and allowing too high a pressure. This safety valve is set at 53 pounds, and will blow down to that with an automatic service application.

If you will remember that the distributing valve depends on the pressure of air in the application chamber to open and close the valves that control the passage to and from the brake cylinder it will make the operation of this valve clear to you. When air gets into this chamber, whether from a leak through either brake valve or the slide valve 31, it will raise the pressure there and apply the engine brake. Or, if the air can pass out of this chamber either the regular way through the brake valves or leaks in the pipe connections the engine brake will release. First study out how the air gets into and out of this chamber and it will clear up many things that otherwise would puzzle you.

There are several forms of the distributing valve in service, with some differences in their construction and operation, and it is likely that other changes will be made in the No. 5 valve from time to time.

36. Q. Describe the Combined Automatic and Straight Air Engine and Tender brake.

A. This brake valve contains two check valves, 8 and 9—see Figures 1 and 2—to admit air from the main reservoir to the brake cylinders and 9 to exhaust the air from the cylinders to the atmosphere. These valves are moved away from their seats alternately by the shaft 2, which when revolved to the right, forces valve 8 off its seat against the pressure of the main reservoir air in *a* and the spring 11; when revolved to the left forces the exhaust valve 9 off its seat against the pressure of the spring 10 and the brake cylinder air. To apply the brake the handle 4 is moved to the right. With valve 8 moved down off its seat, main reservoir air in *a* passes through *b*, b^1 and b^2 —see Fig. 3—and out at *x*—see Fig. 2—through the piping leading to the Double Check valves and cylinders. Exhaust valve 9 at this time is on its seat as shown in Fig.

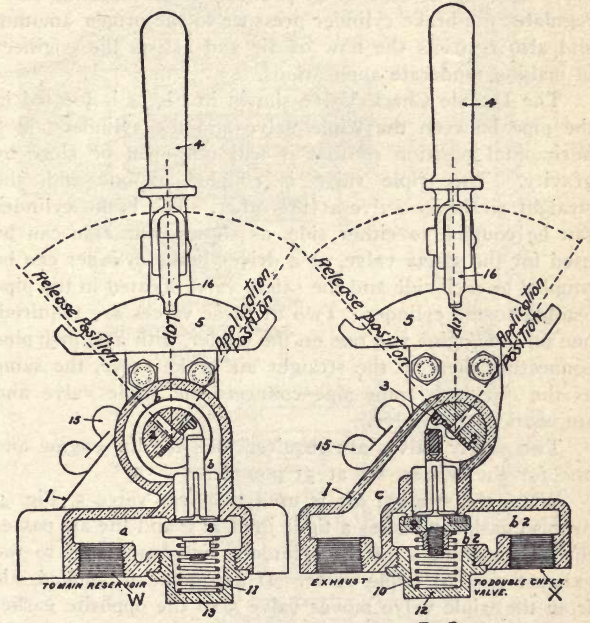


FIG. 1. FIG. 2.

STRAIGHT-AIR BRAKE VALVE.

2, so that no air can pass out through *c* to the exhaust. To release the brake the handle 4 is moved to the left, which allows main reservoir air valve 8 to close and then opens exhaust valve 9, so that air in the cylinders can pass out to the atmosphere. When handle 4 is in mid-position, both valves are closed so that they are "on lap."

A leather washer 6 prevents leakage from *b* to the atmosphere when the brake is applied; spring 7 holds shaft 2 against this washer when there is no compressed air in this part of the valve—see Fig. 3.

To regulate the pressure of the air feed from the main reservoir to this valve, a G-6 Slide Valve Feed Valve is used, located on the pipe between the reservoir and brake valve and set to close at 45 pounds. This reducing valve regulates the brake cylinder pressure to the proper amount, and also restricts the flow of air and assists the engineer in making moderate applications.

The Double Check Valve shown in Fig. 4 is located in the pipe between the triple valve and the cylinders, in a horitzontal position so that it will not open or close by gravity. The triple valve is coupled to one end, the straight air brake valve at the other. The brake cylinder can be coupled to either side, as shown, one side can be used for the safety valve, or a driver brake cylinder can be coupled to each side and the safety valve located in the pipe leading to the cylinder. Two of these valves are required, one on the engine and one on the tender, with a ¾ inch pipe connecting them to the straight air brake valve, the same as the one inch train pipe connects the triple valve and automatic brake valve.

Two safety valves are required, one for the engine and one for the tender, set at 53 pounds.

When the straight air is used it moves valve 5, Fig. 4, over so gasket 7 makes a tight joint at *b* and the air passes through opening *c* to the cylinders, but cannot get to the exhaust port of triple valve. If automatic is applied, air from the triple valve moves valve 5 so the opposite gasket makes a joint at *a* and air passes through ports c^1 to the cylinders but cannot pass to the straight air brake valve. Thus you see the double check valves automatically connect the brake cylinders to either the automatic or straight air system and prevent air passing out of the exhaust port of one system while the other is being operated.

When operating the straight air, move handle 4 over and you will feel the resistance of valve 8; a little practice will enable you to calculate the amount of air you allow to pass into the cylinders in a partial application; you can follow up by admitting additional amounts of air, till if

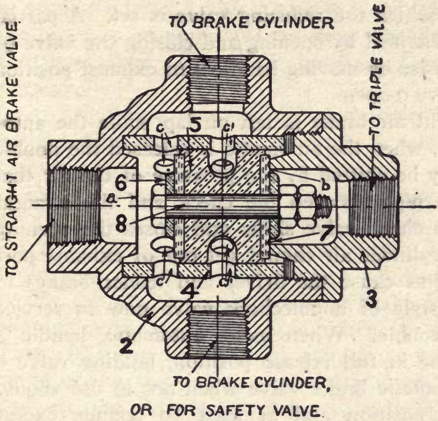


Fig. 4

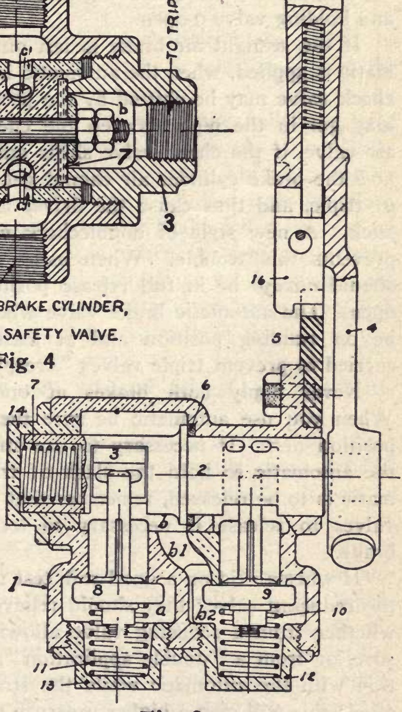


Fig. 3

necessary, the brake is fully applied, of course taking care not to shock the cars attached to the engine by too sudden an application. If it is to be held fully applied leave the valve in application position, so as to feed up any leaks that may reduce the power. For a full, quick application the valve may be opened wide, as the reducing valve will stop the flow of air from the main reservoir when it reaches the pressure at which the reducing valve is set. A partial release can be obtained by opening and closing the valve 9; a quick, full release by moving handle 4 to exhaust position and holding valve 9 open.

If the straight air brake is left on lap while the automatic is applied, when the automatic is released the double check valve may be shifted by the pressure of the air that may get in the pipe between the check and the straight air valve, if the check valve shifts and closes the opening at *b* the brake cylinder air cannot get out of exhaust port of triple, and thus cause the driver and tender brakes to stick. A new style of doublecheck valve now in service prevents this trouble. When using automatic, handle 4 should *always* be in full release position, holding valve 9 open. The automatic brake valve when not in use should be on running position and at least 10 pounds excess carried to prevent triple valves "creeping on" at any time.

Never apply both brakes at once while switching. When you use automatic be sure the other is in release position first. If necessary to use straight air on top of the automatic to hold the slack of train, when the automatic is to be released, remember that a movement of both valves to release is necessary to let off the locomotive brake.

If wheels skid on a good rail, test the safety valves and the reducing valve; they should relieve any over pressure, whether from a reducing valve allowing too high a pressure, or from a "double application"; that is, an application with the automatic while the straight air is still applied; this will give a higher pressure than if the automatic has set full first and is almost sure to slide wheels; therefore must not be used. Straight air gives 45 pounds only in the cylinders at any time; if the automatic is applied on top of this 45 pounds, the 70 pounds in the auxiliary will tend to raise the cylinder pressure close to 65 pounds. The safety valves should reduce it down to 53 pounds.

Both safety valves and the feed valve should be tested at regular intervals with a gage to insure that they regulate the pressure properly. There should be Tees so located in the pipes that a gage can be readily attached for this purpose.

37. Q. How should the automatic brake valve be carried when backing up the train, or when expecting the train men to set brake from rear end?

A. On running position; so the brake will be applied as soon as train pipe pressure is reduced, when brake valve should be placed on lap at once. This also applies to pushing a snow plow if brake is handled from the plow. A few companies require that the brake valve be kept on running position all the time, when backing up a train. There is some difference of opinion as to the proper position of the H-5 valve, some carry it on holding position and use the independent valve to release the locomotive brake.

38. Q. How do you set and release the automatic brake?

A. Reducing the train pipe pressure operates the triple valve to apply the brake and restoring the original pressure releases it; this is the engineer's method. It can be applied from the train by opening the conductor's valve, or the angle cock at the rear of last air brake car. Pulling the hose apart at the couplings, a hose bursting or any bad leak or break in the train pipe will set the brake. When the train breaks in two between air cars all air brakes on both parts of the train that are cut in set instantly. A brake can be set on a car that is alone by opening the angle cock to let air out of the train pipe. In such a case the brake can be released by bleeding the auxiliary reservoir. If a brake is to be released from the train the auxiliary pressure is reduced by bleeding till it is lower than the train pipe so the triple valve will open the exhaust port, or all the air is bled out of both reservoir and brake cylinder.

39. Q. Can a gradual application of the brake be made, that is, with only part of its full force?

A. Yes, by reducing the train pipe pressure only a few pounds, say five to seven pounds for first reduction; this reduction is necessary to make brake piston move over leakage groove; a lighter reduction than five pounds will not always do this; two to three pounds at each of the succeeding reductions, less than twenty pounds in all.

40. Q. Why does this reduction of only a few pounds in the train pipe pressure make a light application of the brake?

A. With a light reduction the triple piston moves down slowly, opening the air valve slowly; the air from the auxiliary reservoir passes into brake cylinder through graduating valve and a small port in the slide valve; as soon as the auxiliary pressure is a little lower than train pipe pressure, the train pipe pressure raises the piston, closing the graduating valve so no more air can pass into brake cylinder, thus setting the brake lightly. To illustrate this, we will let out seven pounds of air, reducing train pipe pressure from seventy to sixty-three pounds, that leaves seventy pounds above triple piston, which moves the triple piston down towards the lower pressure, opening graduating valve *7* first; then moving slide valve *3* so that air can pass through it; when enough air has gone into the cylinder to reduce the auxiliary pressure below sixty-three pounds, the train pipe pressure moves the piston towards the lower auxiliary pressure, closing graduating valve; another reduction produces the same effect, each time setting brake tighter till pressures equalize. The piston moves the main slide valve at the first reduction, but only opens and closes the graduating valve at the following reductions till a full application is made.

41. Q. How much do you reduce the train pipe pressure to make a full service application of the brake if the piston travels are the proper length?

A. About twenty pounds, or from seventy pounds down to fifty, or until the auxiliary pressure has equalized with brake cylinder.

42. Q. Why does a reduction of twenty pounds set the brake "full on"?

A. If the brake is in good order, with a piston travel of eight inches, a reservoir pressure of seventy pounds will fill the brake cylinder and equalize in both at fifty pounds, that will leave fifty pounds on top of triple piston. If the pressure on the train pipe side or under the triple piston is any less than fifty pounds, the piston will stay down and hold the air valve open and pressures must equalize. One pound less will hold it down as well as any amount. When it has equalized, no more air will pass from auxiliary to brake cylinder, pressure on brake piston will not rise above fifty pounds, and brake cannot be set tighter. Any reduction of train pipe pressure that leaves it lower than auxiliary pressure will set the brake tight. If a reduction of twenty pounds opens the air valve and holds it open, any further reduction will not produce any effect on it, and so far as that brake is concerned is only a waste of air which must be supplied from main reservoir when you want to release brake. If any check valves in quick action triples leak, a reduction in train pipe pressure below brake cylinder pressure will let the brake leak off through this check into train pipe.

43. Q. What is necessary to have brakes set alike, with same reduction of train pipe pressure and release at same time, with same increase of train pipe pressure?

A. 1st. The auxiliary pressures must all be the same to move triples down towards the same reduced train pipe pressure. For example, if one auxiliary has seventy pounds, another sixty, a reduction of train pipe pressure below seventy will set the first brake, but it takes a reduction of below sixty to set the other one. 2d. All piston travels must be the same, for with a twenty pound reduction a short travel equalizes at a less reduction with a higher pressure than a long travel. When train pipe pressure is increased, triple controlling brake with long travel will release first as the auxiliary pressure is lowest. Thus, brake with long travel equalizes last with lowest piston pressure and lets go first. 3d. That all triples and brake pistons are in good order and no leaks. 4th. That the main reservoir pressure and volume are sufficient to move all triples to release quickly.

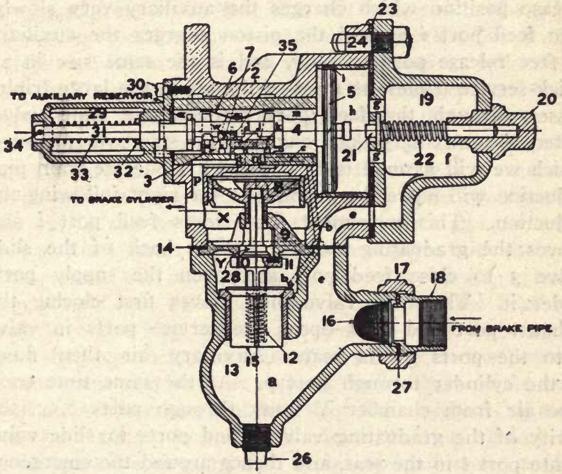
44. Q. What is the difference between the plain engine triple valve and the car or quick-action triple? Why will not the plain triple do as well on a long train?

A. A plain triple gets all its supply of air to set the brake from the auxiliary reservoir only; the quick-action triple gets it all from the auxiliary on a service application; when used with emergency it gets air from both train pipe and auxiliary. With a long train equipped with plain triples it takes some seconds to reduce the train pipe pressure at last car and operate the last triple; the pressure in train pipe is reduced slowly on last cars, which makes them set gradually; the train pipe reduction is made at the engine only. The quick action triple has two separate actions; in one a service application operates only the plain part of it; in the other, plain and quick action parts are operated at once. A quick action triple is not always needed on an engine or tender, as they are so close to the brake valve that they operate quickly enough. In an emergency application the quick action triple allows some of the train pipe air to escape at the triple so that the train pipe pressure is suddenly reduced at this triple; this also operates the next triple quick-action, which reduces the train pipe pressure still more, so that all the triples act quicker than when the reduction is made at the brake valve, and all the brakes are set at nearly the same instant. Thus there is less shock to the rear cars of a full air brake train, as the action of the triples travels from one to the other faster than the slack can run up from car to car.

45. Q. Describe the construction and operation of the Quick Service Triple Valve.

A. The quick service triple valve shown in the next illustration is similar to the ordinary quick-action triple in use for many years, but has some additional features. There is an additional air port *b* leading from the chamber

Y between the train pipe check 12 and the emergency valve 10, up through the triple body to the slide valve bushing at *c*. This port *c* is covered by the slide valve so any air passing through port *c* must also pass through a port in the slide valve to get any farther. The graduating valve 7 is a small flat valve with a cavity in its face, this valve rides on the back of the slide valve 3 and moves each time piston 4 does. There is some lost motion between the



shoulders of the piston stem and the ends of slide valve 3, so the piston can move this distance without moving valve 3, this allows the piston to move and close the feed port *i* as well as open and close the ports under the graduating valve without moving slide valve 3. On the reservoir end of the triple is attached a cage 29, containing a "retarded release" stem 31 and its spring 33. A small pin 34 prevents stem 31 moving too far in the cage when taken off. There is no feed groove in the shoulder of piston 4 where it rests against the slide valve bushing when at its extreme travel in releease position, so that in this position, air passing through feed port *i* can not get into the auxiliary. When the piston and slide valve are in *free* release position the stem 31 and spring 33 are in normal position—not compressed—the exhaust port in slide valve 3 is wide open and the feed ports open so train pipe air can equalize to the auxiliary. In the triples used with 10 inch brakes and larger ones, there is also a feed port through the slide valve that is open in *free* release. There is a *small* feed port through the slide valve that is open only in retarded release position which charges the auxiliary very slowly. The feed port *i* around the piston charges the auxiliary in *free* release position only, and is the same size in all quick-service triples, as most of the air in the large triples passes through the feed port through the slide valve. After the auxiliary has charged to standard pressure, which we will assume is 70 pounds, a moderate train pipe reduction will move the piston 4 to the right following the reduction. This movement first closes feed port *i* and moves the graduating valve 7 on the back of the slide valve 3 to close feed port and open the supply ports under it. The slide valve then moves first closing the exhaust port and next opens the service ports in valve 3 to the ports in its seat. Auxiliary air then flows to the cylinder through port *p*. At the same time train pipe air from chamber Y flows through ports *b*, *c*, the cavity of the graduating valve 7 and ports in slide valve 3 into port *t* in the seat, and thence around the emergency piston—which is not an air tight fit—into X and the cylinder. This small amount of train pipe air passing to the cylinder is not sufficient to cause an emergency reduction; but causes the next triple to operate more certainly and thus applies all brakes in a train in less time than when the entire train pipe reduction is made at the brake valve. The train pipe air passing to the cylinder in a service application increases the pressure there so that a five pound reduction in train pipe and auxiliary will give about fourteen pounds in the cylinder as well as applying the quick-service triples in less time from front to rear of train.

On account of the arrangement and size of the service ports the quick-service triples are not as liable to go into undesired quick action as the older form. When in service position the ports are only open a portion of their full size to reduce the auxiliary pressure as fast as the train pipe pressure is ordinarily reduced at the brake valve. If the triple piston moves over enough to compress the graduating spring 22 the service ports will open wide, this reduces auxiliary pressure so fast that the piston will not go to emergency position for a moderate reduction unless it is defective. When the brake valve is placed in full release and the train pipe at the head of the train charged much higher than the auxiliary pressures there the quick-service triples there will move past *free* release position compressing the stem 31 and spring 33 and the slide valve exhaust cavity will be moved far enough so the wide open port of this cavity will be beyond the exhaust port and the small part of the exhaust cavity will be in register with the port. This causes the air to exhaust from the brake cylinder very slowly and the quick-service triples at the head end that have the high train pipe pressure hold their brakes set some seconds longer than when in free release position. As the train pipe pressure reduces farther back in the train until it is not enough higher than the auxiliary to move the triple piston to retarded release position against the resistance of spring 33, the triples will all move to free release position as fast as the increase of train pipe pressure reaches them. On a fifty car train equipped with the quick-service triples, about one-third of them or fifteen to twenty will go to retarded release and those next will release quickly. This tends to release the middle and rear cars of a long train before the cars next the engine are fully released, and thus prevent the slack running out and breaking trains in two or more parts when releasing brakes at a slow speed. To get the full value of the quick-service triples when the entire train is not equipped with them, these triples should be next the engine. When at the rear they do not release any different than the ordinary quick-action triple.

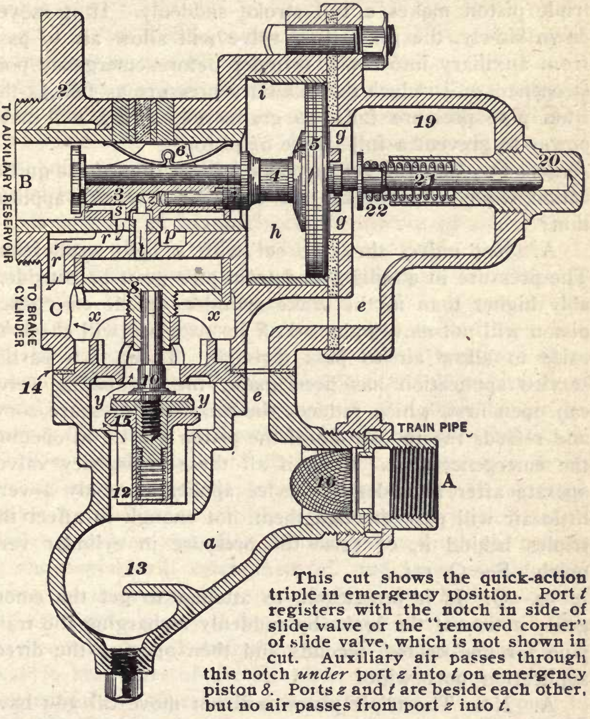
47. Q. What is the emergency or quick application?

A. If the train pipe pressure is suddenly reduced at the first application ten pounds or more, at the quick-action triple, so the graduating valve cannot reduce the auxiliary pressure at the same rate, auxiliary pressure will move piston by the service position, the emergency part of the triple valve is brought into action, opening a large port in the triple so the air goes from the train pipe direct into the brake cylinder, not only setting the brake quick-action but also reducing the train pipe pressure suddenly at that point, instead of all the air going clear to brake valve to escape and reduce pressure. This sudden reduction sets the next triple in the same manner, which sets the next one, and so on to the last car; its action from one car to another is so quick that even on a long train it seems to catch all at once. When a quick-action triple takes air from the train pipe and sets the next triple quick-action, it also takes air from its auxiliary through a small port *s*, after the train pipe has equalized, so the full application is made at sixty pounds, about ten pounds more than the piston pressure in full service application.

A sudden reduction of train pipe pressure which will pull the triple piston down hard enough to compress the graduating spring and let piston make a full travel will open the large air port in plain triple valve, so brake will set somewhat quicker, but does not set with any higher piston pressure.

48. Q. Explain the operation of the quick-action triple when used on the "emergency."

A. A sudden reduction in the train pipe pressure right at the triple must be made, so the triple piston will make a full stroke and open the emergency port in seat under slide valve, which will admit the auxiliary pressure over the emergency piston 8. This in turn pushes the emergency or rubber-seated valve 10 off its seat, and the train pipe air can then go direct to brake cylinder through large port C, raising the train pipe check valve 15 to do this. As soon as the train pipe and brake cylinder pressures have equalized, the check 15 seats itself, and a spring in this check valve pushes the rubber-seated valve 10 up against its seat as soon as the auxiliary and brake cylin-



This cut shows the quick-action triple in emergency position. Port *t* registers with the notch in side of slide valve or the "removed corner" of slide valve, which is not shown in cut. Auxiliary air passes through this notch *under* port *z* into *t* on emergency piston *8*. Ports *z* and *t* are beside each other, but no air passes from port *z* into *t*.

QUICK-ACTION TRIPLE VALVE—EMERGENCY POSITION.

der pressures are nearly equalized. At the same time that train pipe air is passing into the cylinder, the air from the auxiliary is also going through a small port in the end of slide valve 3. This port is made very small to give the train pipe air a chance to equalize into the brake cylinder first, then the auxiliary pressure equalizes with the brake cylinder afterward, at about sixty pounds. The emergency valve 10 is used to hold the train pipe air out of the brake cylinder, therefore in quick-action it must be moved off its seat against the train pipe pressure; this is done only when triple piston makes a full stroke suddenly. If it moves down slowly, the graduating valve will allow air to pass from auxiliary into brake cylinder before emergency port is opened, and reduce the auxiliary pressure as fast as the train pipe pressure falls, so graduating spring will have power to prevent a full stroke of piston.

49. Q. Can you get the emergency action of the quick-action triple while brakes are set with a service application?

A. Not unless they are set with a light application. The pressure in auxiliary and train pipe must be considerably higher than in the brake cylinder, or the emergency piston will not move valve 10 off its seat, nor will check 15 raise to allow air to pass through. Then, if a partial service application has been made, the graduating valve can open first, which reduces the auxiliary pressure some and retards the full stroke of the piston a little in opening the emergency port. Even if all these emergency valves operate after a moderate service application, only a very little air will pass through them, not enough to affect the triples behind it, or raise the pressure in cylinder very much. See Q. 111.

50. Q. Is it practicable to attempt to get the emergency action of the brake by suddenly recharging the train pipe for one or two seconds and then opening the direct application port wide?

A. No. The triple piston will not move till you have reduced the train pipe pressure a little lower than the auxiliary pressure, and no air can pass into the brake cylinder from either train pipe or the auxiliary till piston moves and opens the valves. By this movement you will partially release some of the brakes and get a lighter service application the second time than you had at first.

Don't try it. Unless you have time to recharge auxiliaries to seventy pounds, hang on to what you have.

51. Q. When is it necessary to use the emergency application?

A. Only in case of accident, or sudden danger to train or persons.

52. Q. Is it safe to try and retain air in a train pipe in the emergency application, and why not?

A. It is not safe as a general rule. In an emergency when life or property are in danger, you must act quickly. The point is to get stopped dead as soon as possible, and see about getting started afterwards. An emergency application is the last resort and you must get it when you need it. If you do not let nearly all the air out of a long train pipe, some of the triples will not act quick enough. If three or four triples are cut out, or there are three or four plain triples close together at the head end of the train, the "quick-action" will not catch behind them and all the air must be let out at head end of train to reduce the pressure as quickly as possible. A full reduction of twenty pounds is necessary to set the plain triples on engine and tender so these brakes will do their full share. With a "double header" it is generally necessary to let the air out at brake valve of rear engine to catch the quick action on the train. With a full train of quick action triples a sudden reduction of twenty-five or thirty pounds at the engine will catch them all and leave considerable air in the train pipe, so you can release and back up out of the other train's way if the brake stops you in time. This is the only special exception to the general rule. It is easy to hold part of the air when making tests or in the instruction car; but when you think some one is going to get killed it is not quite as easy as "clear over" to "full emergency."

53. Q. How does the quick action triple operate on a short train if graduating pin is broken?

A. With the emergency on a light service application. If the graduating pin is broken, the graduating valve will be held on its seat by auxiliary pressure, and the emergency port is the first one to open.

If the graduating valve is gummed up or dirty so the air can not flow past it properly, the triple will work with emergency when you make a moderate service application. With a long train the emergency port is opened so gradually that the air can get past the emergency piston and go to the cylinder without moving the emergency piston.

54. Q. If while making a moderate service application your brakes would "fly on" and at the same time the air would stop running for a moment from train pipe exhaust and then begin again, where would you look for the trouble?

A. In one of the quick action triples. This action of the brake valve shows that one of the triples is working quick action only, in advance of the rest, even with a service application. When the triple works quick action, it takes some air from the train pipe, reducing the pressure so the equalizing piston seats for an instant. At the same time the black hand takes a sudden drop for an instant. Probably the graduating pin is broken, although a broken graduating pin in service is very rare. If the graduating spring 22 has been left out it is very apt to cause quick action. If the triple piston or slide valve is gritty or badly gummed so it does not move freely, it will cause this trouble.

If the graduating valve or its ports are gummed up so that the air cannot flow past it out of auxiliary to equalize the pressures as fast as it flows out of train pipe, this triple will be sure to work quick action. A quick action triple that needs cleaning, or has the graduating ports defective in any way, is liable to work quick action with a moderate service reduction. If the train pipe exhaust elbow is gone from the brake valve it will allow so sudden reduction of train pipe pressure that the triples will work quick action on a very short train.

To locate one of these defective triples, close some of the angle cocks so as to use not over ten cars at a time, and make a moderate reduction, say five pounds, then make another of five more. If the brakes work quick action you can be certain the defective triple is on one of these cars. After recharging set the brake again with about seven pounds reduction, and note which brake has not set at all. Cut this one out and make another test which will show if you have the right one. If you do not find it in the first set of ten cars tried, cut in some more and try them. The disabled triple will not always set at the first reduction, and will work quick action at the second one; it is more apt to give trouble in a short train than in a long one.

55. Q. If with a quick action triple, the brake should refuse to release, but kept blowing from the exhaust port or pressure retainer, what would be the matter and what would you do?

A. The emergency valve 10 was likely held off its seat or was worn out and leaked badly. If out on the road and valve would not quit leaking after a few emergency applications, would cut out that brake. If the gasket between the triple valve and cylinder head on a passenger brake or next the reservoir on a freight brake had blown out, it would let auxiliary reservoir air into exhaust and the blow would soon be down to the capacity of the feed port in triple valve. A small leak past the emergency valve when the brake is set will soon equalize the brake cylinder and train pipe pressures. With a sticky triple this brake might not release with increase of train pipe pressure and wheels be skidded. Better cut out such a brake and bleed it.

56. How do you locate a leak that lets off the brake?

A. If it leaks off through piston packing leather the air will blow out of the hole in spring case or lower head in push down brake; with a pull up brake, around piston rod or through the vent hole in top head. A leaky train pipe check valve 15 will let the air out of brake cylinder into the train pipe, but only when train pipe pressure is lower than cylinder pressure. This will be the case when hose bursts or train breaks in two, or engineer reduces the train pipe pressure too much. In ordinary service stops, leaks at this point do not affect the work of the brake.

A test for leaky train pipe check valve 15 in the quick action triples can be made at the brake valve. Reduce the pressure twenty or twenty-five pounds from seventy, and if the air comes out full and strong and the equalizing piston seats its valve promptly without a leak, make another reduction of fifteen or twenty pounds more. With this reduction the brake cylinder will have about fifty pounds and train pipe thirty. If any train pipe check valves leak, the fifty pounds will try to equalize with the thirty, and make it more than the pressure above equalizing piston, which will raise and let air blow out of exhaust as fast as it comes past the check valve.

To locate a leaky rotary or any leak in brake valve that lets off the brake, set the brake; close the cut-out cock at once; brake will stay set and black hand will raise or train pipe exhaust open. Then open cut-out cock and brake will release through exhaust port of triple.

To locate a leaky graduating valve, set the brake with a light application; it will release through exhaust port of triple about as quick as you can lap the brake valve. Then, after recharging the auxiliary, set with a full application and brake should stay set.

When a leaky graduating valve lets off the brake with a light application, it is because the air from the auxiliary leaks past the seat of valve 7 into the brake cylinder until the auxiliary pressure is enough lower than train pipe pressure so triple piston will move air slide valve up into exhaust position, releasing air from brake cylinder through the exhaust port. This it cannot do with a full application, as in this case the air pressure has equalized between the auxiliary and cylinder, so a leaky valve cuts no figure; air will not pass through after pressures are equal. A leaky piston ring in the triple makes this matter worse, as the train pipe and cylinder pressures can equalize and stick the brake. A leaky triple usually is in bad order in other ways.

57. Q. If the brake is defective and leaks off through piston packing, or any leaks in piping to brake cylinder, is it any advantage to let all the air out of train pipe in such a case?

A. It seems to make a leaking brake hold a little longer, but it is so short a time that it does not help very much to stop the train. A gage put on this brake cylinder will show that it only holds for a few seconds, and during that time with a light pressure. The proper way is to stop the leak.

58. Q. What makes the driver brake so slow to take hold if coupled to a train when it works all right if engine and tender are working without a train?

A. Generally it is because it leaks somewhere, so the air leaks out without setting the brake when a light reduction is made for the train brake. See about the leaks the first thing. The piston packing leather gets dry and hard from being so close to the fire box and it needs soaking up with water and oil frequently in the summer time. Tallow and oil is good to put in driver brake cylinders, as it does not evaporate so quickly as oil or water and keeps the packing leather soft and pliable. On account of freezing up no water can be used in the winter time, oil only. To test for leaks, set the four-way cock in plain triple for straight air (if possible); this will give you time to go around and find the leaks. If the piston leather leaks, the air will blow out of hole in the spring case or lower head of push down brake. Using the brake valve on direct application position for service stops will sometimes kick the driver brake off, after setting the train brake. This is because when you use the direct application port to set the brake you make a heavier reduction at head end of the train pipe than at rear end. The head end triples equalize for this reduction; air from rear end rushes up after you close the brake valve and releases head triples. This is another reason why the direct application should never be used unless you want the emergency action of every brake.

59. Q. Why does the tender brake sometimes stick and refuse to let off till auxiliary is bled a little, when all the other brakes on the train release promptly?

A. Generally because not enough excess pressure is carried. Always carry a sufficient excess if you want the automatic brake to work properly. Some old tenders have 12 x 33 inch auxiliary reservoirs for an 8-inch brake cylinder; if, in this case, the piston travel is short, the brake piston pressure is six or seven pounds higher than other brakes equalize at and train pipe pressure must be raised correspondingly higher to release tender brake. Then the tender triple gets more sand and dirt in it than any other triple, which causes it to wear and get defective. A leaky triple piston packing ring will allow any brake to stick unless very high excess is used, as it will let air equalize past the triple piston into auxiliary without moving piston up to exhaust position.

60. Q. If the train pipe is charged up with a high pressure from main reservoir when brake is released for a second application stop, will the brake set again at once with a small reduction of train pipe pressure?

A. It will not set again until the train pipe pressure is reduced below the auxiliary pressure. For example: If the brake has been set tight, the auxiliary pressure will be about fifty pounds for the first application; if you turn ninety pounds into train pipe you must let forty pounds out again, to draw train pipe pressure below fifty, before the triple piston will move; all this time your train is getting nearer the stopping point. This is one of the reasons why you run by when trying to make a stop this way; it takes so long to draw your train pipe pressure down where it was before. In case you expect to apply the brake at once after releasing it wholly or partly, put the brake valve on full release for an instant, just long enough to charge up the train pipe its whole length, and then put it on lap. This movement will hold your train pipe pressure so near the auxiliary pressure that the triple is ready to act instantly with light service application.

This is the proper method of making partial release if you are going to stop too soon or expect that slippery track will skid the wheels just as the final stop is made.

61. Q. Why are some of the train brakes more likely to stick on a *long* train after a light application than after a heavier one?

A. Because after a light application the pressure has been reduced so little in the auxiliaries that the main reservoir does not have enough more pressure to move all the triples. A light reduction on a long train does not always move all the triple pistons and their feed ports remain open ready to take train pipe air, which holds the train pipe pressure down. With a heavy reduction the triples all operate, no feed ports will be open till triples release and the train pipe pressure will raise higher at the moment of releasing brakes. This is a trouble peculiar to long trains only; small main reservoirs and sticky triples with leaky packing rings make it worse.

62. Q. Is it possible to let off part of the brakes and leave part of them set?

A. Yes. After a full application this can be done, especially if train pipe pressure has been reduced much more than twenty pounds. When you go to full release, if the train pipe is not at once charged up above the highest auxiliary pressures by the main reservoir air, as soon as the train pipe pressure is a little higher than the lowest pressure in any auxiliary, its triple will move up into exhaust position, releasing that brake. Then this auxiliary will begin to recharge through feed port and help hold train pipe pressure down till that auxiliary and the train pipe are charged up high enough, when another brake will let off; and so no, until all are let off. The brake with longest piston travel usually lets off first, because it has the lowest auxiliary pressure; this operation takes place after a full application when piston travels are unequal. When pumping off the stuck brakes you have to raise the pressure in all the auxiliaries of the released brakes as well as in the train pipe. When you think the brakes are releasing in this manner, lap the brake valve and pump up the excess; when this is turned back into the train pipe they will usually all let go. Do not attempt to work steam, you will risk a break-in-two.

63. Why do some of the brakes creep on when the train is running?

A. Because there is a leak that takes air out of the train pipe; this leak may be in the train pipe, triple valve or auxiliary reservoirs. It can also be on account of the auxiliaries not having all equalized after releasing the brake. The auxiliaries at the head end of train will charge to a higher pressure on full release than the rear ones; when the brake valve is moved to running position the higher auxiliary pressure will cause the head triples to move to service position. If air is fed into the train pipe faster than it leaks out, the brakes will not creep on. If air sanders use so much air that the pump can not supply air to hold up main reservoir and train pipe pressures the brake will set; this is a main reservoir leak taking air out of train pipe.

64. Q. How can these brakes be released the quickest and surest way?

A. If a main reservoir leak reduces train pipe pressure, shut off the escape of air if possible and run the pump faster till train pipe pressure is raised so brakes will release. If a leak from train pipe sets the brake, see that you have excess pressure first, then turn it back into train pipe by moving the brake valve handle from "running position" to "full release" just long enough so the rush of air from main reservoir will charge up the train pipe, and putting it back to running position before any of the auxiliaries are charged any higher. This forces the triple valves of the sticking brakes up into release position, so air from brake cylinder exhausts and does not give time to raise the pressure in any reservoir. Sometimes this must be done a second and third time to release all of them. If brake valve is held on full release long enough to charge a reservoir higher than the standard train pipe pressure, that brake will be sure to set as soon as brake valve is returned to running position. This is the case when the feed ports are too large in proportion to the auxiliaries that they supply.

65. Q. If governor is set at seventy pounds with D-8 valve or any brake valve of that type, and train pipe is charged from main reservoir higher than that pressure, is the brake apt to creep on?

A. Yes; the pump is stopped and will not start again till train pipe pressure is lowered to seventy pounds. The excess valve will remain shut so no air can pass into the train pipe, and if there are any leaks the train pipe pressure will drop. During this time brake is pretty sure to go on.

66. Q. How can this be avoided?

A. By not allowing main reservoir to charge train pipe and auxiliaries at over seventy pounds. When standing at a water tank, or any stop, with brakes set, the main reservoir pressure is apt to run very high. If all of this is turned into train pipe and allowed to equalize at over seventy pounds, with brake valve carried in full release regularly, there is no way to prevent the brake setting if train pipe leaks. In this case, set it a little and at once release it; this will reduce the train pipe and auxiliaries below seventy pounds, so pump will go to work and you can hold brake off.

67. Q. In making a stop how should you release the brakes on a freight train? On a passenger train?

A. On a freight train not till it has entirely stopped, or you run the risk of train breaking in two. The train pipe pressure on a long train is increased next the engine first; hence brakes let go there first; even if it is only a few seconds sooner. Part of the shock is from unequal piston travel, which gives unequal piston pressure; brakes with long piston travel let go first after a full application. With a "part air" train the slack of entire train runs up against the head cars; releasing brake while train is moving slowly, is liable to part the train; working steam before slack is all evened up in train is sure to break it in two. Using pressure retainers on the head end of such a train or the Straight Air brake on engine will hold the slack all bunched till all triples have released when retainer handle can be turned down or engine brake released.

With a passenger train, release should be made just a few feet before the train stops, so there will be just enough power to stop the train and avoid tilting the coach truck forward at the instant the train stops. If the brake beams are hung from the body of the car the truck will not tilt forward.

68. Q. Why should a brake on a short passenger train be let off just before coming to a full stop?

A. Because, as most all coaches have outside hung brakes, the brake shoes pull down on the forward end of the truck and push up on the back part of the truck and thus tilt the truck; if brake is not let off until after the train stops, when the truck rights itself it rolls the wheels back a little and throws the body of the coach back, annoying the passengers, even if it is not severe enough to throw them against the seats. This trouble is not felt so plainly by the engineer when he has a good driver and tender brake, as the brake on the coach is what jerks the coach. Then less power is required to stop a train going very slow, as at the instant of stopping, than when running at full speed; if power enough is left on to hold a train at full speed, it must stop very forcibly at slow speed. The brakes should begin to release about half a rail length from where the train finally stops; a little farther if going very fast, a little less if a very slow stop is being made. Practice will teach you the distance.

There is an exception to this rule in the case of a very long passenger train, say over twelve coaches, especially if it is not vestibuled and the buffer spring slack all taken up solid between the cars. Experience will teach you that in stopping a train of this length less shock will be given the front end of train if brake is held on moderately tight just at the instant of stopping till train stops; i. e., handle a very long passenger train about the same as a freight train of the same length.

69. Q. How should a "two application stop" with a passenger train be made?

A. Make a full application when running at a high speed so as to have a high brake power at high speed. When the speed is reduced to 15 or 18 miles an hour, and you are stopping short of the desired point, go to full release for an instant, just long enough to start *all* triples to exhaust, then begin the second application at once by a moderate reduction which should set all brakes at a moderate power. You can increase the brake power with another reduction so as to stop at the exact point, and, if necessary, leave the brake set without having power enough to tilt the trucks and shock the passengers. This method reduces the risk of sliding wheels, as brake is set tight at high speed when wheels do not slide, then let off and set with less power at slow speed.

70. Q. Describe the position of the handles to all valves and cocks in the air brake and signal equipment, whether open or shut.

A. All the handles, except to angle cocks, stand at right angles or crosswise of the pipes when they are open; parallel to pipe when "cut out"; plain triples and pressure retainers follow the same rule, their handles are horizontal or crosswise when "cut in". The crooked handle of angle cock is parallel with pipe when cut in. This is so the hose will protect handle from being struck by anything flying under the car and getting shut off, as the old style straight handled cock is liable to. A small groove square across the end of plug shows whether cock is open or shut, as the groove runs same way with hole in plug.

71. Q. Do you understand that all air cars in a train should be connected and train pipes charged with air, whether brakes are cut in or not? Why?

A. Yes. All train pipes should be coupled up and air working through them, so that if the train breaks in two anywhere in the line, all brakes will be set that are working. Interstate Commerce Commission rules say so.

72. Q. What should be done with a car on which the train pipe is broken?

A. If it cannot be plugged at leak and allow air to pass freely to cars behind it, it must be switched behind all other air cars; have air in hose that is coupled to next car in front; brakeman should look after that car and all behind it. If you have two ¾-inch air brake hose, the signal hose can be taken off signal line, brake hose put on, and signal line used for brake line through that car to get air back to other cars.

73. Q. If the pipe at one end of the car should come loose, would you consider it dangerous? Why?

A. Yes. If the pipe at end of car gets loose so cock will bounce up and down and strike the handle end of plug against the dead wood or any part of car, it is liable to work shut gradually. This is caused by the spring which holds the plug in its seat, turning plug a little each time it strikes. If the spring is wound one way, it works open; if the other way, it works shut.

74. Q. 1. After coupling to train why should you not immediately try to apply the brakes for inspection? 2. How long should you wait?

A. Because you must wait till a full pressure of seventy pounds is stored in auxiliaries so a full application of brakes can be obtained to get the piston travel. The time you should wait depends on the pressure maintained in the train pipe from the moment of coupling on; if seventy pounds is held steadily, two and one-half minutes is the shortest time for some of the older makes of triples. The triple valves of late design charge to seventy pounds in about seventy seconds. The pressures must be equal in all the auxiliaries even if it takes longer before testing. When the governor stops the pump with the standard pressures shown on both hands of the gage it is usually long enough.

75. Q. Should the train brakes be inspected? How? When? Why?

A. Yes, by applying them with full service application in the same maner as for a station stop with a moving train; then examine each car to see that the piston travel is the proper length and that there are no leaks that will let brakes off; then release them and examine each car to see that all release and that there are no leaks through exhaust port. They should be inspected at all terminals and tested whenever train breaks in two, or cars are taken on or set off, as the wrong angle cocks may be closed or left closed at such points. This is necessary because it is not safe to depend on a brake till it is shown that it will set and release properly. Hand brake should always be let off before testing. If pressure retaining valves are tested they should be turned up after the first test is completed, a reduction of ten pounds made in train pipe, and the train pipe recharged to release the triples. The retainers should then be examined to see that they are all quiet; handles should then be turned down. If they are in good order the air held in brake cylinder will come out as soon as handle is turned down. If no air blows out the retainer is useless.

76. Q. Would you consider a train safe to leave with if the brakes had been tested by opening angle co ck at rear of train? How would this affect your main reservoir pressure?

A. No, sir, not unless some other test has been made. This would not set all the brakes unless the brake valve was on lap. It would draw down main reservoir pressure and waste air without doing any good. This test is only good to show that air hose are coupled, angle cocks open and train pipe charged from engine to last car.

77. Q. If you release the brake and apply it again immediately, would you expect to obtain the same power you had before? How long would it take to regain the original pressure?

A. No, sir! *never.* About forty seconds, if main reservoir had thirty-five or forty pounds excess over auxiliaries, sometimes less time. The feed ports in triple valves which regulate the time of charging are not always the proper size for the reservoirs they supply. A short train and light application would reduce this time to twenty or twenty-five seconds. Generally it takes longer than the tests show it with everything in good working order, for the feed ports are not always clean and strainers free. The pressure at which auxiliary equalized after first application is what you begin with on second application after first release, generally it is fifty after first full application; with full release of brake and immediate application you get thirty-five and a little more on second full application; the third time you will have less than thirty pounds piston pressure.

78. Q. Can an auxiliary reservoir be recharged without releasing the brake?

A. No, not if the triple valve is in good order. The ports are so located in the triple valve that the "feed port" through which auxiliary is charged does not open till after exhaust port is open, which releases the brake first, recharges the auxiliary afterward. By the use of a pressure retaining valve, which holds some of the air in the brake cylinder, the auxiliary can be recharged without releasing the brake entirely.

79. Q. Why does it take so long to regain the original pressure in the auxiliaries after releasing brakes?

A. Because the feed port in the triple through which the air passes from train pipe to auxiliary is small. This feed port is shown at "m" in the plain triple, and at "i" in the quick-action triple. It is necessary to have this port small for two reasons; first—when setting the brake, the feed port must be small or when train pipe pressure is reduced at brake valve for a light service application, the auxiliary air could flow around the triple piston through the feed port "i" as fast as it is taken out of train pipe; so triple piston would not move. If the feed ports were larger, when brakes are to be released, it would be impossible to charge up a long train pipe from the engine and hold the pressure up quick enough to release all the brakes at as nearly the same instant as possible, as the first few ports to open would take some of the train pipe air and hold the pressure down; if they were large enough a few of them would do this. The quick-service triples are now arranged to help this matter out. These feed ports must be the proper size for the auxiliaries they supply, so different sized auxiliaries will charge to the same pressure in the same time from the same train pipe. The auxiliary reservoir for a 10-inch coach brake holds about 3,100 cubic inches, that for an 8-inch freight brake holds about 1,620 inches; therefore a feed port for a 10-inch brake reservoir must be the right size to pass nearly twice as much air through in the same given time as for an 8-inch brake. This is the reason for using only the proper triple for each reservoir. Then the reservoirs are a certain size for the brake cylinders they supply, so an auxiliary pressure of seventy pounds will equalize with brake cylinder of 8 inches piston travel at fifty pounds. This in turn gives a standard piston pressure for which to arrange the brake leverage on each car or engine, so as to get the full effective braking power. The older style of plain triples, F-24, used with 8-inch engine brakes, have feed ports the proper size for 12 x 33 auxiliaries. This gives a quicker recharging and a prompter application with these brakes in switching service. If engine brake creeps on from this cause when coupled to a train they are easily released as they are close to the brake valve and main reservoir. The present style of plain triples, G-24, have the proper sized feed ports for the 8-inch brake.

80. Q. Where are leakage grooves located? What are they for? Is it necessary to allow for them when applying the brake? How do you do this?

A. Leakage grooves are small grooves cut in the inside of brake cylinders at the top or side. The later freight brake cylinders have them at the side. When the brake piston is in release position this groove is uncovered so that a small amount of air passing into the brake cylinder from a very light application, or when the brakes are creeping on, will escape through the groove without moving the piston. When the triple valve is in release position any air that gets into the cylinder from leaks can pass out through the exhaust. They also prevent the brake holding when the piston travel is taken up too short. In old equipment they are long enough so that a piston movement of three inches is necessary to cover the groove, in later equipment they are much shorter. It is necessary to allow for them at the first reduction by making it strong enough so that the brake piston will go far enough at the first movement to cover the groove. Five to seven pounds reduction should do this; a short train does not take as heavy a reduction as a long one. The leakage groove must be covered at the first reduction or the air passing into the cylinder will be wasted, a number of small reductions will waste all the air so train cannot be stopped. This is a common fault in operating the brake. If the hand brake is set on a coach or the piston travel shortened to less than three inches that brake will not hold.

81. Q. Does the difference in travel of pistons in brake cylinders increase or decrease your braking power? Why?

A. Long piston travel decreases the braking power because it gives less air pressure on piston, short piston travel gives higher piston pressure. With 8-inch piston travel, seventy pounds auxiliary pressure gives fifty pounds on piston per square inch. An inch difference in the travel make close to two pounds in pressure, thus seven inches would give nearly fifty-two pounds, nine inches a little over forty-eight pounds. The piston travel can be correct with a heavy car and high leverage, and the shoes will not clear the wheel much when released. If levers and brake beams spring much with 8-inch travel, the shoes will not have much slack when let off. Brake levers may catch on something so piston travel is correct and shoes not touch the wheels. With the straight air brake or the distributing valve the piston travel does not affect the pressure on the brake piston, as these valves do not take air from an auxiliary as the triple valve does.

82. Q. How do you cut out the brake on engine and tender without interfering with the train brake?

A. By turning the four-way cock in top of plain triple so the handle is at an angle of forty-five degres; this will lap all ports and allow no air to pass from train pipe or auxiliary to brake cylinder; see that brake is entirely released first, and open bleeder in auxiliary. With the latest type of engine triple the cut out cock is in the cross over pipe, so closing the cock cuts out the triple. Open bleeder in auxiliary so the brake cannot creep on from a leak in the triple.

83. Q. What is the difference between cutting the air out from a car and cutting it out from a brake?

A. Shutting the angle cock at the end next engine cuts out that car and all behind it; shutting the cock between train pipe and triple cuts out that brake only and allows all the rest to operate.

84. Q. If one brake beam under a car was broken how would it affect that brake? How would you cut out the brake on that car and allow air to pass to other cars?

A. If one brake beam or rod is broken, the brake on that car is useless and it must be cut out by shutting the cock in the crossover from train pipe to triple, or by turning the four-way cock in plain triple. This will allow air to pass through train pipe to other cars without operating disabled brake. Be sure the brake with plain triple on either engine, tender or coach is released before it is cut out, as no air can get out of brake cylinder after cock is turned. The plain triple used on freight equipment before the quick action triple was perfected, which is still in service on a great many freight cars, bleeds the brake cylinder when the handle of plug cock in triple is turned to the cut out position but does not bleed the auxiliaries, so the brake is likely to set when handle of cock is turned to automatic again. There is no bleeder in the cast iron auxiliary for this triple and the air escapes from brake cylinder through a bleed hole in the plug of cut out cock. This is shown in question 100. If this hole gets stopped up, cut out the car from the others, open the stop cock at hose, turn the cock in triple for straight air and air will escape from brake cylinder through train pipe, after which the cock in triple can be set for cut out position. All quick action brakes can be bled by opening the bleeder in auxiliary reservoir and allowing all air to escape, as the cut out cock does not close the communication between brake cylinder and the bleed cock in auxiliary.

85. Q. In going down a long, steep grade how would you handle the brake to control the train? Why is it necessary to recharge the auxiliaries on a hill? How is this done?

A. Air braked trains on a long, steep grade must be taken down at a moderate speed in order to control the train; much less brake power will hold it at a slow speed than a fast one. If the train once gets the start of you it may not be held at all. Run slow enough so you will not need all the brake power to *steady* the train, or you will not be able to stop when necessary.

Leaks in train pipe, auxiliary, or brake cylinder pressures make it necessary to recharge; very few if any trains are absolutely air tight. If train pipe leaks, the brake will set at full power, which should stop the train; this will call for a release and recharging to standard pressure. Auxiliary or brake cylinder leaks will reduce the braking power so train will run away; to avoid this disaster it is necessary to recharge the auxiliaries frequently; you can then hold the auxiliary pressure up close to the standard amount all the way down the hill and have plenty of brake power. As triple valves release a brake and recharge the auxiliary afterward, to hold the brake set while auxiliaries are recharging, pressure retaining valves are used, which hold some of the air in the cylinder after triple has gone to release position. Before starting down the grade turn up the handles of retainers, use as many as possible and not have them stop the train at any of the let-ups in the grade. The more retainers used the less hot wheels, as the holding power is on a greater number of cars; if the full brake power is used on any cars all the way down a long hill the wheels are liable to get so hot as to damage them. Make a moderate application at first; when the train slows down, release and leave brake valve in full release position to recharge as quickly as possible, which should not take over forty-five seconds. On the next application, a light reduction will usually steady the train, as with retainers used the pistons are over the leakage grooves and considerable pressure held in the cylinders. Light reductions give more power to brakes with retainers working than heavy reductions without the retainers; this saves both train pipe and auxiliary air. Pick out places where sharp curves or let-ups in the grade slow up the train to recharge auxiliaries. Air braking on a long hill should be learned on that particular hill—no exact rule can be set down; the instructions here given are general. To test the brake power developed on various cars, feel of the wheels at the bottom of the hill when possible; cold wheels on some cars and hot wheels on others show unequal braking power. Use the independent engine brake while recharging, this will help hold the train.

86. Q. What is the difference between handling a long train having part air in front and one entirely of air?

A. A great difference. It requires more skill and practice to make a good stop with a part air train than with a full air train. With part air you must be careful to "bunch the train" so slack will run up easily against the air brake cars before setting the brake very tight; this takes some seconds. If you make a second reduction before the rear end feels the effects of the first one, the two light applications make one heavy one, as far as the shock to the rear cars is concerned. When backing up, extra care must be taken, or train will break in two and merchandise be damaged in cars. With a full air train the first reduction of train pipe pressure takes so much longer to start all the triples to work that you must wait about as much longer after the train pipe exhaust stops flowing before making a second reduction. The brakes are longer in releasing, and this requires more time after releasing before the train runs free.

87. If you had a freight train with "part air" cars in operation and you used the emergency application,

would it make any difference whether the slack was out or not? In case there was a shock, on what part of the train would it fall?

A. Using the emergency brake with part air train always sets the head end hard and solid; if slack is all run up against the engine the shock is not as great. In any case the rear end gets all the damage; the weakest cars and draft gear behind air cars suffer. Empty flat cars next the air are likely to be wrecked.

88. Q. Which engineer should handle the brakes in double-heading, and what should the other engineer do?

A. The leading engineer should handle all the brakes when double-heading, as he is the only man who can see clearly all the signals and the condition of the track ahead, so as to act promptly to stop the train when necessary. The following engineer should shut the cut out cock under his brake valve, which should be in running position with the 1892 valve, on lap with the H-5 valve, keep the pump running and a full supply of air. If there is no cut out cock, place brake valve on lap so no air can get into the train pipe from his main reservoir and plug up train pipe exhaust elbow, so that when head engineer releases brakes the train pipe air will not escape through second brake valve. If cut out cock works open or is left open so main reservoir air feeds into train pipe; when the leading engineer makes a service reduction the air from the following engine will hold the equalizing piston of head engine up so that train pipe exhaust will blow strong and continuously. If head man is sure that second engine is feeding into the train pipe when brakes are to be set, he should go to emergency at once, whistle for brakes, get stopped or have second cut out cock closed. The emergency port of first brake valve will take air out of train pipe faster than the second pump and reservoir can supply it, especially if second valve is on running position.

When testing the train brakes from a double-header be sure that main reservoir air of following engines is cut out from train pipe and that the test is properly made from leading engine.

If the rules allow it and a definite arrangement is made between the engineers, the second man can assist in releasing stuck brakes or in charging auxiliaries by opening his cut out cock when signalled to do so with brake valve in full release. As soon as train is moving cut-out cock should be shut so the leading engineer can stop the train at once if necessary.

The rule to carry brake valve on running position with cut-out cock shut varies on different railroads. One prominent system requires that the brake valve be carried on emergency position so that in case of necessity brake will go on at once if cut-out cock is opened. Rules of your own road apply in this case to position of valve.

89. Q. What would you do if an air hose burst? How would you know it? Should you have extra hose? Of what kinds?

A. Put brake valve on lap; whistle out a flag. If in a dangerous place to wait, or when a train is close behind, shut the first cock ahead of bursted hose; let off brakes on head end from engine; bleed the cars behind bursted hose; get to a safe place and replace the bursted hose with a new one. If with bad grades or all air train, put in a new hose any way, if possible. It would be known at once because brake would set; black hand would drop way down; main reservoir pressure would also run down quickly. Put brake valve on lap to save your main reservoir air. To locate the bursted hose put brake valve on running position just so you will keep a little pressure in the hose and trainmen can hear the air blowing out of bursted hose and find it.

Extra hose should be carried on engine, one of each kind used. Trainmen should have a 1-inch, a 1¼-inch, a signal hose and one double end or splice coupling to use in case drawheads or coupling of cars are so long the regular hose and couplings will not meet each other.

90. Q. What course would you take should your train break in two and set the brakes?

A. Put brake valve on lap, shut off steam, whistle out a flag, shut the open angle cock on rear end of last car connected to engine, let off brakes on head section from the engine. When they are released and you get a signal to do so, back up to rear section; after coupling up to it, if brakes cannot be let off from engine, bleed a few of the sticking ones at back end of train until train can be started. Be very careful to shut the bleeder as soon as air begins to escape from triple exhaust port or you will set some of the others, and that will hold the train longer than necessary. All air bled out is wasted; it is done only to save time, which is valuable in a case of breaking in two. If you break in two or burst a hose on a bad grade, shut both angle cocks next the opening in hose, this will save any air that leaks past the triples into the train pipe and hold leaky brakes set till you are ready to release them to move the train.

91. Q. Do you know what the "pressure retaining valve" does? And how? If the pipe leading to this valve should break off would you plug it? If you did, how would it affect the brake?

A. The pressure retaining valve holds some of the compressed air in the brake cylinder after the triple valve has moved to exhaust position. It is attached to exhaust port of triple valve by a piece of pipe and placed where it can be conveniently reached when train is in motion. When set to operate, its handle is turned up to a horizontal position, which closes the direct opening, so the air goes out slowly under a weighted valve; and then passes out of the case of valve through a small opening so air escapes slowly. When pressure falls to fifteen pounds per square inch in brake cylinder, this valve shuts off the escape altogether and holds the air in there, keeping the brake set at fifteen pounds; this allows the auxiliary reservoir to be recharged to full pressure again. It is use d on long, steep grades. If the pipe leading from the triple valve exhaust to the retainer was broken off that retainer would be useless. The pipe should never be plugged, as that brake would not let off at all; there would be no way for the air to get out of the brake cylinder.

92. Q. When air blows out steadily from the pressure retaining valve, should it be closed or left open?

A. Left open by all means. The air that blows out there comes from a leak in the triple valve; shutting the pressure retainer only stops air coming out there and sets the brake, or if leak is a small one, makes it go out through the leakage groove in the brake cylinder. If pressure retainer is turned up, even if the brake does not set right off, it will stay set when engineer sets it and tries to let it off. Never turn up retainers unless you want to hold the brake set the next time engineer releases it. If the pressure retainer is broken off or the pipe leading to it from triple is broken or leaking badly, it does not affect the operation of the brake in any way, except that the retainer cannot be used on that car. If retainer is broken off and pipe plugged the brake cannot be released at all from the engine, as there is no way for air to escape from triple valve exhaust. If there is a leak in pipe from triple valve to retainer, the retainer is of no use, as air will escape from the pipe at leak when retainer is set to work. Sometimes the pipe to pressure retainer gets stopped up so air cannot get through it, in which case the brake will set once and not release till bled off. It is not unusual to find nests of insects in the pipe right at retainer. Pressure retainers are put on all freight cars used in interchange service. Very few coaches have them, only those running on mountain roads. Sleepers and official cars usually have retainers. They are used on level roads extensively to hold the slack bunched in a long train; in this case they are usually applied to the driver brake triple valve and located in the cab in easy reach of the engineer. They are valuable aids in making smooth stops with freight trains at water plugs.

93. Q. How does the air signal operate? If the air signal on the engine whistled each time you released the brakes, what would be the trouble? If the whistle blows frequently when not in use, what is the matter? If it blows one long blast? If the whistle is weak on engine

will it usually help it to blow out the signal hose on the rear of tender?

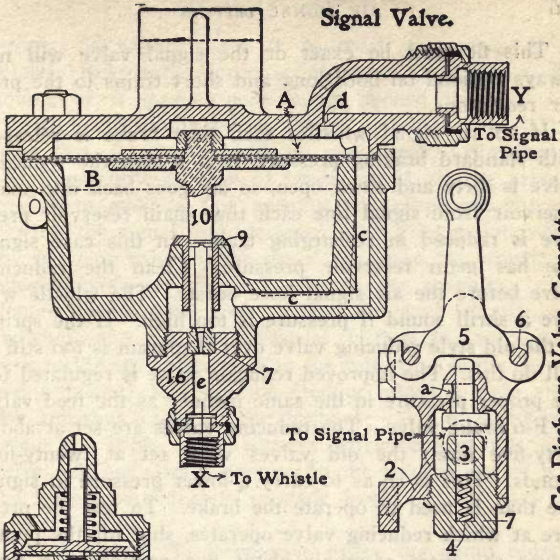
A. The air signal valve on the engine is operated by a reduction of pressure made in the signal line. This signal line is supplied with air from the main reservoir which passes through a reducing valve set at a much lower pressure than the standard braking pressure, so the operation of the brake will not interfere with the operation of the signal. The opening through the reducing valve is choked down to restrict the flow of air into the signal pipe and allow a reduction to be made in its pressure. This reduction must be a *sudden* one, like an emergency reduction for the triple valve, or the reducing valve will feed air into the signal pipe as fast as it is taken out at the car discharge valve. When the pressure is reduced in the signal line at the car discharge valve and this reduction extends to the signal valve, it affects the pressure in chamber A above the diaphram 12 first, so that the pressure in B under the diaphram lifts it up, also raising the discharge valve 10 off the seat at 7, which allows the air to pass to whistle.

If the diaphram gets bagged down, the pressure in B will raise the baggy part of the rubber and valve will not raise off the seat.

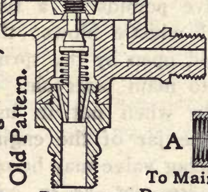
The stem of valve 10 has the sides flattened except for a short distance at the top, where it enters bushing 9, when this stem rises the flattened part comes above bushing 9, and air from B also goes to the whistle, this reduces the pressure in B. When the car discharge valve is closed and the signal line pressure is increased by the reducing valve, as the stem of 10 makes a moderately close fit in the top of bushing 9, air passes into B slowly while recharging. Chamber A is therefore charged up first so diaphram is sure to set valve 10 promptly.

If the fit of the stem at the top of the bushing is too loose the valve is liable to rise on its seat so the signal will "repeat" and give more than one blast for each pull of the car discharge valve.

Signal Valve.

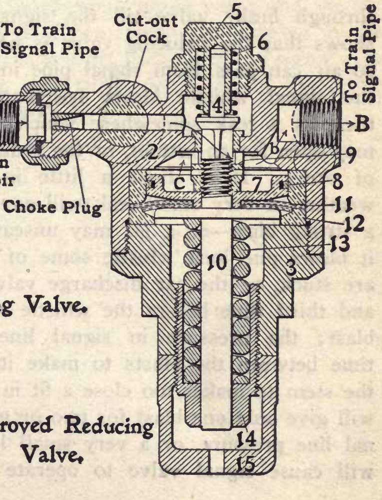


Car Discharge Valve, Complete.



Reducing Valve, Old Pattern.

Pressure Reducing Valve.



Improved Reducing Valve.

This fit must be exact or the signal valve will not always respond on both long and short trains to the proper reductions.

If an air signal whistles each time brake is released with standard braking pressure, it is a sign the reducing valve is dirty and stuck open, so air goes back into main reservoir from signal line each time main reservoir pressure is reduced in recharging train. In this case signal line has main reservoir pressure. Clean the reducing valve before the air signal hose bursts. The whistle will give a shrill sound if pressure is too high. If the spring in the old style reducing valve over diaphram is too stiff it will do this. The improved reducing valve is regulated for the proper pressure in the same manner as the feed valve on F-6 brake valve. The reducing valves are set at about forty-five now; the old valves were set at twenty-five pounds. This is so as to carry a lower pressure in signal line than is used to operate the brake. To test the pressure at which reducing valve operates, shut off the pump, reduce the main reservoir about five pounds at a time through brake valve till the signal whistle blows; this shows that the reducing valve is held open by the spring so air can pass from signal pipe into main reservoir. If the signal whistle blows frequently when not in use, there is a leak somewhere which the jar of the engine may open for an instant, or the reducing valve may be out of order. If it sticks a little in its seat, as in cold weather, a very small leak will cause the whistle to give a strong blast—or a jar may unseat signal valve. When it blows one long whistle some of the valves on engine are stuck, or the car discharge valve is opened a second and third time before the whistle stops blowing the first blast; the pressure in signal line must equalize each time between the blasts to make it work accurately. If the stem 10 makes too close a fit in bushing 9 the whistle will give only one blast for two or more reductions of signal line pressure, or a very small leak in the signal line will cause signal valve to operate at intervals, when a proper fit would allow it to work properly. If the whistle bell works loose so it does not make a clear sound, or is located near partly opened windows so a strong draft of air blows across it, when train is running fast, the sound will be very weak. Blowing out the signal hose at rear of tender gives all the valves a chance to make a full opening and clean out the dirt. To test the signal line for leaks, shut the cut out cock at the reducing valve; if the signal line leaks, the whistle will blow as soon as the leak reduces the pressure. On a double header both whistles should sound for the same reduction of signal line pressure. If they do not, close the cock in the reducing valve on the following engine so only one reducing valve will be feeding into the train signal line and thus allow the car discharge valve to do its work properly. With both reducing valves cut in the signal valve will not always operate on the leading engine when the train pipe reduction is made from the rear cars of a long train.

With the E. T. locomotive brake the same reducing valve is used for the independent brake valve and the air signal system. There is a non-return check valve in the signal pipe so the air can not get back from the signal pipe when the independent valve takes air to apply the brake as it would sound the whistle.

FOR TRAINMEN.

94. Q. When coupling the engine to an air brake train, equipped with quick action triples and already charged with air, which angle cock should be opened first?

A. The one on engine always, so as to fill the hose from engine. If cock on car is opened first, the train brake is liable to set with emergency action. Get in the habit of opening the cock on engine first, whether train is charged or empty.

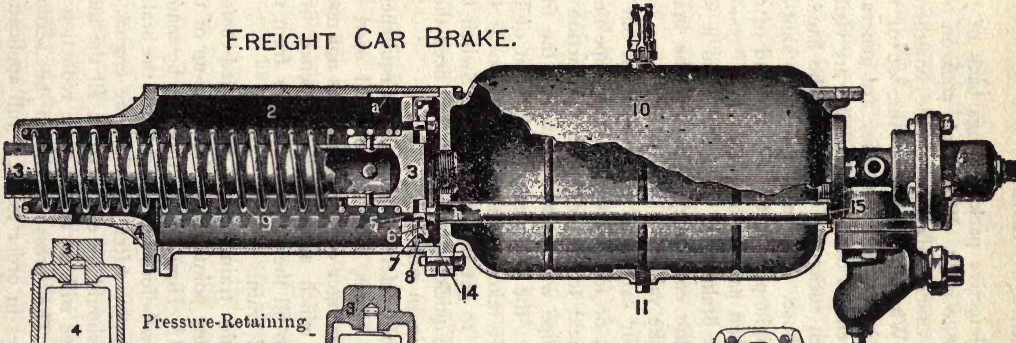
95. Q. When coupling an empty car to other cars already charged and working, how should the angle cocks be opened?

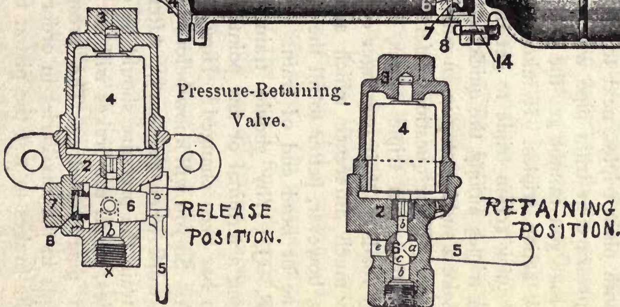
A. Open the one on empty cars first, so the empty train pipe and empty hose will be connected. Then open the angle cock on the charged car slowly so the pressure in train pipe will not be reduced any faster than the engine can supply it. This will prevent the brakes setting on head end of train, which they will do with emergency action if angle cock is opened suddenly. A little practice will teach you the advantage of this. This applies to coupling up the air on a train that has been separated to open public crossings. When coupling to cars on a side track that are going with your train, make the air brake connections also, so the auxiliaries will be charging ready for operating the brake while you are getting out on the main track, this will save time in testing the brakes, as they will be ready when train is all coupled up. When air braked cars are to be set on a coming train, charge these cars with air from the engine used to place them on the train, it saves delay.

96. Q. If an angle cock at head of end train is only partly opened or there is an obstruction in the train pipe, how will it affect the operation of the brake?

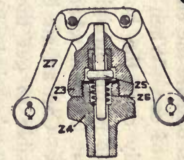
A. The brake can be set with service application, but it releases very slowly as the air does not get back fast enough to move all the triple valves to release promptly,

FREIGHT CAR BRAKE.





Pressure-Retaining Valve.



Release Valve, complete.

and any triples with defective packing rings back of the obstruction will be sure to stick. With angle cock on tender partly open, you cannot always get the emergency action of the brake. When passing over the top of the train, angle cocks can be inspected, as they are generally for enough outside the end of car so the handles are visible from top of car. When cocks are wide open the handles are exactly over the hose. The old style plug shut-off cocks come in the straight pipe just under the end of car and cannot be seen when passing over the cars.

97. Q. Can an air brake train be made up so it will be impossible to get the emergency action of the brake from the engineer's brake valve?

A. If there are four cars with the brakes cut out at cross over near triples, or four cars with train pipe only, or with plain triples, next to the engine, the reduction of air pressure in train pipe will be so gradual on the fifth car that you cannot get the emergency application of the quick action triples. It takes a sudden reduction at the first quick action triple to get the emergency. Switch the plain triples among the quick actions; you may need them to make a sudden stop in an emergency.

NOTE—These questions refer to quick action equipment. With the plain triple valves, such as are still used on many roads on their passenger equipment, it does not make very much difference which angle cock is opened first. It is, however, better to fill the hose in all cases from the engine or head end of train.

98. Q. Why should train brakes be tested before leaving a terminal or any point where the make-up of the train has been changed? How should this test be made?

A. So you will know before starting out that the brakes will work when necessary. After coupling the engine on the train the pressure should be equalized in all the auxiliaries, so all the brakes will set at the same reduction of train pipe pressure. The pressure should be seventy pounds in the auxiliaries in order to get a full application of the brakes to test the piston travel. While the engine is charging the train to standard pressure, which will take some time on a long train, a careful inspection should be made for leaks, and to see that all train pipe cocks, cross-over cocks and pressure retainer handles, are in the proper position to operate all the brakes. When standard pressure is reached the brakes should be applied from the engine that is to handle them with a full service application made in the same manner as when making a station stop of the moving train. The train men or inspector will then examine each brake to see that it is set with not less than five nor more than nine inches piston travel. When all brakes are inspected if they are set properly he will give a signal to the engineer to release brakes and examine each brake to see that they have released properly. If any brakes require adjustment of piston travel it must then be done. Be sure to close the cut-out cock in the cross-over while doing any work on the levers or shoes, so the brake will not set and injure the workman, opening it when adjustment is made. If pressure retainers are to be used, they should be tested after the piston travel is tested, by applying the brakes with a ten pound reduction, with retainer handles turned up. As soon as the retainers are quiet, go along and turn down the handles, the air should blow out from each of them, which shows that they hold the pressure in cylinders. Long freight trains can be tested by two inspectors, one at each end working towards the middle of the train till they meet. On passenger trains equipped with the air signal, the signal for releasing after a test should be given with the car discharge valve from the rear platform of the last car.

99. Q. How can the piston travel on a freight car be tested and then taken up the proper length when car is not charged with air and brake operated?

A. See that the push rod going from piston to brake cylinder lever is clear in against the bottom of piston sleeve. Make a mark on the push rod even with end of the sleeve. Set the brake by hand as tight as possible, with a club if necessary; the distance push rod is pulled out of sleeve is the piston travel. There is generally over an inch more piston travel when car is moving than when standing; it is more with heavy braking power on a car than with light. The piston travel on an empty car may be very short, say four inches, and when loaded the same car may have nine inches. When testing from the engine, have the brakes set with full service application, so you will get full piston travel.

100. Q. If the brake sets tight when you are charging the auxiliary reservoir with air when first coupling the hose to another car, should you cut out that brake?

A. If it is a quick action triple it is a sign that air leaks through some of the joints or valves in the triple into the brake cylinder. Have the engineer set and release the brake suddenly, once or twice; if there is dirt on the rubber seat of the emergency valve which causes the trouble, it will sometimes blow it off; if it does not make the brake work all right, very likely some of the gaskets are leaking badly; in such a case cut it out and bleed it. With the freight brake there may be a leak in the pipe from the triple valve to the brake cylinder which passes through the auxiliary reservoir, nothing can be done on the road for a leak of this kind but cut out the brake. Most always in these cases the air blows out of exhaust port or at the pressure retaining valve. With the plain triple the plug cock in triple may be turned out for "straight air." This will allow the air to go direct from train pipe to brake cylinder; none of it will come out of exhaust port, as the triple is cut out from train pipe and cylinder. In this case cut it in for automatic. If the handle is gone, or put on wrong, examine the marks on the end of plug which show which way the air openings are and you will know which way to turn the plug. If this plug cock leaks, the air can get past it from train pipe to brake cylinder. If brake will not work after one or two applications, cut it out. With all plain triples the brake should be released first, although the plain triple used on freight equipment is built to bleed the brake cylinder when brake is cut out. Sometimes this bleed hole, which is in one side of plug cock in the plain freight triple valve, gets stopped up, in which case it may be necessary to let all the air out of the train pipe—set this triple for straight air which will bleed brake cylinder, after which cock in triple can be placed in cut out position.

101. Q. If the piston travel is too long or too short what effect does it have on the brake as to its holding power?

A. If it is too short it will not cover the leakage groove, and air will leak out of cylinder; it must travel three inches to cover this groove. If it is too long it will strike the cylinder head, which will get the force instead of the brake shoes; it must travel twelve inches to do this. All brake pistons on coach, freight and tender equipment of standard gage have 12-inch piston stroke, but should not have over 8 or 9 inches piston travel. The piston travel should be adjusted equally so the braking power will be equal on all cars. Unequal piston travel gives unequal braking power. This is the cause of many severe shocks to long trains when first applying the brakes, and still more severe shocks when releasing the brakes at a slow speed. For instance if some of the brakes have only five inches piston travel, when the engineer makes the first reduction of train pipe pressure to apply the brakes, those with short travel will set hard enough to take up the slack of train quicker than the other brakes with long piston travel. A first reduction in applying the brakes is at least seven pounds, less than this will not apply all the brakes on a long train. This will give a pressure of twenty-three pounds on the piston with five-inch travel, eight pounds on one with nine inches travel, one with ten inches travel will not show any pressure at all, the shoes will just come nicely up to the wheels. A few short travel brakes can give serious shocks in a train that are plainly felt at the rear end.

102. Q. If air blows past piston packing so freight brake leaks off, can it be fixed on the road?

A. Sometimes this is from want of oil in the cylinder;

[illegible]

if the oiling plug near back cylinder head where it makes a joint with cast iron auxiliary reservoir is taken out and four or five tablespoonsful of black oil put in, it will soften the packing so it will be tight. The piston sleeve should then be turned around one-half turn to bring the softened packing to the top of the cylinder. This should be attended to by car inspectors, but is not always done. In no case should oil or water be put in the hose and be blown back into the triple with the air. It will carry the dust and sand back in the pipe towards the triple; this stops up the strainers, and if any gets by the strainers it spoils the rubber seat of the emergency valve, and cuts the triple to pieces very fast. Putting oil in the hose will destroy the efficiency of the brake in very short time.

103. Q. How can the air signal whistle be operated from the cars most successfully?

A. By allowing just enough air to escape at the car discharge valve to reduce the air signal line pressure clear to signal valve on engine, so that it will operate promptly, then allowing car discharge valve to close and remain closed till signal line is recharged to standard pressure; this sometimes takes two seconds. A heavier reduction with a longer interval between pulls is needed for a very long train than a short one. The whistle will give only one blast if the car discharge valve is opened a second and third time before the whistle stops blowing the first time.

If you make a second and third reduction before the reducing valve on engine has had time to charge signal line to standard pressure, the second and third blasts of whistle will be very weak; in cold weather the reducing valves do not always work perfectly. Sometimes when a car discharge valve is opened, a sufficient amount of air will seem to blow out there, but on account of an obstruction near the train pipe Tee under car it does not reduce the pressure enough at the engine to operate the signal valve, and the whistle cannot be operated from that car when it works from other cars. If the whistle blows once when engine is coupled to train and cannot be sounded afterward, look for a bad leak near rear end of train.

If the whistle cannot be sounded from any cars back of a certain car, the cock in back end of that car is shut, or train pipe is stopped up so you cannot make a sudden enough reduction there to affect the signal valve on the engine. If one blast of the whistle is used to start the train without using any additional signal, remember that one blast of the whistle can be given (without opening car discharge valve) when you do not want the train started. For instance, if the signal hose has been uncoupled (without the knowledge of the engineer) for any purpose; when the cock is opened enough air goes into empty hose to sound the whistle, giving signal to start the train before the man coupling hose can get out from between coach platforms. Other causes may cause the whistle to give one blast when not intended, therefore it is not always safe to use one blast of the whistle when standing still, to start the train.

104. Q. If hand brakes are used on part air train, on which cars should they be used?

A. On the cars next behind the air braked cars so the hand brakes will hold these cars and prevent slack running out of rear cars when air brakes are released. In case of an emergency all hand brakes should be set on cars that do not have air brakes working. Care should be taken that hand brakes are released on rear end of a part air train first, air brakes last, when running forward and in the reverse manner when backing a train.

105. Q. On an air braked passenger train in case the engineer whistles for brakes what is the trainmen's duty?

A. Open the conductor's valve first. An angle cock may be closed which prevents the engineer applying all the brakes. If the air escapes freely and the brake goes on let the hand brakes alone. If no air escapes from train pipe the brake may have already been set. Try the hand brakes last, if the brake is set with air pressure you can not move it by hand. If it is not set with air you can set it by hand, the air may have leaked out of cylinder.

106. Q. How do leaks affect the operation of the brake on a car or coach?

A. If the train pipe leaks the brake will continue to set tighter after the first reduction till full set. This leak affects a single car or a short train more than a long train, as a short train pipe has less volume of air to leak out.

A leak from the train pipe past the seat of the emergency valve will allow the train pipe air to equalize with the brake cylinder when the brake is applied so the triple slide valve has closed the exhaust port; this may stick this brake especially if the triple piston packing ring also leaks.

Any leak from the auxiliary which makes that pressure less than the train pipe will move the triple to exhaust position; the air in cylinder will escape through exhaust. With a leaky packing leather the air will blow past it, coming out around the piston rod or sleeve; none will come out of the exhaust.

107. Q. Where should you look for the trouble if the brake applied properly but would not release?

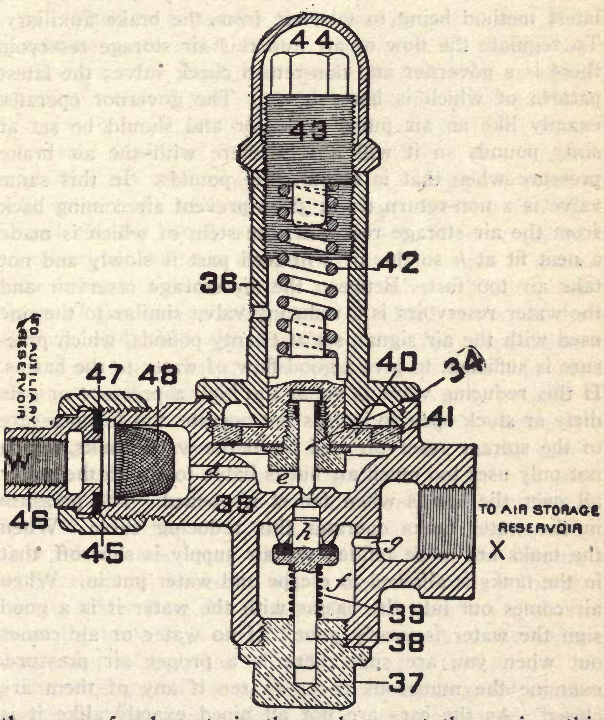
A. Very likely the pressure retaining valve was closed; examine it first to be sure it is open. On some sleepers and official cars both the triple valve and retainer are concealed by the reservoirs and lockers, so it is necessary to hunt them up, beginning with the triple exhaust, and if any pipe is attached following it up. If the retainer pipe is stopped up or plugged no air can come out of triple exhaust. In cold weather the water from drip valves of steam heated cars may splash over the exhaust ports of triple valve and freeze on; this may stop up the exhaust.

Levers or rods may catch on bolt heads or other projections under the car and hold the brake after the air has exhausted from cylinder. If the release spring in cylinder is broken the piston will not move back. Stopped up strainers at the triple have been known to prevent release of brake; air would pass out of valve but could not return quickly.

108. Q. In case a brake is noticed to be sticking regularly, can you help it to release at the same time the others do?

A. Short piston travel may cause this trouble. By extending the piston travel it will lower the auxiliary pressure on a full application so the triple is more likely to move up promptly. As brakes are more apt to stick on

WATER PRESSURE GOVERNOR VALVE.



the rear of a long train than when next the engine, this car can be set ahead if necessary to use its brake.

Leaky triple packing rings and choked strainers will also cause this trouble. Better cut out the brake than risk spoiling the wheels. Report this defect to the proper party.

109. Q. How does the water raising system used on Pullman cars operate?

A. This system has so many modifications and is so complicated that a full description cannot be given here. There is an air reservoir which is charged with air up to train pipe pressure, sometimes directly from the train pipe; at other times from the brake auxiliary reservoir; the latest method being to take air from the brake auxiliary. To regulate the flow of air into this air storage reservoir there is a governor and non-return check valve; the latest pattern of which is here shown. The governor operates exactly like an air pump governor and should be set at sixty pounds so it will not interfere with the air brake pressure when that is below sixty pounds. In this same valve is a non-return check 38 to prevent air coming back from the air storage reservoir, the stem of which is made a neat fit at *h* so the air will feed past it slowly and not take air too fast. Between the air storage reservoir and the water reservoirs is a reducing valve similar to the one used with the air signal, set at twenty pounds, which pressure is sufficient to give a good flow of water to the basins. If this reducing valve is set at too high a pressure or gets dirty or stuck open so it does not operate, the full pressure of the storage reservoir will be in the water tanks, which not only uses too much air but is liable to splash the water all over the basins when faucet is opened. The pressure in the water tanks operates this reducing valve. When the tanks are to be refilled the air supply is shut off, that in the tanks is allowed to escape and water put in. When air comes out into the basins with the water it is a good sign the water is nearly gone. If no water or air comes out when you are sure there is a proper air pressure, examine the numerous cocks to see if any of them are closed. As the cars are not all piped exactly alike it is usually necessary to trace the pipes up and locate the stop cocks and valves when making an inspection. There are also heating pipes connected with the devices of the water raising system to prevent freezing up. Gages are usually located up in the cars which show the air pressure in the storage reservoir and water tanks, 70 in the former after charging fully, and 20 in the water tanks. Suitable cocks under control of the porters are provided to open or close the passage of air from brake system to the water raising system with a code of rules for operating these cocks.

110. Q. How does this water raising system affect the operation of the brake?

A. When air is passing from train pipe or auxiliary to air storage reservoir it takes a little time to charge the storage reservoir. If at that time brake is applied as when making a terminal test of train brakes, air passing from the train pipe will set the brakes tighter; if it goes from the brake auxiliary it will likely release that brake, especially if set with a light application. If the non-return check valve leaks back after air storage reservoir is fully charged, this air can flow in the train pipe if so connected and release all the train brakes. If the connection is made to the brake auxiliary, a leaky check valve will allow the volume of the storage reservoir to be added to that of the auxiliary and skid the wheels on a full application. If all the stop cocks are not properly operated and the valves in good order the work of the brake may be interfered with, which shows that it is absolutely necessary that they should be inspected at regular intervals by competent men and be maintained in proper order. If the governor which restricts the flow of air from the brake system is in perfect order and set at the proper pressure, unless a large amount of air is used by the water system, the operation of the brake will not be materially affected. If air is taken from the brake system during the application of the brake it is sure to affect the work of the triple valve, either to apply the brake harder or release it.

The wide spread use of this system requires that coach inspectors inform themselves as to its construction and operation, and that train men and porters comply strictly with the rules for its operation.

111. Q. Can you get the emergency action of the brake with the pressure retainer holding 15 pounds?

A. Yes; if the triple is in exhaust position, with train pipe and auxiliary equalized at 70 pounds, when a sudden reduction of train pipe pressure is made, it will move the triple piston full stroke, opening the emergency port. With air at 70 pounds pressure in auxiliary the emergency piston, having only 15 pounds pressure under it, will be forced down at once, the train pipe air pressure will still be so much above 15 pounds that train pipe air will flash into the brake cylinder, and this sudden reduction made by the triple will affect the next triple so it will work quick action also. Question 49 explains why quick action can not be had after a moderate service application. The use of retainers interferes so little with the quick action that the emergency action will jump over as many cars with the brakes cut out at the cross-over cocks with all retainers holding 15 pounds as when retainers are not being used, provided the triple valve starts from exhaust position and auxiliary recharged to 70 pounds.

THE HIGH SPEED BRAKE.

This improvement on the quick-action automatic brake for passenger equipment is designed to enable the engineer to apply the brake as is ordinarily done in service applications, or in case of an emergency with the train running at a high speed, to apply it with a higher force which can be proportioned to the speed of the train.

For ordinary speed, below thirty miles an hour, the 70 pound automatic brake is able to control the train in the ordinary manner, but when the speed is much higher, more power is required in proportion as the speed is higher. It is the friction of the brake shoes on the wheels that arrests the speed of the train and finally brings it to a stop. In addition to arresting the momentum of the train this friction must also arrest the rotary motion of the wheels turning around at high speed; this takes considerable brake power. There is a difference in the amount of the friction of the same shoes and wheels at different speeds, it being greater at a low speed than at a high one.

What is called the co-efficient of friction, which is the proportion between the brake power applied to the shoes and their holding power, is about .074 at sixty miles an hour, increasing to .241 as the speed is reduced to ten miles an hour, to .273 at five miles an hour and just as the final stop is made it is .330, so you see the brake shoes really hold less at a high speed than at a low one, and more brake power can be applied at the high speed than could be safely used at a low one and make the holding power about right for each speed.

Now it follows that if the full brake power was the same for all speeds, if it was the proper power for a moderate speed it would be much too low for a high speed. If a high speed was the standard the full brake power would be too high for the low speed, the wheels would skid on the rail and a loss of about one-third of the brake power would result. This would allow the train to run considerable farther than if the wheels were held back by the shoes just up to the sliding point—*without sliding.*

Therefore, an attachment to the brake that would give a very high brake power when first applied while running at a very high speed and gradually reduce this brake power at about the same rate the speed was reduced, would be proper for all speeds.

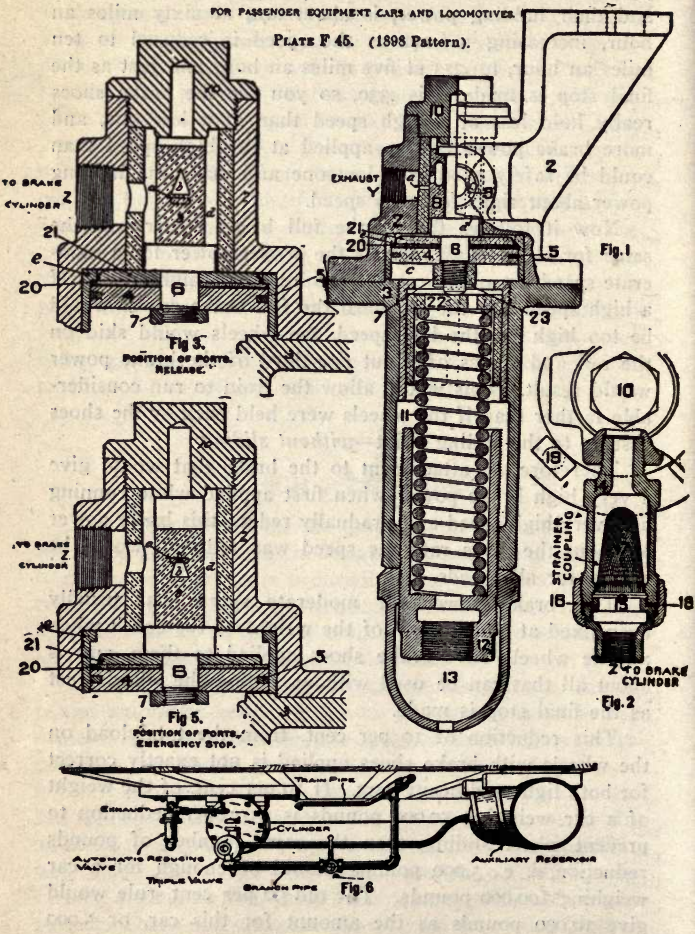
This brake power for moderate speeds has usually been fixed at 90 per cent. of the weight of the coach when all the wheels have brake shoes applied to them, and is about all that can be used without sliding the wheels just as the final stop is made.

This reduction of 10 per cent. from the total load on the wheels with brake shoes applied is not exactly correct for both light and heavy cars. If 10 per cent. of the weight of a car weighing 50,000 pounds is a proper reduction to prevent wheel sliding, then the same number of pounds reduction, i. e., 5,000 pounds should be enough for a car weighing 100,000 pounds. The old 90 per cent. rule would give 10,000 pounds as the amount for this car, or 5,000 pounds more than needed. Therefore, to get the best ser-

HIGH SPEED BRAKE AUTOMATIC REDUCING VALVE

FOR PASSENGER EQUIPMENT CARS AND LOCOMOTIVES.

PLATE F 45. (1898 Pattern).



vice the same amount of reduction in pounds should be made from all cars braked to the same per cent.

For emergency action the high speed brake is intended to apply the brakes at first with a brake power of 125 per cent. of the weight of the coach and gradually reduce the brake cylinder pressure as the speed is reduced, till it reaches the standard amount of sixty pounds, which gives a 90 per cent. brake power, at which point the reduction ceases, leaving the cylinder pressure at the amount and the braking power at the percentage, at which the wheels will not slide when the car is about to stop.

To get this increased brake power the train pipe and auxiliary pressure is increased to 110 pounds. With an emergency application the pressure at first is about eighty-five pounds. The brake cylinder pressure is reduced by an automatic reducing valve, which is here illustrated.

This reducing valve, the latest pattern of which is shown in Fig. 1, is fastened by the bracket at *x* to the coach frame (see Fig. 6) and connected to the brake cylinder by suitable piping at *z* (see Fig. 2). When the air enters the cylinder at the time the brakes are applied, it also comes in on top of piston 4. This piston is held up by the spring 11 against a pressure of sixty pounds per inch, so that if no more than sixty pounds comes into the cylinder the reducing valve remains stationary in the position shown in Fig. 3.

It should be noted that the area of the reducing valve piston 4 that the brake cylinder air presses against is slightly less when the gasket 20 is up solid to the shoulder of the bushing *e* than after it is moved down.

When a graduated service application is made, if the brake cylinder pressure raises above sixty pounds the piston 4 is moved down far enough to open the triangular port *b* in the slide valve 8 to exhaust port *a* in the seat so that the widest part of port *b* is open as shown in Fig. 4. The air can then pass out of the brake cylinder about as fast as it comes in through the graduating valve of the triple; when the brake cylinder pressure drops below sixty pounds the spring under piston 4 moves slide valve 8 up and laps ports *a* and *b*, as shown in Fig. 3, and no more air can escape.

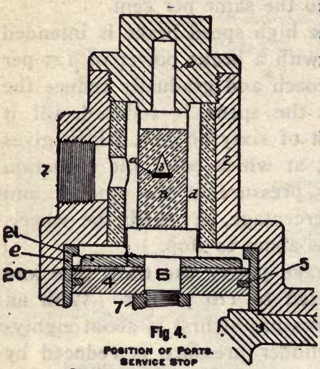


Fig 4.
POSITION OF PORTS.
SERVICE STOP
PRESSURE EXCEEDING 60 POUNDS
IN BRAKE CYLINDER.

In case an emergency application is made the brake cylinder pressure rises like a flash up to eighty-five pounds, piston 4 is forced down at once against the tension of the spring to the lower limit of its travel into the position shown in Fig. 5. This pulls slide valve 8 clear down, the small end of the triangular port *b* is open to port *a*, and the brake cylinder air escapes slowly to the atmosphere. As the pressure is reduced the spring 11 has power to move piston 4 up and the triangular port *b* opens wider which reduces the brake cylinder pressure faster, down to sixty pounds; at which point the slide valve is moved up to lap ports *a* and *b* so no more air can escape from brake cylinder, this position is shown in Fig. 3.

The size of this exhaust port *b* has been determined by experiments so as to reduce the brake cylinder pressure proportionate to the reduction in speed. It is a different size for each size of reducing valve to suit the different volumes of air which should pass out of small and large cylinders in about the same time.

With a service application the reducing valve reduces the brake cylinder pressure only, as the triple valve closes the air port from the auxiliary. With an emergency application where the train pipe pressure drops below sixty pounds the triple holds the air port open and the reducing valve has to reduce both brake cylinder and auxiliary volumes to sixty pounds.

When the brake is first set with emergency at a high speed the pressure is about eighty-five pounds in the cylinder; as the speed of the train is reduced by the action of the brakes, the pressure is also reduced by the reducing valve at about the same rate, till it reaches sixty pounds, where it remains till the brake is released in the regular way.

After an emergency application the reducing valve lowers the cylinder pressure very slowly at first through the small pointed end of the port *b*, and faster as the pressure drops till it reaches 60 pounds, when the valve closes. The speed of the train is reduced by the action of the brakes slowly at first, and the reduction of speed is more marked each succeeding second of time till when nearly at a stop the speed is reduced very fast. The pressure is reduced at about the same ratio as the speed, so as to have it reach 60 pounds at about the time when 60 pounds will do the work properly.

This gives a very high brake power ready to use if found necessary at high speeds and still leaves the service application feature unchanged, ready for use in ordinary stops. With the service application the reducing valve remains in position as shown in Fig. 3. A reduction of twenty pounds from 110 applies the brake fully, as this reduction will fill the brake cylinders at fifty pounds, the full pressure of an ordinary service application; as well as leaving a high auxiliary reservoir pressure of ninety pounds ready for two more full service applications of the brake if found necessary before re-charging; during these moderate service applications the reducing valve does not move.

The train pipe and auxiliary pressure is set at 110 pounds with this type of brake—it may be more if the conditions seem to call for it. As the engines equipped for drawing these high speed braked trains may be used to draw coaches without the high speed attachments, some arrangement is needed for changing the standard train pipe pressure from 110 pounds to the lower pressure and vice versa. For this purpose there are two feed valve attachments on the engine. One of them is set at 70 pounds, the other at 110, and there is a reversing cock between them which can be turned to "cut-in" either one for service as is desired, only one being operated at a time. This reversing cock and valves are coupled to the brake valve with suitable piping. Likewise there is a duplex governor for the air pump, one side of which is set for ninety pounds main reservoir pressure, for the ordinary 70 pounds train pipe pressure, the other side set at the higher pressure required, and a suitable cock to cut out the ninety pound side when using the higher pressure. As these high speed trains are usually short, ten pounds excess has been found sufficient, but more is needed with a longer train; in some cases 30 pounds, in order to be sure to release all brakes, after a light application. The tender is equipped with a quick-action triple and reducing valve the same as a coach. An engine truck brake is a necessary part of this equipment, which is supplied with air from the driver brake triple; a reducing valve similar to the coaches is used, set at fifty pounds. Any extra coaches placed on these high speed braked trains require a reducing valve, although a safety valve set to blow off at sixty pounds through a restricted opening can be used temporarily by screwing it into the oiling plug hole in the cylinder head. This safety valve is not as reliable as the reducing valve, and is only used as a temporary relief.

This type of brake will stop a train running at sixty miles per hour in about 450 feet less distance than the ordinary quick-action brake.

After a full emergency application with 110 pounds train pipe and auxiliary reservoir pressure the maximum brake cylinder pressure in a 14-inch cylinder with six inches piston travel will be eighty-eight pounds; seven inches travel will give close to eighty-five pounds. If at this emergency application the train pipe pressure is all let out or reduced below sixty pounds, the reducing valve will reduce the pressure in brake cylinder and auxiliary to sixty pounds in from twenty-seven to thirty-one seconds. With an emergency reduction and equalization of reservoir and brake cylinder pressures at eighty-five pounds the reducing valve will reduce the brake cylinder pressure in from sixteen to twenty seconds.

In making a graduated service application, with a pressure of sixty pounds in the brake cylinder, when a further service reduction of train pipe pressure is made the cylinder pressure will increase but slightly above sixty pounds and immediately be reduced to that amount unless a full continuous service reduction is made, in which case the pressure may rise to seventy-seven or eighty pounds, being soon reduced to sixty pounds by the reducing valve. After a cylinder pressure of sixty pounds is obtained, a full service reduction to below sixty pounds should never be made except at high speeds in an emergency.

A high speed brake train is handled in much the same manner an expert engineer handles an ordinary passenger train of the same length. Remember that air at 110 pounds pressure moves through the air ports more rapidly than at 70 pounds, so when listening to the sound of the air discharging from the preliminary and train pipe exhausts watch the gage closely. To make the brake valve reduction more gradual a larger brake valve reservoir is now used, which holds about 812 cubic inches. The older ones hold close to 600 cubic inches.

A 20 pound service reduction will give about the same brake cylinder pressure from 110 pounds that it does from 70, i. e., about fifty pounds.

A 22 pound service reduction will give close to 60 pounds in the cylinder, anything over that may be wasted, as the reducing valves will not let the cylinder pressure rise above 60 pounds.

With 110 pounds on the back of the slide valve at the beginning of a service application and 90 pounds at the time of a release, the slide valve cannot be moved as easily by the triple piston as when the pressures are 70 and 50 pounds, and it will take more change of pressures each side of the triple piston to move it.

The graduating valve has no such frictional resistance. Triple valves when dirty, or when they need oiling, give more trouble with 110 pounds than with 70, on account of the increased pressure on the slide valve which makes them more apt to work quick action with a gradual service reduction. For that reason both the triple valves and brake valve must be kept clean and well oiled and good stiff excess is needed with a long train.

When coupling to a train having 110 pounds train pipe pressure with an engine carrying 70 and 90 pounds, put the brake valve on lap and leave it there till the 110 pounds pressure has blown down to 70 pounds and the reducing valves on the cars have blown down to 60 pounds. Then with full excess go to full release and the brakes should all release.

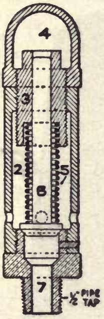
In handling any very long passenger train a straight air brake on the engine and tender is a valuable aid in preventing break-in-twos or serious shocks when releasing at a slow speed, the E. T. equipment on the locomotive is still better.

Unless an emergency arises requiring a very sudden stop, do not use the emergency application with 110 pounds, when running at a slow speed, say below twenty-five miles an hour. Unless the rail conditions are perfect the wheels are apt to slide; this will increase the length of the stop. When an emergency, such as danger to life or property, confronts you, remember that all the brakes act quickly with the emergency application—in less than three seconds—which they will not do as quickly with a service application. Difference in piston travel does not affect the work of the high speed brake as much as it does the 70 pound brake with full service applications. As soon as the reducing valve operates it equalizes the cylinder pressures for long and short travels, for all will reduce to the same final pressures. If the leverage is proper, all cars will be braking alike. One of the best preventives of wheel sliding is equal and maximum brake power on all the cars, tender and engine. With all wheels holding back alike tests show that wheel sliding is rare.

HIGH PRESSURE CONTROL.

With the heavy capacity cars now in general use, the empty weight of the car on which the braking power is calculated is such a small proportion of the full loaded weight that some provision must be made to increase the braking power on the loaded cars. This is particularly the case with coal and ore cars, which usually run empty to the mines and return loaded. For this class of cars a two-pressure system has been devised in which a moderately low pressure of 55 to 65 pounds is carried in the train pipe and auxiliaries of the empties, while with the loaded trains 90 pounds can be carried and thus increase the brake power about 50 per cent. The duplex governor and reversing cock which is part of the High Speed Brake is used with the High Pressure Control, but the duplex governor is piped a little different. There are two separate pipes leading to the governor, one from the main reservoir to the side of the governor set for the highest pressure, the other pipe leading from the left side of the reversing cock, which is set for the lowest pressure, to the low pressure side of the governor, so that when the low pressure feed valve is cut in, the low pressure governor is also cut in.

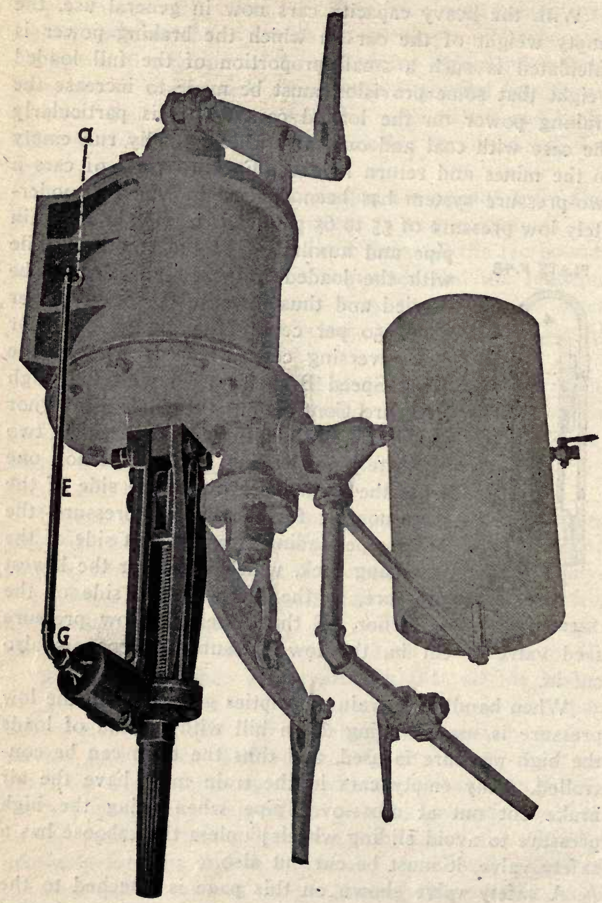
PLATE F.48



SAFETY VALVE.

When handling a train of empties going up hill the low pressure is used, coming down hill with a train of loads the high pressure is used, and thus the train can be controlled. Any empty cars in the train must have the air brake cut out at cross-over pipe when using the high pressure to avoid sliding wheels; unless the caboose has a safety valve, it must be cut out also.

A safety valve shown on this page is attached to the brake cylinders of the engine and tender. This same type of valve is also used on any extra coaches set in a High Speed Brake train.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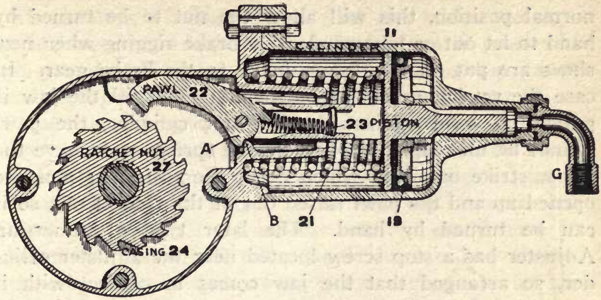


THE AMERICAN AUTOMATIC SLACK ADJUSTER.

The illustrations of the American Brake Co.'s Automatic Slack Adjuster show how the adjuster cylinder and adjusting screw is attached to the brake cylinder and dead cylinder lever. A small port is drilled and tapped in the brake cylinder at the point *a* which is to be the limit of the *running* piston travel. A pipe E is connected from this port *a* to the adjuster cylinder at G.

The brake piston acts as a valve to admit air to the adjuster cylinder. When it moves beyond port *a* during a brake application, air from behind the brake piston passes out of port *a* through the pipe E into the slack adjuster cylinder, pushes the piston to the left against the strength of the spring 21, carrying the pawl 22 out; spring 23 pushes the pawl down, hooking it down over a tooth of the ratchet 27. When the brake is released the air in the adjuster cylinder passes out, spring 21 then returns the adjuster piston to its normal position which pulls back pawl 22; this rotates ratchet nut 27 on the screw attached to the dead cylinder lever fulcrum jaw, moving the end of the lever up $^1/_{32}$ of an inch, taking up some slack in the brake rigging. The slack is not taken up when the brake is applied, but after it is released, when there is no strain on the cylinder lever. When the spring pushes back the piston and pulls the pawl, the lug A strikes the stop B, this raises the pawl out of the ratchet, so that the ratchet nut can be turned either way, if the adjuster piston is in normal position, this will allow the nut to be turned by hand to let out or take up slack in brake rigging when new shoes are put on, or repairs made to the brake gear. In case the ratchet nut is turned on its screw till the jaw is pulled up solid against the adjuster cylinder, the pawl cannot be moved far enough by the spring 21 to have the lug A strike on B; in which event the casing 24 must be opened up and the pawl raised out of the ratchet nut, so it can be turned by hand. The later type of American Adjuster has a stop screw located near the adjuster cylinder, so arranged that the jaw comes in contact with it instead of the cylinder; by removing this screw and turning the ratchet by hand the pawl is released. A still later type has a tap bolt in the end of the adjuster nut casing, slack off this tap bolt and the screw will turn a little more and release the pawl. The pawl and ratchet are enclosed in a tight case to keep out ice and foreign matter which would prevent their movement.

In case the brake piston does not travel to port *a* the adjuster does not move any of its parts, but is at rest. If port *a* is partially or fully opened by the piston, which acts as a valve, compressed air is admitted to the adjuster cylinder, so it is operated.

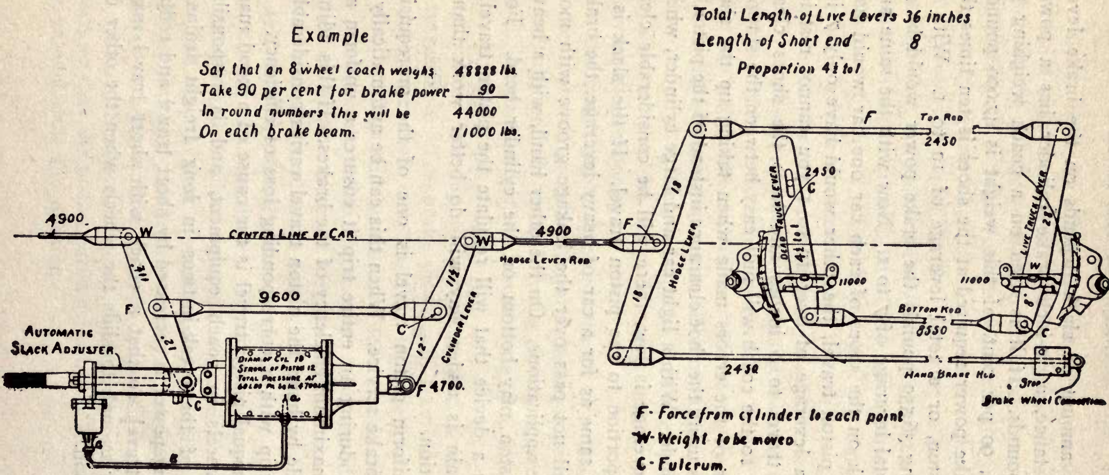
Slack adjusters take up the travel beyond a certain running travel limit. The brake piston will travel farther on a running car than one standing still, because the journals and bearings will be crowded to one side of the oil boxes and all lost motion that can be taken up in the truck comes out when running. For that reason the piston travel is usually found to be less when measured at a standing test than the actual distance of the port *a* from the pressure head of the cylinder. If this port *a* is eight inches from the head to allow eight inches' travel it is not unusual to find the travel at a standing test, less than six inches. When locating port *a* first see how for the edge of the piston packing leather is from pressure head *x*. Port *a* is very small where it comes through the wall of the cylinder, so that the piston packing leather will not be cut when passing over the opening.

The amount of slack depends on the brake leverage. For instance, a 10-inch brake cylinder has a power of 4,700 pounds. If it is used on a coach weighing 52,220 pounds, 90 per cent. of this weight is 47,000 pounds, so the brake power required at the shoes is ten times that at the piston, or a total leverage of 10 to 1. With a car weighing 36,550 pounds the brake power would be 32,900 or a total leverage of 7 to 1. Now with the same amount of slack on the shoes of each car one car would have 10 inches piston travel, the other would have only 7 inches. With a leverage of over 10 to 1 you cannot restrict the piston travel to 6 inches and have the shoes clear the wheels so the coach will pull easy between the stations.

One of the errors made when taking up the slack by hand is using the shoe clearance instead of the piston travel as a guide. With a light car and large cylinder, where the total leverage is low, there will be considerable clearance in proportion to the piston travel. If the slack is taken up the same as for a car of heavy leverage, the brake piston will not pass over the leakage groove with moderate service applications. On the other hand, with a heavy car, the piston may bottom on the cylinder head. For this reason a device that will regulate the piston travel while the train is under way will do better work than hand regulation.

Uniform piston travel is one of the prerequisites of good brake service. When this can be automatically maintained during an entire trip it ensures a uniform as well as a maximum efficiency of the brakes. If this adjustment is made by hand the piston travel varies considerable on a long trip with a corresponding loss of efficiency.

Unequal piston travel is the cause of a good many slid flat wheels in coach equipment, and is responsible for some of the break-in-twos in long freight trains. The braking power is increased by short travel and reduced by long travel, so that a coach with short travel may have power enough to slide the wheels when the other cars do not skid.



Example
Say that an 8 wheel coach weighs 48888 lbs.
Take 90 per cent for brake power .90
In round numbers this will be 44000
On each brake beam. 11000 lbs.
Total Length of Live Levers 36 inches
Length of Short end 8
Proportion 4½ to 1
4900
CENTER LINE OF CAR.
4900
HODGE LEVER ROD.
9600
CYLINDER LEVER
4700.
AUTOMATIC
SLACK ADJUSTER
HODGE LEVER
DEAD TRUCK LEVER
LIVE TRUCK LEVER
TOP ROD
2450
BOTTOM ROD
8550
11000
HAND BRAKE ROD
Brake Wheel Connection
F - Force from cylinder to each point
W - Weight to be moved
C - Fulcrum.

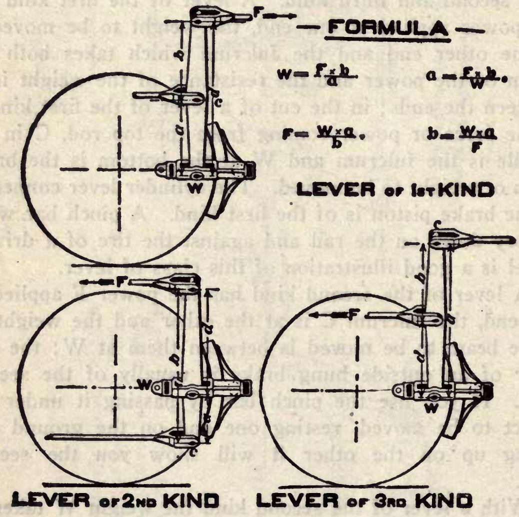
BRAKE LEVERAGE.

Ability to figure up brake leverage is an accomplishment for an air brake operator—not always a necessity—it pays to know something definite about it. The rules are not complicated and formulas help to shorten the calculations. You should first learn how the several classes of levers operate and the difference between those of the first, second and third kind. A lever of the first kind has the power applied at one end, the weight to be moved is at the other end and the fulcrum which takes both the strain of the power and the resistance of the weight is in between the ends; in the cut of a lever of the first kind F is the force or power coming from the top rod, C in the middle is the fulcrum and W at the bottom is the brake beam or weight to be moved. The cylinder lever connected to the brake piston is of the first kind. A pinch bar when we pry down on the rail and against the tire of a driving wheel is a good illustration of this class of lever.

A lever of the second kind has the power F applied at one end, the fulcrum C is at the other and the weight or brake beam to be moved is between them at W; the live lever of an outside hung brake is usually of the second kind. If you use the pinch bar by passing it under the object to be moved, resting one end on the ground and lifting up on the other it will show you the second kind.

With a lever of the second kind the weight W takes as much strain as both the power F and fulcrum C. A lever of the third kind has the power F attached between the ends W and C; a lever of this class takes more power in proportion to the weight to be moved than either of the other kinds. With any class of lever the strains at the ends added together equal the strain in the middle. So you see the power developed by any one of three kinds of levers of the same length depends on the relative positions of the power, weight and fulcrum.

When you make measurements and calculations of brake power, in case the pins or brake jaws are much worn set the brake by hand and measure the levers carefully as a mistake of a very short distance on the short end of a live lever will alter the power considerable. Always multiply the power or force in pounds by the distance in inches from the point F where power is attached to the fulcrum C and divide this product by the distance in inches from fulcrum C to brake beam W.



On page 154 is a small cut of the arrangement of levers for a coach brake with the Hodge system which we will use to illustrate this explanation.

Beginning at the brake cylinder where the power is first exerted, the pressure at F where the piston is attached to live cylinder lever is 4,700 pounds for a 10-inch cylinder with quick action triple. This lever being of the first kind with fulcrum C between the ends, we multiply the power 4,700 by 12, the distance to the fulcrum C, and divide this product by 11½, the distance from the fulcrum to W, the Hodge lever rod connection, and have 4,900 pounds strain on this rod which goes to the Hodge lever at X. This is a lever of the third class and being equally divided, each end gets half this power or 2,450 pounds, which is the force at the top end of the live truck lever. We next multiply 2,450 by the distance on this lever from F to C, 36 inches, and divide this product by 8, the distance from C to W, and we have 11,000 pounds, the strain on the brake beam. A shorter way is to multiply the pull at top end of live lever 2,450 pounds by 4½ the proportion of the live lever. To get the proportions of a live lever, divide the total length between the centers of outside pin holes at F and C by the distance from C to W—called the short end—in this case 8 into 36 or 4½ to 1. If the force at F is 2,450 pounds and the strain at W is 11,000 pounds; the resistance at C will be 8,550 pounds, as the sum of the strains at both ends of a lever must balance the strain in the middle. This strain of 8,550 pounds on the bottom rod goes to the bottom end of the dead truck lever at F and is to be multiplied by the distance from F to C—the outside length of dead lever—and the product divided by the distance from C at the top end of dead lever to W the brake beam connection; if the dead lever is the same proportion as the live one the result will be 11,000 pounds.

Now going back to the cylinder levers, the tie rod has a strain of 9,600 pounds which is the sum of 4,700 and 4,900, the strains on both ends of the live cylinder lever. This strain goes to the point F in the floating cylinder lever which is shown fulcrumed at C on the cylinder head and its free end W connected to the Hodge rod for the floating lever at the other end of the car and from there the power goes to the live and dead truck levers of the other truck as already explained.

By this arrangement of levers we get a braking power on each end of the car equal on both trucks, with a total amounting to twice what the brake piston has; but we get it because the piston travels twice as far as it would if the fulcrum C in the live cylinder lever was fixed stationary; both cylinder levers move and the piston travels far enough for the two.

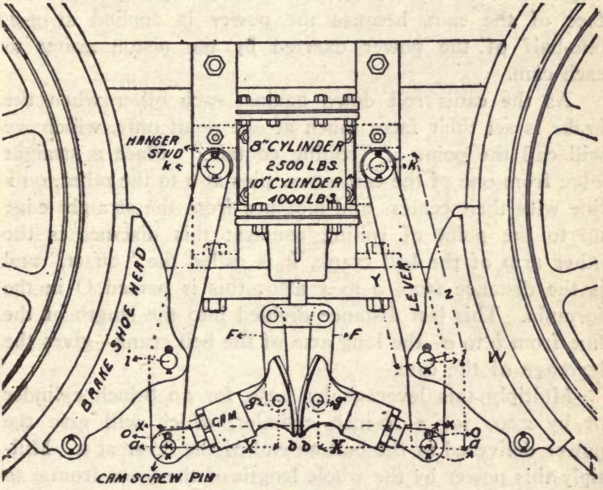
Both cylinder levers need not be of the same length, but they must be of the same proportion if the same strain is to go to each end of the car. Coaches have cylinder levers exactly alike for each end of the coach; freight cars do not, although they are the same proportion.

In making calculations for braking power for coach equipment, take 90 per cent. of the weight which the wheels having brake shoes attached put on the rail under them. With all wheels braked this means 90 per cent. of the weight of the coach when empty, a twelve wheel coach with only eight wheels braked takes $^8/_{12}$ of the weight as a basis for calculation. Use 70 per cent. of the light weight of any freight car used in interchange service; while 100 per cent. of the light weight of a tender is generally used, a tender usually has a supply of water, fuel and tools which hold its weight up above the skidding point. The light weight of cars and coaches is used when making leverage calculations to keep the brake power below the limit at which the wheels will slide when the brake is operated on an empty car. If the brake cylinder receives its supply of air from the auxiliary *only*, as is the case with the plain triple valve and some of makes of quick-action triples, use fifty pounds as the equalized piston and auxiliary pressure. If part of the supply comes from the train pipe, as is the case with the Westinghouse quick-action triple, use sixty pounds.

Driver brake leverage is 75 per cent. of the weight at the rail; an engine-truck brake should have less than that, as there is no way to get sand to the rails for the truck wheels on slippery track.

CAM DRIVER BRAKE LEVERAGE.

The limited space in this book will not allow a full description of how the cams and levers are designed, but some information on calculating their brake power will come handy to the men operating them. The illustration of the cam brake shows its various parts.



FORMULA.

$$W = \frac{F \times X \times Z}{O \times Y}. \qquad O = \frac{F \times X \times Z}{W \times Y}. \qquad X = \frac{W \times Y \times O}{F \times Z}$$

These cams are really segments of wheels with *x-x* for the centers. If they are properly laid out no matter how far they roll down, the point of contact at the edges of the wheels will always be on the line between the centers *x-x*.

The cam as used with the brake is a bell crank with the long arm from *g* to *x* and the short arm from *x* to *a*. A true bell crank requires a fixed fulcrum at *x* to act as a brace to transmit the power at *g* to *a*, but in the case of the cams no fulcrum is needed there, for the faces of the cams rolling against each other act as fulcrums.

To calculate the brake power, set the brake full on and measure the distance between the cam link pins at *a-a*. Also measure the distance between the cam link pins *g-g* and subtract this distance from the distance *a-a*; one-half of this remainder will be the long arm of the bell crank included in the design of each cam, which distance we will call X in the formula. We do not measure clear to the face of the cam, because the power is applied at *g-g*, one-half of the power exerted by the piston going to each cam.

As the cams roll down against each other when the brake is set their faces touch at one point only, which we will call the point of "rolling contact." Place a straight edge from one of the cam screw pins at *a* to the other, on a line with their centers and measure from the straight edge up to the point of rolling contact; this distance is the other arm of the bell crank, it is called the "offset," and is the distance from *a* to *x* also; this is named O in the formula. This last distance divided into the length of the line from *b* to *a*—the long arm of the bell crank—gives the leverage of the cam.

Multiply this leverage by 1,250 for an 8-inch cylinder or by 2,000 for a 10-inch cylinder, which will give the power delivered at the bottom end of the lever at *a*. Multiply this power by the whole length of the lever from *a* to *k*, called Z in the formula, and divide the product by the distance from the pin *k* to the pin *i* in the brake shoe head, which is distance Y; this quotient is the brake power delivered at that shoe; four times the power for one shoe will be the brake power for all shoes, which should be 75 per cent. of the weight on drivers. In all these calculations we use fifty pounds as the air pressure per inch on the brake piston.

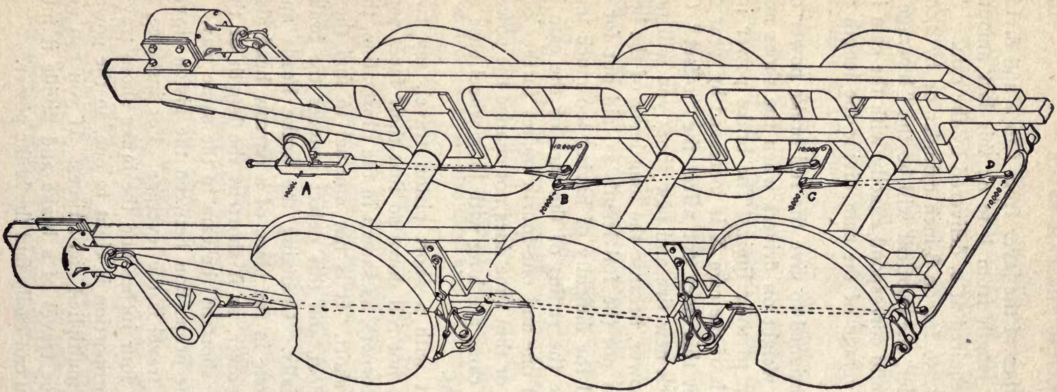
To calculate the other way take 75 per cent. of the weight on the rail at the drivers, one-fourth of that will be the power required at each shoe. Multiply this amount by the length in inches of the lever from *i* to *k* and divide the product by the length from *k* to *a*; this last amount will be the power required at *a*, delivered by the cam.

Divide this by 1,250 for an 8-inch cylinder or by 2,000 for a 10-inch cylinder, the quotient will be the "leverage" of the cam, and should correspond exactly with the cam in use. To get the leverage of the cam divide the length at X by the offset.

The cams are designed to give the full brake power of 75 per cent. of the weight on drivers when the shoes and tire are worn down to their limit. The brake power increases as the length of the cam X is increased by wear of shoes and tires, but this does not affect the "offset" O. Therefore, with thick new tire and new shoes you will not get the full brake power, because the long lever of the bell crank in the cam is not the full length as laid out for a thin tire. To avoid the difficulty of having too much leverage with thin tire the radius of the face of the cam is struck from a point one and one-fourth inches further out than at *x*. A thick or thin shoe does not change the power as much where the cams are long with long wheel base as with very short cams.

If you find that with a short piston travel, say two inches, the cams do not roll down so that their faces separate at the lower corners, as shown in the illustration, the cam links are too short. It is not unusual to find these links put up too short, and this defect reduces the brake power very materially. Changing the brake heads and putting on a wide one in the place of a narrow head also reduces the brake power, as it shortens the length of the cam. A thick shoe shortens the cam in the same way.

In any brake the proportion between the piston travel and the brake shoe travel is the leverage. For instance, if the piston travel is four inches and the brake shoes travel one-half inch, the proportion is eight to one, so the power from the piston is multiplied eight times. If you can get the exact brake shoe travel of a brake and divide it into the piston travel you can easily find the brake power.



The above cut shows a perspective view of outside equalized pressure brake as applied to a six-wheel coupled engine, showing system of levers and distribution of power.

The power shown at bottom end of cylinder lever A is 30,000 pounds. This all goes to the lever at B, which is so divided that 10,000 pounds goes to the brake shoe, and 20,000 pounds to the lever at C. This lever is evenly divided, 10,000 pounds goes to the shoe there and 10,000 pounds to the brake beam connection at D, which equalizes the braking force on all shoes.

CALCULATIONS FOR AIR PRESSURES.

To calculate at what final pressure two separate volumes of air at different pressures will equalize when connected so air will flow from the higher to the lower pressure, it is necessary to reduce the volumes and pressures to one standard of comparison.

Suppose that a reservoir has a volume of 1,620 cubic inches with a gage pressure of seventy pounds per inch. If that same air was expanded to one pound gage pressure per inch it would occupy seventy times as much space or 70 x 1,620 which is 113,400 cubic inches at one pound pressure. We will call this amount cubic-inch-pounds, all volumes and pressures can be reduced to this standard.

A gage shows the pressure above the atmospheric line, but "absolute" pressure begins at the vacuum line; to get absolute pressure we add fifteen pounds to the pressure shown on the gage, before the calculations are made and subtract fifteen pounds from the result to get back to the gage pressure again. If the calculations refer to volumes which contain air at or above the atmospheric pressure, this fifteen pounds need not be taken into account. If any question of piston travel is connected with it, the fifteen pounds must be considered.

We will take the case of a main reservoir of 16,000 cubic inches at ninety pounds and an empty train pipe of twenty-five cars which will be the same volume. Multiply the volume of main reservoir by the pressure and divide the product by the combined volume of both reservoir and train pipe. 16,000 x 90=1,440,000 cubic-inch-pounds, this divided by 32,000 gives 45, the gage pressure at equalization.

Suppose this train pipe instead of being empty has forty pounds gage pressure in it, and the main reservoir ninety, forty pounds in the train pipe will be 640,000 cubic-inch-pounds, this added to the amount in the reservoir and the sum divided by the combined volumes will give sixty-five as the pressure at equalization.

A retaining valve is holding 15 pounds in the brake cylinder. After charging the auxiliary to 70 another full application is made, we can figure the equalizing pressure as follows: 450 cubic inches at 15 pounds is 6,750 cubic-inch-pounds. The auxiliary at 70 holds 113,400 cubic-inch-pounds, the total amount in both is 120,150 cubic-inch-pounds, which now expands into the total volume of 1,620 plus 450 or 2,070 cubic inches. Divide the full amount of air by the total space and we have 58 pounds. We do not figure from the vacuum line in this case.

When calculating the pressure at which the brake cylinder and auxiliary will equalize when the piston moves out, remember that there is no atmospheric air in the space left by the piston in moving out and this space must be filled with air from the vacuum line of absolute pressure, so we must add fifteen pounds to the gage pressure of seventy pounds, which gives eighty-five pounds.

The auxiliary holds about 1,620 cubic inches at eighty-five pounds, this is 137,700 cubic-inch-pounds absolute pressure. The volume of an eight-inch brake cylinder with eight inches travel, including the clearance and piping from the triple, is close to 450 cubic inches; the combined volume is 2,070 cubic inches. Divide 137,700 by this combined volume and subtract fifteen from the quotient, you will then have the equalizing pressure about 51.5 pounds.

To find how much of the brake cylinder air at 60 pounds comes from the train pipe with an emergency application and how much from the auxiliary, proceed as follows: The brake cylinder volume of 450 cubic inches at 75 pounds absolute pressure is 33,750 cubic-inch-pounds. The auxiliary of 1,620 cubic inches loses 10 pounds, from 70 down to 60; this is 16,200 cubic-inch-pounds from the auxiliary; this subtracted from 33,750 leaves 17,550 cubic pounds to come from the train pipe. Divide 17,550 by the volume 450 cubic inches we have 39 pounds absolute pressure; subtracting 15 pounds to get gauge pressure we have 24 pounds as the part the train pipe supplies; this varies with the piston travel and condition of strainers, it is usually less than this.

When you make a *partial* application of the brake and want to know what brake cylinder pressure will result from any certain reduction in the auxiliary, proceed as follows: Say we make a ten pound reduction. If the volume of the auxiliary is 1,620 cubic inches, at ten pounds per inch the total amount passing from the auxiliary to the brake cylinder would be 16,200 cubic-inch-pounds. In this calculation we will allow for the air contained in the clearance space of the cylinder, the auxiliary tube between the triple valve and cylinder, and the triple valve itself, which amounts to an average of 47.92 cubic inches, which contains air at 15 pounds per inch or close to 718 cubic-inch-pounds. This added to the amount coming in from the auxiliary makes 16,918 cubic-inch-pounds, and it will equalize in the 450 cubic inches total volume of the brake cylinder and clearance at 38 pounds absolute pressure, or 23 pounds gage pressure. You can calculate for any given reduction the same way from any pressure; just as long as you do not make a train pipe reduction that will cause the brake cylinder and auxiliary to equalize, or when you do that it stops the auxiliary reduction. A ten pound reduction from 90 gives just the same pressure as at any lower pressure till you reach the equalizing pressure, which is usually below 50. The next ten pound reduction from the auxiliary into this cylinder of air having a pressure of 23 pounds will show a greater proportionate raise on the gage, for the first reduction had to fill the cylinder from the vacuum line up to gage pressure—15 pounds—the second one had this work done for it, and therefore made a better showing on the gage.

When making tests the gage will not always show these exact amounts, as the leakage groove uses considerable air, auxiliaries are not all the size specified, the clearance in the end of cylinder varies, and the expansion of air lowers the temperature, which alters the pressure.

The question of the fall of temperature is not taken into consideration in these calculations, as the temperature of the air in the brake equipment on a car is very close to that of the atmosphere at all times.

To get the area of the piston, multiply the diameter by itself and that product by .7854. To get the volume of the cylinder, multiply this area by the piston travel and add the clearance. This clearance consists of the space between the piston and the pressure head, usually ⅝ of an inch, the pipe between the triple and the cylinder and the space in the triple valve that is filled with brake cylinder air.

Reservoirs are so constructed that it is difficult to calculate their exact volume from their outside dimensions, this can be obtained exactly by weighing them while empty, then filling full of water and weighing again; the difference in weight will be the amount of water contained. A pound of water at 62 degrees occupies 27.71 cubic inches; 1 cubic foot weighs 62.355 pounds.

A cast iron auxiliary for an 8-inch freight brake holds about 1,620 cubic inches.

10 x 24 in. wrought iron auxiliary 1.510 cubic in.
12 x 33 in. wrought iron auxiliary 3.030 cubic in.
14 x 33 in. wrought iron auxiliary 4.120 cubic in.
16 x 33 in. wrought iron auxiliary 5.322 cubic in.

The equalizing reservoir from 590 to 621 cubic inches, the latter pattern 10 x 14½ inches long, hold 800 cubic inches. A freight car has about 640 cubic inches in the train pipe, hose, cross-over pipe and triple valve to the bottom of the triple piston—all this space contains train pipe air.

Main reservoirs vary in size to suit their location on the engine, when of sufficient volume there are usually more than one, having the air from the pump passing into the first one, from there to the next, and so on to the brake valve. This gives the air a chance to cool down to the normal temperature of the atmosphere, when it will deposit all its moisture as water in the main reservoir. If the air passes through the brake valve without cooling down it will leave some of the water in the train pipe—see question 8—and give trouble in the operation of the brake.

Main reservoirs should have a volume of at least 20,000 cubic inches. Freight engines should have 1,000 cubic inches capacity for each car in the train. An engine that can handle a 75-car train should have 75,000 cubic inches. Large main reservoir capacity is necessary to promptly release all brakes on a long train and will in a measure prevent stuck brakes and slid flat wheels on the rear cars—see question 9. A large main reservoir also tends to save a pump, as it can run at a slower speed, for it can run continuously, not intermittently.

When air at a temperature of 60 degrees is compressed from the atmosphere line up to a gage pressure of 70 pounds the temperature rises to about 400 degrees; with a pressure of 90 pounds it is about 450 degrees, at 105 pounds it is 490 degrees. As this heat is the result of the mechanical energy of the steam developed through the air pump, you can readily see that it takes more power from the boiler to reach a high pressure than a moderate one. Also the air piston will come nearer the end of its stroke before the air is compressed to 105 than at 90 pounds, so that a less amount of 105-pound air is delivered than of 90. As the air usually cools off to the normal temperature before it passes into the brake cylinder, we can take no advantage of any expansion of air by the heat of compression.

The heat that is given out by compression is taken up when the air is allowed to expand. When air expands through any opening from a high to a low pressure it takes up or absorbs heat from all surrounding bodies, this accounts for its being so cool when coming out of the bleed cock, exhaust port of a triple or exhaust pipe of an engine run by compressed air, in some cases it will form ice.

When studying the equalizing processes in the operation of compressed air equipment, remember that it is *air* that flows from one part of the equipment to another and *not* pressure. Pressure is a condition, air is a substance or material. When air flows from the auxiliary to the cylinder it will change the conditions or pressure in these places, but the pressure does not flow either way.

It will take away much of the mystery of equalization if you bear these facts in mind.

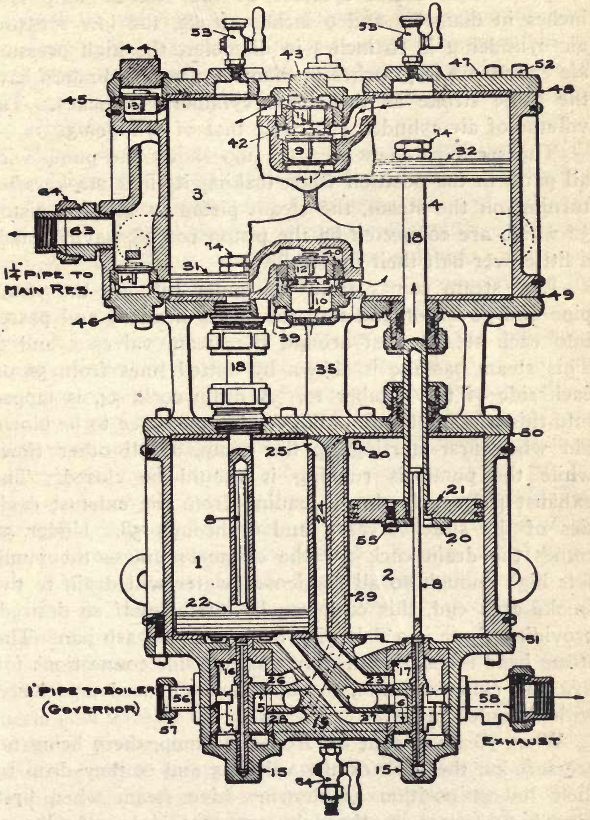
THE NEW YORK AIR BRAKE.

The important parts of the New York Air Brake that differ from those of the Westinghouse Automatic Brake, are the Duplex Air Pump; Governor; Engineer's Valves; Compensating Valve; Quick Action Triple Valve; Air Signal Valve and Train Pipe Strainer. The Brake Cylinders and pistons in all their details; Reservoirs, both main and auxiliary; Pressure Retaining Valves; Reducing Valve for the air signal system; Train Pipe with Hose Couplings, Angle and Cut-out Cocks and Conductor's Valves are the same in both systems of equipment; their construction and operation have already been described in this book.

As freight cars in interchange service are moved from one railroad to another when of the same guage, there will be in all freight trains some cars equipped with the Westinghouse and others with the New York brake. The Master Car Builders' specifications require that all brakes in a train shall be so constructed that the different kinds will operate in unison, so as to control the speed of the train without shocks. For that reason the general rules for the handling of trains are the same, whichever brake is used. There are several differences in the construction of these two kinds of brake equipment, that give different results when they are operated; these points will be explained later on.

THE DUPLEX AIR PUMP.

This pump has two steam cylinders, 1 and 2, and two air cylinders, 3 and 4; the steam valves, 5 and 6, being operated by reversing or tappet rods, 8-8. These tappet rods are operated by the tappet plates 20, which are securely fastened to the lower side of each steam piston by bolts 55. The steam cylinders each receive steam from the boiler and exhaust to the atmosphere, the air cylinders each receive free air from the atmosphere; but the air in cylin-


1¼" PIPE TO MAIN RES.
1" PIPE TO BOILER (GOVERNOR)
EXHAUST

der 4 when compressed passes into cylinder 3 and from there is forced into the main reservoir. Thus, the air cylinders compound the air, while the steam cylinders work simple. Each steam cylinder of the No. 2 pump is 7 inches in diameter and 9 inches stroke, the low pressure air cylinder 4 is 10 inches in diameter, the high pressure air cylinder 3 is 7 inches in diameter; both cylinders have the same stroke as the steam cylinders, 9 inches. The volume of air cylinder 4 is twice that of cylinder 3.

The sectional view on page 169 shows the pump with all parts in the position when making its first stroke after turning on the steam, the steam piston 21 and air piston 32 which are connected by the piston rod 18, having made a little over half their up stroke.

Live steam comes from the boiler through the steam pipe and governor and into the steam head 19 and passes into each steam chest around the steam valves 5 and 6. This steam passage is shown by dotted lines from 56 on each side of the number 19. A drain cock, 54, is tapped into this passage to allow the condensed water to be blown out when first starting up the pump, at all other times while the pump is running it should be closed. The exhaust passage is shown leading from the exhaust cavities of the slide valves 5 and 6 through 58. Under 58 comes the drain cock for the exhaust; unless the pump sets high enough so all condensed water will drain to the smoke arch end, this cock can be left open if so desired, providing there is a drip pipe leading to the ash pan. The steam head is made with right and left side connections for live and exhaust steam, the openings not used are closed with threaded plugs.

When steam is shut off from the pump, there being no pressure on the back of the valves 5 and 6, they drop to their lowest position as shown. Live steam when first turned on passes up through port 23-24 into cylinder 1, and if piston 22 is not already at the bottom of its cylinder 1, it is forced down and held there. At the same time live steam passes through port 26 under piston 21, forcing it and air piston 32 upwards; the air in cylinder 4 above piston 32 raises valve 11 and passes into the upper end of high pressure air cylinder 3 above piston 31. At the same time while piston 32 is moving up, free air from outside raises inlet valve 10, passing into the lower end of low-pressure cylinder 4 and filling it ready for compression on the down stroke of its piston. Piston 21 then remains at the top of its stroke till the other steam piston makes an up stroke.

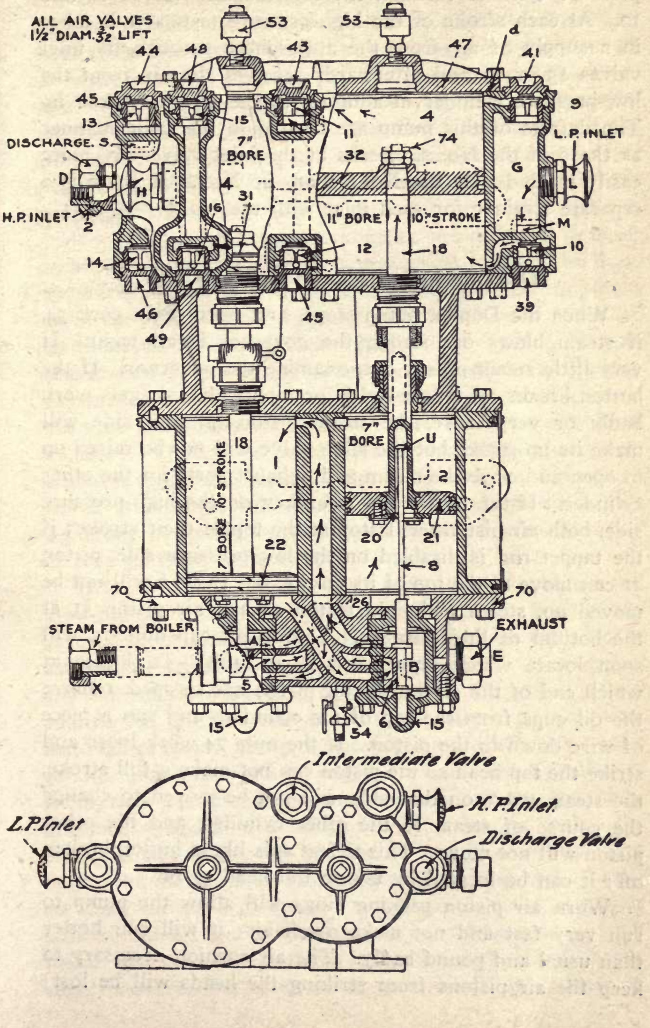
When steam piston 21 approaches the top limit of its stroke, tappet plate 20 catches the button on the top end of the reversing or tappet rod 8, drawing this rod and slide valve 6 up so that port 27 is uncovered to the live steam and port 23-24-25 is connected to the exhaust. With live steam passing under it and the upper side connected to the exhaust, piston 22 moves upward, carrying air piston 31 with it and forcing the air in upper end of the high-pressure cylinder past the final discharge valve 13 into the main reservoir. At the same time, air from the atmosphere flows in past valves 10 and 12, filling the lower end of the high-pressure cylinder 3 with free air. The low-pressure air cylinder has one inlet valve for each end, 9 and 10; the high-pressure air cylinder has to draw its supply of free air through two inlet valves at each end, 9 and 11 at the top end and 10 and 12 at the bottom. Valves 11 and 12 are the discharge valves for the low-pressure cylinder; 13 and 14 are the *final* discharge valves from the high-pressure cylinder to the main reservoir.

As piston 22 nears the end of its up stroke, the tappet plate moves rod 8 up, drawing valve 5 upwards, this connects port 26 with the exhaust so that the steam in cylinder 2 under piston 21 will pass out; port 28-29-30 is opened and live steam passes in above piston 21, forcing it down, bringing air piston 32 with it and compressing the air in the lower end of cylinder 4 past valve 12 into the lower end of high-pressure cylinder 3, and drawing a supply of free air past valve 9 into the upper end of cylinder 4. During this downward movement of piston 21, piston 22 is stationary at the top of its stroke. As piston 21 nears the bottom limit of its stroke, tappet plate 20 strikes the shoulder on rod 8, moving it and steam valve 6 to their lower position; this opens port 23-24 to live steam and 27 to the exhaust; steam piston 22 then is forced down, bringing air piston 31 with it; the air in the lower end of cylinder 3 is forced past final discharge valve 14 to the main reservoir, free air from the atmosphere passes by valves 9 and 11 and fills the upper end of cylinder 3. This completes a round trip of both steam and air pistons.

By means of the tappet rod each steam piston moves the slide or steam valve that opens and closes the steam and exhaust ports for the other cylinder, so that when one steam piston completes its stroke it has moved the steam valve to operate the other steam piston and then remains at the end of its stroke while the other piston makes one. This ensures that the air pistons make a full stroke and leave no clearance space at the ends of the air cylinders except the volume of the passages to the discharge valves and leaves the air pistons in the proper position so the air from the low-pressure cylinder can pass into the high-pressure cylinder ready for the final compression to the main reservoir. All the air valves have a lift of $^1/_{16}$ of an inch. Oil cups 54 are in the top heads of each air cylinder.

The No. 6 Duplex Pump here shown has the steam end constructed in much the same manner as the No. 2 Duplex Pump. The air inlet and discharge valves are placed in another manner, the No. 6 pump has a separate air inlet for each cylinder to take in atmospheric air, their location is shown in the cuts of the top end of the pump and the sectional view. The bore and stroke of each cylinder is shown in the cuts as well as the course of the steam and air by the arrows, during the first up stroke. A description of the No. 6 is not necessary here, as with the description of the No. 2 pump and the illustrations, the operation of the pump can be readily understood. The low-pressure cylinder takes in air from the atmosphere at each stroke of its piston 32 and delivers the compressed air to the high-

NO. 6 DUPLEX AIR PUMP.



pressure cylinder through the intermediate valves 11 and 12. At each stroke of the high-pressure piston 31 it takes in a supply of air from the atmosphere through its inlet valves 15 or 16 and afterwards receives the air from the low-pressure cylinder in addition to the free air taken in. The defects of this pump are treated in the same manner as those of the No. 2. Leaks at the inlet valves are more easily located with the No. 6 than the No. 2, as there is a separate strainer for each inlet with the No. 6.

DEFECTS OF THE DUPLEX PUMP.

When the Duplex pump stops, first open drain cock 54, if steam blows out strong the governor is all right. If very little steam passes out, examine the governor. If the button breaks off tappet rod 8, or tappet plate 20 gets worn badly or very loose, the steam piston on that side will make its up stroke but the slide valve will not be raised up to open and close the steam and exhaust ports for the other cylinder. If the tappet rod is broken on the high-pressure side, both air pistons will stop at the top of their stroke; if the tappet rod is disabled on the low-pressure side, piston 21 can move to the top of its stroke, but valve 6 will not be moved up, steam will hold piston 22 and air piston 31 at the bottom of their strokes. Taking off cap nuts 15 will soon locate which tappet rod is at fault. To locate at which end of the stroke the air piston has stopped, remove the oil cups from the top of air cylinders and run a piece of wire down to the piston. If the nuts 74 work loose and strike the top head so the piston can not make a full stroke, the steam valve on that side will not be moved to change the course of steam to the other cylinder, and the other piston will not move. This defect acts like a button broken off; it can be located by taking top head 47 off.

Worn air piston packing rings will allow the pump to run very fast and not make much air; it will run hotter than usual and pound badly. The air cushion necessary to keep the air pistons from striking the heads will be lost;

this will cause the pound. Leakage of air around the high-pressure piston rod will waste the air already compressed, and allow the piston to strike the lower head; it will also make the strokes uneven. To locate worn air piston packing rings, run the pump very slowly against full pressure in the main reservoir. If the rings leak considerable, compressed air will get past the piston in the latter part of its stroke; this will reduce to nothing the amount of free air drawn in at the inlet valves. To locate the defective piston, note which one in making its stroke is not drawing in air properly. This is not a very good test for the high-pressure piston, as it may be drawing part of its supply from the low-pressure cylinder, which has been expanded by the heat of the cylinder. If the pump works all right at a low air pressure, and as the pressure increases the low-pressure cylinder seems to be doing most of the work, examine the high-pressure side to see why it is not doing its share. The low-pressure piston ordinarily works against a pressure of three atmospheres—30 pounds gage pressure, which is the pressure on the high-pressure piston at the beginning of its stroke when both cylinders have filled full of free air from the atmosphere.

If an inlet or receiving valve 9 or 10 leaks, the air will blow out past it as piston 32 moves towards it. Both valves 9-11 or 10-12, will have to leak if any air gets back to the atmosphere from the high-pressure cylinder. Open the oil cup on the low-pressure cylinder, run the pump slowly against the full reservoir pressure; if valve 11 leaks when the high-pressure piston is moving up air will pass valve 11 and blow out of the oil cup. If final discharge valve 13 leaks stop the pump, opening the oil cup on the high-pressure cylinder will show it. If valve 14 leaks, the piston, if not at the top of cylinder 3, will move up there unless the air can blow out around the piston rod. Leaky air inlet valves will cause the pump to make irregular strokes, quick towards the leaky valve and slow away from them. If *discharge* valves leak, the piston will move slowly towards the leaky valve and quickly away from it.

A leak by the gasket 48 will show like a leaky air valve; to be sure which it is, the best way is to take up head 47 and examine the gasket and air valves. When the air valves or their seats have worn so as to materially increase the lift or allow them to leak, it is best to put in new valves and seats that are in perfect order. When new valves are placed in the old seats or the old valves ground in to a fit, be careful that the lower end of the wings of the valve does not strike on the cages or the stops of the valves under them.

The exhausts from the pump when run very slowly against standard pressure, will usually show where the air leaks are located.

Leaky steam piston packing rings will cause an intermittent blow. Run the pump slowly against full air pressure, open the drain cock in the exhaust at 58; you can soon locate the defect. A leaky steam slide valve will usually give a steady blow.

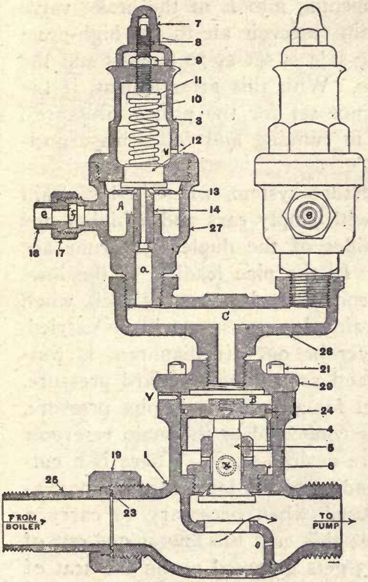
Steam escaping at the piston rod packing is liable to be drawn in at the air inlet valves, and fill the equipment with water; this is very dangerous in cold weather.

THE PUMP GOVERNOR.

The New York Air Brake Co. make three styles of governors: the Single, Duplex and Triplex. As these only vary in the number of air diaphram bodies attached to a single steam valve body, we will describe the Duplex governor, which is the one most generally used. Air enters the governor at *e* from the train pipe to one diaphram body and from the main reservoir to the other diaphram body. At *f* is a strainer to prevent dirt or grit passing from *e* into chamber A. Air passes into the chamber A under the corrugated diaphram 13, which is held down on its seat 14 by a regulating spring 10, acting on the diaphram button 12. When the air pressure under the diaphram exceeds the resistance of the spring 10, the diaphram is raised off its seat on 14, this allows air at the train pipe pressure to pass down through *a* and C into B on top of piston 4, which at once moves down, also moving steam valve 5 down against its seat and shutting off the supply of steam from the boiler to the pump. A small hole at *o* lets a little steam pass through to the pump so it will make a stroke at intervals. A vent port *V* in the cylinder 1 over piston 4 allows air to blow out steadily while the air pressure is operating the governor, this also tends to keep the pump moving. When the air pressure drops so that spring 10 can hold diaphram 13 on its seat, the air escapes from chamber B over piston 4 through vent *V*; valve 5 and piston 4 are raised by the steam pressure and the steam again passes to the pump. When valve 5 is at the top of its travel a steam tight seat is at *S*, so no steam can work up under the piston 4. The dotted lines at *x* show the location of the drip opening in the side of the cylinder 1, which allows any steam that works up past valve 5 or air that comes down by packing ring 24 to escape to the atmosphere. When valve 5 is partly open, steam can blow out at the drip steadily as its stem does not make a steam tight fit in the guide 6. The regulating springs over the air diaphrams are adjusted by the small adjusting screw 8 and fastened by the jam nut 9.

Duplex Governor.

PLATE Q 8.



The later pattern of governors have a large adjusting nut, it is shown in the Duplex Controller.

The single governor is usually set at 70 pounds, as it controls the train pipe pressure and is piped to passage E in the brake valve on the train pipe side of the excess pressure valve 97.

The Duplex governor has the low-pressure air diaphram chamber connected to the train pipe or chamber A of the brake valve, the opening into E of the brake valve must be plugged, and main reservoir air to the high-pressure side. The train pipe side is set at 70 pounds and the main reservoir side at 90. With this arrangement, if the governor diaphrams are not set for the proper pressures, the train pipe pressures in running and full release positions will not be right.

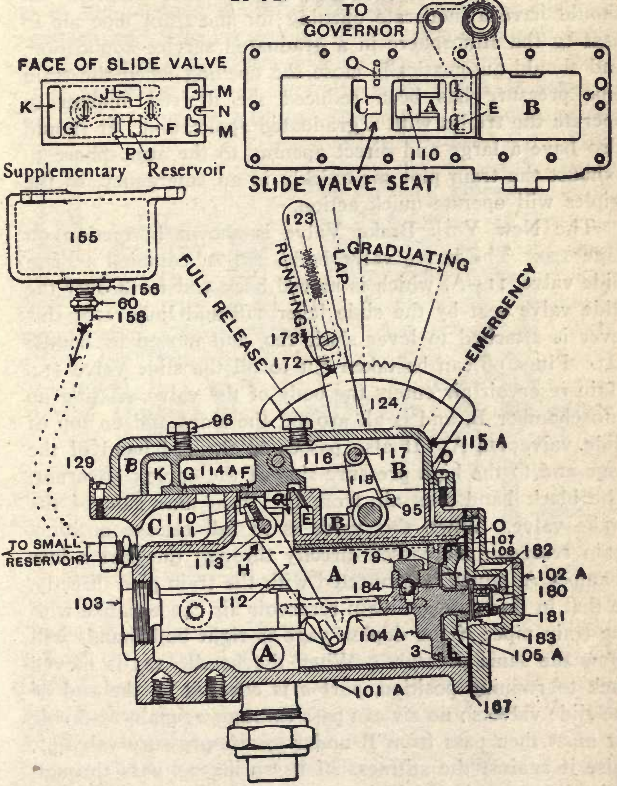
With the Double Pressure system, where a low train pipe pressure is carried with empty cars and a higher one with loaded cars, both sides of the duplex governor are piped to the opening E. In the pipe leading to the low-pressure side of the governor there is a cut-out cock, when this is shut the higher train pipe pressure will be carried.

With the Triplex governor one air diaphram is connected to the train pipe and set at one standard pressure, the second diaphram is set for a higher train pipe pressure, and the third diaphram is connected to the main reservoir air and set at the pressure desired there. There is a cut-out cock in the air pipe leading to the lowest train pipe diaphram, which can be closed when necessary to carry a higher train pipe pressure; this cuts the lowest one out of service. The diaphram 13 gets gummed up on the seat of 14 so that in some cases air leaks by it and the governor piston is operated before the proper pressure is reached. Or it may get gummed up so much that air can not pass down to the piston. For defects common to governors, see page 40.

THE 1902 MODEL BRAKE VALVE.

The duty of the brake valve is to control the passage of air from the main reservoir to the train pipe; from the train pipe to the atmosphere or stop the flow of air through it in any direction. The engineer's brake valve, when in full release position, should allow the main reservoir air to

Engineer's Brake Valve.
1902 MODEL.

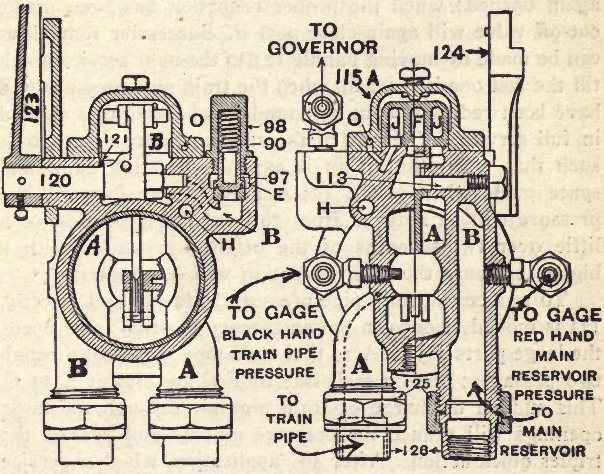


flow directly to the train pipe through large ports to equalize these pressures quickly. It should allow the air to pass through smaller openings in running position and maintain a higher pressure in the main reservoir after the train pipe pressure has reached a standard amount. It should have a moderate opening for the train pipe air to pass to the atmosphere in a graduated service application, and should automatically close the opening when the train pipe pressure has been reduced the desired amount to operate the triples with a graduated application. It should also have a large and direct opening to the atmosphere to exhaust the train pipe air quickly in an emergency, so the triples will operate quick action.

The New York Brake Valve is shown in section on page 179. The brake valve body, 101-A, contains a main slide valve, 114-A, which is moved back and forth over the slide valve seat by the slide lever 118 and links 116; this lever is attached to lever shaft 120, and moved by handle 123. Plugs 96 can be taken out to oil the slide valve 114. Main reservoir air enters the body of the valve, passing up into chamber B, and is all around the sides and on top of slide valve 114-A. It also passes to the red hand of the gage and to the high pressure side of the duplex governor. The black hand gets air from the train pipe side of the brake valve. When this valve is in full release position, main reservoir air passes directly through the port *a* into chamber A, which is connected with the train pipe directly, so that in this position main reservoir air can equalize with the train pipe; if the duplex gage is right both hands will show the same pressure. When the handle 123 is moved back to running position, port *a* is covered by the end of the slide valve so no air can pass through *a*; main reservoir air must then pass from B under excess pressure valve 97, raise it against the stiffness of its spring 90, pass through E into the cavities M-M in the face of the slide valve and through *a* into A. Train pipe pressure is also holding valve 97 down in addition to the stiffness of spring 90, so that with main reservoir pressure on one side and train pipe pressure on the other side of 97, spring 90 is able to maintain a steady difference in these pressures, at whatever amount the main reservoir pressure may be. This difference is usually 20 pounds.

Two sectional views are shown on page 181 giving the position of the excess pressure valve 97, the ports from B to E, and showing the main reservoir, train pipe and gage connections. The connection to the supplementary reservoir and port H is shown on page 179.

In the lower part of the valve body, 101-A, is a piston, 104-A, moving in a bushing; this piston by means of the



graduating valve lever 112, can move the graduating or cut-off valve 110, which rests against the lower face of slide valve 114-A, and in its normal position covers the port F that is connected by a passage through the middle of the slide valve with port G, which in service position is open to the atmosphere through cavity C. When the slide valve is moved to the first notch in service application position, train pipe air can flow from A through *a*, ports F and G into C, and reduce the train pipe pressure. Chamber D on the other side of the piston 104-A is connected with the supplementary reservoir 155, which has a pressure in it at the beginning of the train pipe reduction equal to that in the train pipe. As the train pipe pressure is reduced, the air in chamber D and 155 expands, and moves piston 104-A towards the reducing train pipe pressure in A, this in turn moves cut-off valve 110 back and closes port F, thus cutting off the flow of train pipe air to the atmosphere, without any movement of the handle 123 to lap position; this is expected to reduce the train pipe pressure about 4 pounds. A further movement of handle 123 to the next service notch will move valve 114-A so that port F will be again opened; when the proper reduction has been made, cut-off valve will again close port F. Successive reductions can be made by moving handle 123 to the next service notch till the last one is reached, when the train pipe pressure will have been reduced about 23 pounds, and the brakes applied in full service. The size of the supplementary reservoir is such that when the air in it expands into the additional space made when piston 104-A moves clear forward, the pressure will be reduced from 70 to about 47 pounds, or a little over two-sevenths of the original pressure; with a higher pressure the total reduction will be greater.

To reduce the train pipe pressure suddenly and directly, 123 is moved at once to the emergency position; this opens the large ports J-J to A so that train pipe air passes through two passages; one on each side of F-G and out at K to C. This sudden discharge of train pipe air through the large openings will reduce the pressure quickly and operate the triples quick action. After any application, whether service or emergency, the brake valve should be placed in full release position till the train pipe has been charged its full length, and all triples moved to release position, if it is desired to release all brakes properly.

If piston 104-A has been moved forward by the pressure in chamber D at the time of a reduction of train pipe pressure, it must be moved back to its normal position when the brakes are released if it is to be ready to move cut-off valve 110 to graduate the next train pipe reduction. To do this some of the air in chamber D and reservoir 155 must be discharged to the atmosphere. This is done through port and passage O, which passes through the valve cover 115-A, as shown in illustrations, back into the valve body 101-A and out to C through port J when the valve is in full release, or through cavity P in the slide valve when in running or lap position. Another passage, H, connects chamber D at all times with reservoir 155, so that when air can pass out of chamber D through O, it can also pass out of reservoir 155. With air exhausting from chamber D and train pipe pressure in A, piston 104-A is at once moved back to its normal position; also moving cut-off valve 110. In the end of piston 104-A is a valve, 180, that closes port O when the piston is in the normal position and the brake valve in full release, running position or lap, and prevents any air from chamber D flowing out at port O. Air from the train pipe can flow from A up past ball valve 184, and recharge chamber D at all times when the pressure is less in D than in A; but cannot flow back into A as the valve 184 prevents this. This recharges chamber D and reservoir 155 as soon as piston 104-A moves to normal position and seats valve 180, closing passage O. The opening past ball valve 184 and through the piston into chamber D, is much smaller than O, so chamber D air can be exhausted through O faster than it can feed in at 184, this ensures the movement of piston to its normal position. The older pattern of Vaughn-McKee valve does not have this recharging attachment, and in all cases in releasing brakes the valve *must* be replaced in full release an instant to discharge the air from chamber D, then moved to running position to recharge chamber D, in order to get the graduating action of piston 104.

As the supplementary reservoir is supplied with air from the train pipe, while this reservoir is charging after an application and release of the brake on a lone engine with the older type of the Vaughn-McKee valve, the train pipe pressure will be reduced at the instant of placing the valve on running position. This reduction of pressure may apply the engine brake; as soon as air begins to pass the excess valve the brake should release.

If the supplementary reservoir pipe is broken or leaking so a blind joint must be made at the valve, there will be so little air in chamber D that the equalizing piston will not move valve 110 to graduate and stop the flow of air from train pipe, and handle 123 must be moved to lap position to stop the discharge of train pipe air.

As this valve has two sets of exhaust ports, one small for the service application and a large port for the emergency application, the work of reducing the train pipe pressure is very easily regulated.

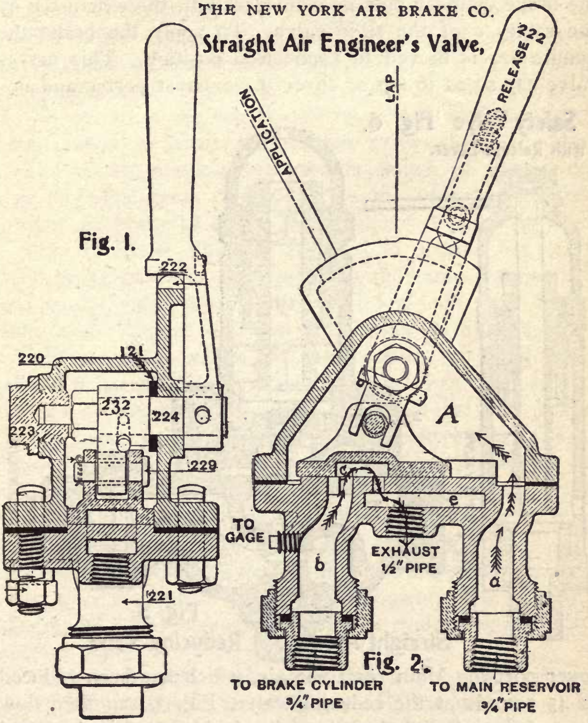
DEFECTS OF THE BRAKE VALVE.

If air leaks past main slide valve into train pipe, it will not maintain excess pressure, if the valve is in service or lap position during an application of the brake this leak will recharge the train pipe and release the brake. To test for this leak, place the valve on lap, close the cut-off cock and start the pump; any leak into the train pipe will be shown on the black hand. If the leak is only shown when the valve is in running position, the excess pressure valve is at fault; it usually only needs cleaning. While doing this do not scratch either the valve or its seat, or it will surely leak after cleaning. If the cut-off valve 110 leaks, it will not stop the flow of air from the train pipe in a service application; you can hear the continuous blow at the exhaust opening. This blow will stop if you move the valve back to lap. If the cut out cock is closed, the black hand will drop to zero unless there is a leak into the train pipe cavity A. A leak through the leather gasket under the cap 115-A that allows main reservoir air to get into port O, will cause a blow at the exhaust in any position between lap and full release. In any other position it will charge chamber D direct from the main reservoir. The openings in the gasket at O should be the exact size of the port O.

A leak from the supplementary reservoir or its connections, if to the atmosphere, is easily detected, and should be remedied if the automatic closing of the cut-off valve 110 is to be satisfactory. This leak will reduce the pressure in the reservoir so the piston 104 will not move. A leak from chamber D back into the train pipe can be detected by closing the cut out cock under the brake valve, placing the valve in emergency for an instant to empty chamber A and then in the second service notch; a leak into chamber A will be shown on the black hand. This leak may be past the leather packing ring or by the ball valve.

THE NEW YORK AIR BRAKE CO.

Straight Air Engineer's Valve,

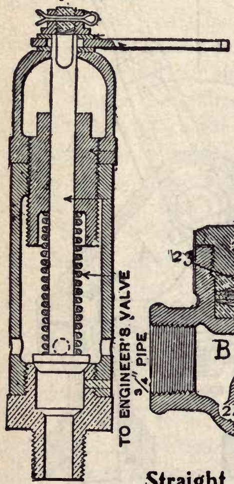


Before making this test be sure main slide valve does not leak from main reservoir into train pipe. Lost motion between handle 123 and main slide valve will allow the slide valve to leave the ports only partially open; this will affect the release of the brake very seriously. This affects a train pipe reduction when made in the first graduating notch.

THE STRAIGHT AIR BRAKE.

The Straight Air Brake valve shown on page 185, Figs. 1 and 2, has a slide valve *227*, which is moved by the lever *222* with its lever shaft *224*, and slide valve lever *232*. When in release position, Fig. 2, the port *b*, leading from the brake cylinder pipe is connected with the exhaust *e* by the cavity *c* of the slide valve. To apply the brake the handle *222* is moved to application position. This moves valve *227* so as to lap or cover the exhaust port *e* and uncover port *b*.

Safety Valve Fig. 6.
With Release Lever.



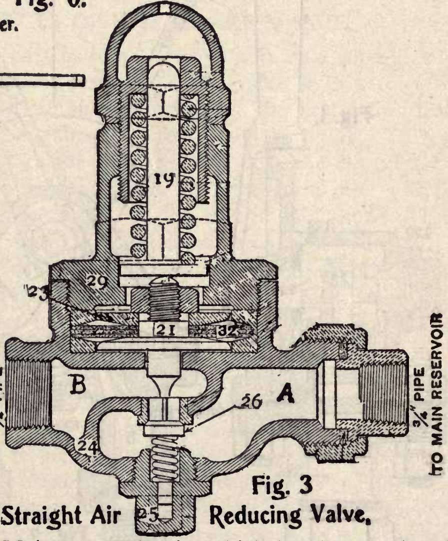


Fig. 3
Straight Air Reducing Valve.

cover port *b*. Main reservoir air, which has been reduced to 45 pounds at the reducing valve, Fig. 3, can then flow from A into *b* and thence to the double check valves and brake cylinders. Gasket 121 prevents leakage of air along the shaft 224. The reducing valve shown in Fig. 3 is located between the main reservoir and the brake valve. The diaphram complete consists of the stem 21, the washer 23 and the rubber diaphram 32. It is held down against the air pressure in B by the regulating spring and its stem

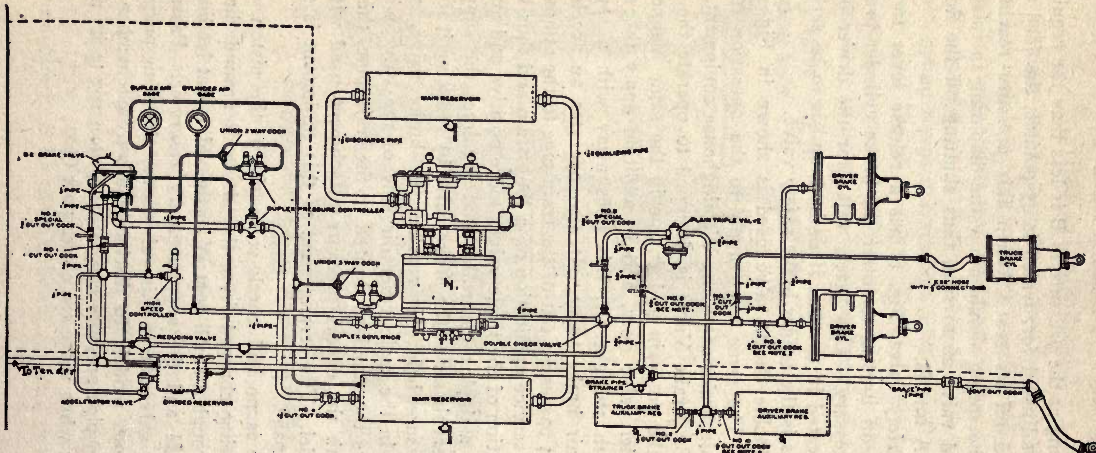
19. As long as the pressure in B is less than the regulating spring is adjusted for, which is 45 pounds, the feed valve 26 is held off its seat. When this pressure reaches 45 pounds, the spring should allow the diaphram to raise and allow feed valve 26 to seat, thus shutting off the flow of air from A into B.

The safety valve, Fig. 6, has a release lever to raise the valve off its seat to lower the brake cylinder pressure when necessary. This safety valve for the driver brakes can be located in the cab, if desired, and is to be set at 52 pounds, as is the tender brake safety valve.

The double check valve used is shown in Fig. 4, on page 89. The same rules apply to the operation of this straight air brake as to the Westinghouse equipment.

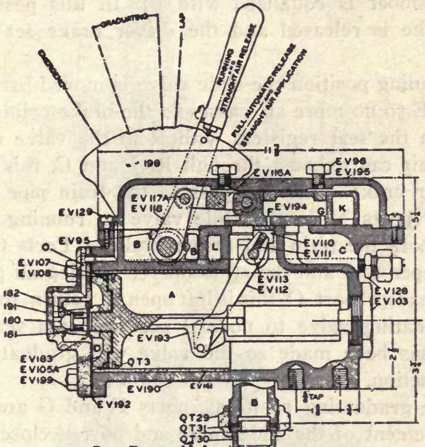
The B2 Brake Valve is designed to operate the automatic brake on train and engine in the same manner the 1902 model valve does, and in addition apply the driver brake with straight air, this does away with a separate straight air brake valve. It also operates an accelerator valve that passes air out of the train pipe to the atmosphere during a service application on a long train and thus makes the operation of the triple valves more positive and quicker. There is a duplex controller that regulates the supply of main reservoir air to the brake valve by reducing it to train pipe pressure before it reaches the brake valve, so the pressure in the main reservoir side of the valve will not rise above the standard desired in the train pipe, this does away with the excess pressure attachment used with the 1902 model. The arrangement of this equipment is shown on next page.

There is no ball check valve 184 in the piston, chamber D being charged from the air in B around the slide valve through a small port W in the valve seat leading into passage H and the supplementary reservoir. Passage O and vent valve 180 in this valve serve the same purpose as in the 1902 model; to discharge air from chamber D so that train pipe pressure can return piston 193 to its normal position; when valve 180 closes port O.

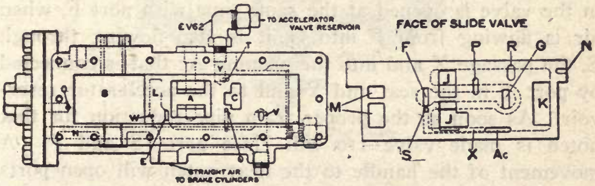


PIPING DIAGRAM B2—HS EQUIPMENT.

A sectional view of the B2 valve is shown, also a plan of the face of the slide valve and its seat. The chief differences between this valve and the 1902 model are the ports in the slide valve and the seat. Two ports, E and V, in the seat are connected by a cored passage shown by dotted lines through the valve body and located above



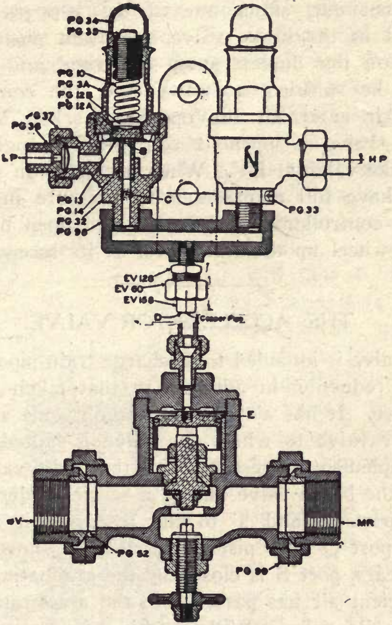
B-2 Brake Valve.



passage H, into this passage the pipe leading to the brake cylinders is attached. When the slide valve is clear ahead in full release it uncovers port E so air from the top of the valve in B can pass through the reducing valve set at 40 pounds, to the brake cylinders, this applies the engine brake straight air. Air from B passes by the end of the slide valve and also through ports M in the slide valve into the train pipe as fast as the air can pass the controller, releases the train brake and charges the train pipe and auxiliaries. Port T in the seat, leading to the accelerator reservoir is open through J in the slide valve and exhaust C to the atmosphere and port O is the same as explained with the 1902 model. Port W is open and keeps chamber D equalized with B. In this position the train brake is released and the driver brake set straight air.

In running position the slide valve is moved back covering port E so no more air passes to the brake cylinder pipe, port V in the seat registers with R in the valve so brake cylinder air can exhaust through R, J and C, this releases the driver brake. Air can pass to the train pipe through the large ports M in the slide valve so running position releases both the train and driver brakes. Ports O and T are still open to J and the atmosphere. On lap all ports are blanked except port O, this is left open to return the piston and graduating valve to normal position, if a service reduction has been made so the valve will graduate at the next reduction.

In the graduating positions, ports F and G are opened by a movement of the slide valve and port F closed by the graduating valve as with the 1902 model. But as port S in the valve is opened at the same time with port F, when air is flowing from F into G, it is also flowing through S, the passage X and into the opening Ac that is connected by port T in the seat and Y and to the accelerator reservoir. As soon as the proper train pipe reduction for that notch is made valve 110 will close ports S and F. A movement of the handle to the next notch will open ports S and F again and valve 110 will close them; train pipe air flows to the accelerator valve chamber at the same time it flows through F and G and exhaust C. When the last graduating position is reached the restricted passage N in the end of the slide valve has been moved over port V so air begins to flow from the brake valve to the brake cylinder. As the engine triple valve has been sending air to the cylinders during the service application the supply of air through port V tends to maintain the pressure during a full application. The action of the valve in emergency is exactly like that of the 1902 valve before described. The reducing valve used with this equipment is the same one described in connecttion with the Straight Air Brake.



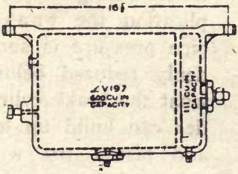
DUPLEX CONTROLLER.

THE DUPLEX CONTROLLER.

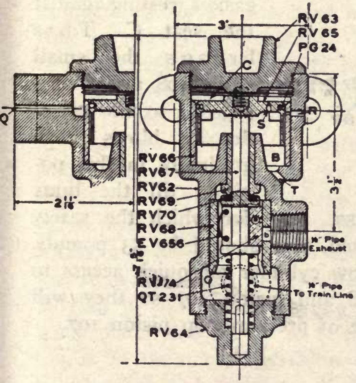
This valve is located between the main reservoir and the brake valve; its duty is to reduce the main reservoir pressure to that required in the train pipe before reaching the brake valve. There are two forms of it in service, only the latest form of it is here illustrated. In its construction it is like the duplex pump governor except that its valve has a leather seat. The regulating tops can be located in the cab and connected to the controller body by a copper pipe. One of the tops is adjusted for the ordinary train pipe pressure, the other for the higher pressure used with the High Speed Brake. When one side is cut in by the union three way cock the other is cut out, either one of the two pressures can be carried in the brake valve and train pipe. The description of the duplex pump governor and its operation will be sufficient to show how the controller operates. Air enters at the opening marked MR, if the controller valve is open it can pass through and out to the brake valve at BV. When necessary in steep grade work to have full main reservoir pressure in the brake valve the controller valve can be held open by screwing the hand wheel up the full travel of its screw.

THE ACCELERATOR VALVE.

This valve is intended to discharge train pipe air during a service reduction in addition to that taken out by the brake valve. It has a divided reservoir; one side for the accelerator valve to which the valve is bolted, the other is the supplementary reservoir for the brake valve. When air from the brake valve during a service reduction passes through ports S and T to the reservoir it also comes tthrough port Q over piston 65. With a short train, less than ten cars, port S is closed by the graduating valve before sufficient air has passed into the accelerator chamber to operate its valve. With a train of over ten cars the pressure in the chamber will build up till it is sufficient to force piston 65 and with it stem 67 and valve 74 down against the tension of spring 31 in the bottom of the valve. In valve 74 is an oblong port *a* and in the seat a Λ shaped port *b*. When valve 74 is moved down port *a* first opens to the pointed end of port *b*, and train pipe air coming in at the opening TP begins to flow out of *b* slowly. As the valve 74 is moved farther down by the increasing pressure of the air above piston 65, ports *a* and *b* are opened wider till their full opening is made; this gives a gradual discharge of train pipe air that with a long train begins about four seconds after the brake valve begins discharging air. It requires 15 to 17 pounds pressure in the chamber to operate the valve. Through piston 65 is a small port S through which air that comes over the piston can discharge into the space under the piston and then to the atmosphere through port T; air flows out here at the same time it comes into the reservoir and prevents any sudden rise of pressure in the reservoir. When piston 65 moves down it uncovers port R in the bushing, this also takes air out of the reservoir. As soon as the graduating valve laps port S in the brake valve, no more train pipe air will flow to the chamber; ports S and R in the accelerator piston will then gradually reduce the pressure in the chamber and allow spring 31 to move valve 74 and piston 65 up, gradually closing ports *a* and *b*. When piston 65 closes port R the flow of air out of S alone is so much slower that piston 65 gives a very slow closure to port *b*. The gasket 70 makes a tight joint on its seat around stem 67 when the valve is closed, so train pipe air cannot escape around the stem.



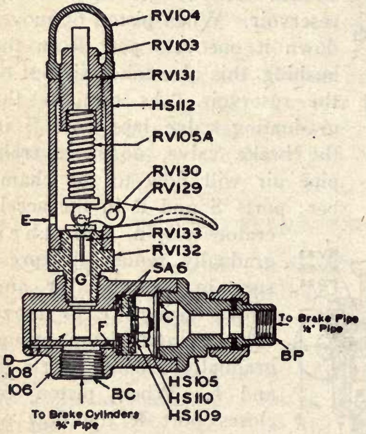
Divided Reservoir.



ACCELERATOR VALVE.

THE HIGH SPEED CONTROLLER.

The high speed controller connects with the brake cylinder pipe at BC and to the train pipe at BP, so that train pipe air pressure is always in the body of the valve and when greater than brake cylinder pressure will hold piston 107 in normal position as shown, leather gaskets are on each side of the piston to make the joint tight. A moderately large opening around the valve 108 allows air from the cylinder to reach the safety valve freely and rapidly reduce any excess of pressure above that the safety valve is set for, this takes place in a service application.



HIGH SPEED CONTROLLER.

In an emergency application the train pipe pressure is suddenly reduced below what the brake cylinder can build up to, and piston 107 will move over to the right with the leather gasket resting against the seat C. This brings the small valve 108 under passage G so the cylinder air blows down gradually in this position till the limit for which the safety valve is adjusted is reached, this should be 53 pounds. Ports D and F are to allow cylinder air quick access to the ends of the valve 108 and piston 107 so they will move with a low difference of pressures on piston 107.

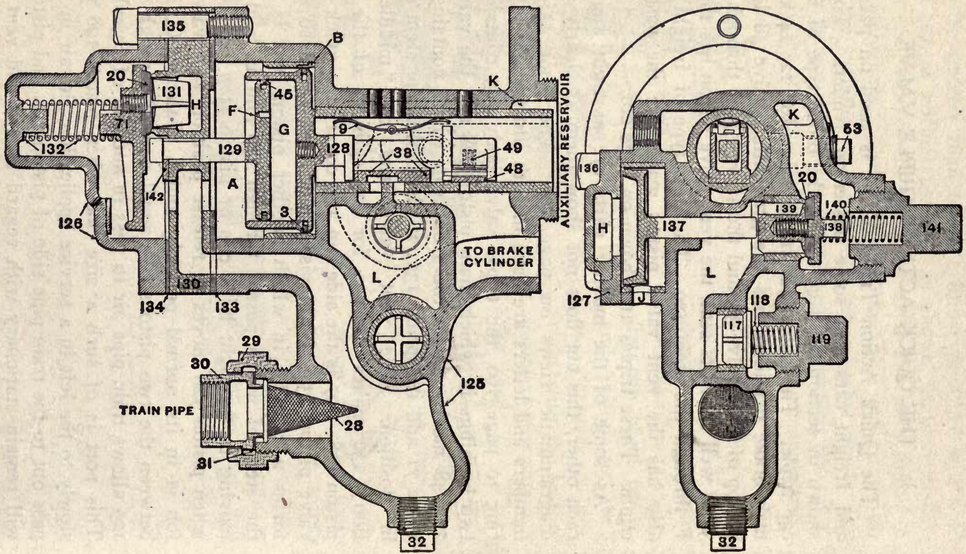
THE QUICK ACTION TRIPLE VALVE.

The Quick Action Triple Valve is used on passenger and freight cars and some passenger tenders. The one shown in section on page 196 is the older type of freight car triple. The passenger triple valve for 12, 14 and 16 inch brake cylinders has the graduating valve 48 located on top of slide valve 38, and the service port through valve 38 as well as in its seat, the vent valve piston has the port F through the stem 129. The new type of freight triple also has the vent valve piston made like the passenger triple. These triples are shown on page 201.

As some of the moving parts are at right angles to each other, this cut does not show them as clearly as the diagrammatic views on page 198. The same reference numbers and letters are used in both illustrations. Referring to page 196, the triple valve body 125 contains the two bushings in which main piston 128 and the valves 38 and 48 move; 126 is the front cap which contains vent valve 71 and its spring 132; it also holds the stem of 129 in position. The vent valve seat or "middle section" 130 makes the cap for the cylinder of the triple piston 128. 127 is the side cap and covers the quick action valve piston 137. Main piston 128 is extended so that it forms a cylinder in which another piston, 129, is fitted, the stem of which passes through 130 and is held from moving to the right by a clip or piston stop 142, so that when piston 128 moves to release position vent valve piston is in its normal position, and a chamber, G, is left between the two pistons. A small port F through piston 129 allows train pipe air to pass in and out of chamber G. This port is of such a size that when piston 128 moves slowly to the left in a service application, the air in G can pass out to the train pipe side of piston 129, and piston 129 will remain stationary with regard to 130 and vent valve 71, as shown in service position on page 198. This vent

Quick Action Triple Valve.

PLATE Q 6.

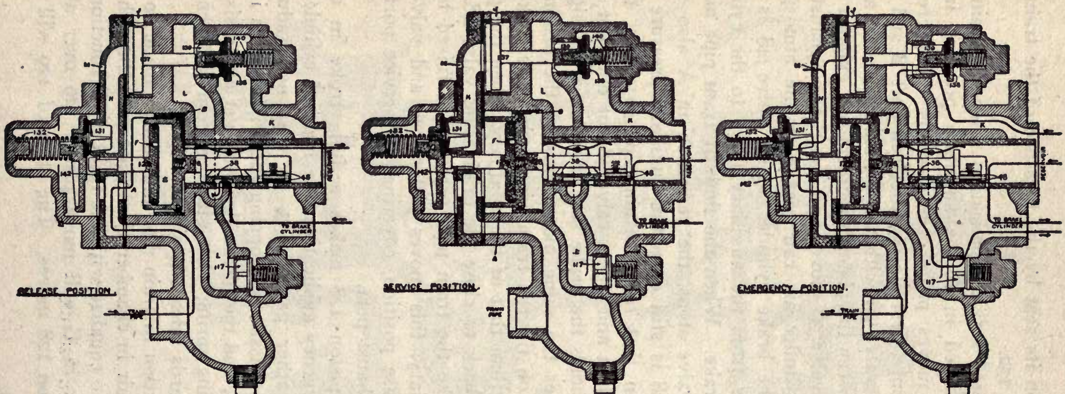


valve is held on its seat by the pressure of the train pipe air and spring 132.

In a graduated service application when the train pipe pressure is reduced in A the auxiliary pressure in the auxiliary side moves piston 128 towards the decreasing train pipe pressure, first closing the feed port B and moving graduating valve 48 with the piston. As soon as the lost motion between the piston shoulders and exhaust valve 38 is taken up valve 38 moves and closes the exhaust port so no brake cylinder air can escape to the atmosphere. The port to the brake cylinder under valve 48 is next opened, and air from the auxiliary flows to the cylinder, applying the brake. When the flow of train pipe air out of the brake valve stops, the reduction in A also stops, and as valve 48 is still open the auxiliary pressure soon gets lower than that of the train pipe so piston 128 is moved to the right and closes valve 48 but does not move valve 38; this holds the brake set. Another train pipe reduction produces the same movements of the piston and valves and so on till the train pipe reductions make the pressure lower than that of the auxiliary, when the piston will not move back to close the graduating valve 48. To release the brake the train pipe pressure is raised higher than the auxiliary, this moves piston 128 and valves 38 and 48 to release position, covering the service port and opening the exhaust port.

The triple piston 128 makes a full stroke in either service or emergency application, the edge of cylinder 128 striking the leather gasket 133, so that no graduating spring is used to assist in stopping the triple piston in the service position, and the piston does not get any assistance from a graduating spring when starting from emergency or full stroke towards release position.

If the reduction in train pipe pressure is made so suddenly that the air in chamber G can not pass through port F fast enough to equalize with the train pipe reduction, the pressure of air in G will move piston 129 over at the same time piston 128 moves. The stem of 129 will push



In these diagrammatic views of the quick action triple valve the various parts are shown in a straight line; by comparison with the other sectional cut of the valve, their action may be easily traced. The arrows and lines joining them show the course of the air through the valve in each of the three positions.

vent valve 71 away from its seat, as shown on page 198 and 201, emergency application; train pipe air from the chamber around valve 71 can flow rapidly into passage H, and thence against the quick action piston 137. This in its turn is moved to the right by the pressure of train pipe air and quick action valve 138 is unseated, opening a large passage for auxiliary air to flow through K into L—L, forcing check valve 117 off its seat; the air also passes into the brake cylinder through the usual opening at the graduating valve. No air from the train pipe reaches the brake cylinder, only that from the auxiliary, but the auxiliary air passes through such large ports K and L that the equalization between the auxiliary and cylinder is almost instantaneous after valve 138 is opened. As soon as these pressures have equalized, check valve 117 closes and prevents brake cylinder air flowing back into L and thence around the stem of piston 137 to the atmosphere. In the meantime air in chamber G has equalized through port F so that spring 132 can push vent valve 71 and piston 129 to their normal positions. When vent valve 71 seats, no more air flows from train pipe to passage H; air escaping from ports M and J at once reduces the pressure on piston 137, which is moved to the left, its normal position, by the stiffness of spring 140. Valve 138 is closed and no more air can pass from the auxiliary into L, and all the quick action parts of the triple valve are returned to their normal positions. Piston 128 having made a full stroke, valve 48 is open so that auxiliary air can pass into the brake cylinder and keep the pressures equalized. With 70 pounds auxiliary pressure and the standard piston travel the equalization is the same for full service and emergency applications, 50 pounds per inch.

Venting the train pipe air to the atmosphere past valve 71 and through ports M and J, should reduce its pressure below that in the auxiliary; this will hold piston 128 in service position.

The sudden venting of train pipe air to the atmosphere at this triple makes a sudden reduction at the next triple, which in turn operates quick action, and so on from one triple to another to the end of the train; this is called the "serial" action.

If there are, close to the head end of the train, several triple valves cut out, or defective triples that do not operate the vent valve so as to vent enough air from the train pipe, or cars with train pipe only, the sudden reduction may not extend far enough to affect a quick action triple so it works quick action and continues the sudden serial reduction. About three "cut out" triples next the engine is the limit to have the quick action "jump over." At the rear end of the train the quick action will jump more than three cars, because the volume of train pipe air behind these defective triples is less than when they are near to the head end of the train.

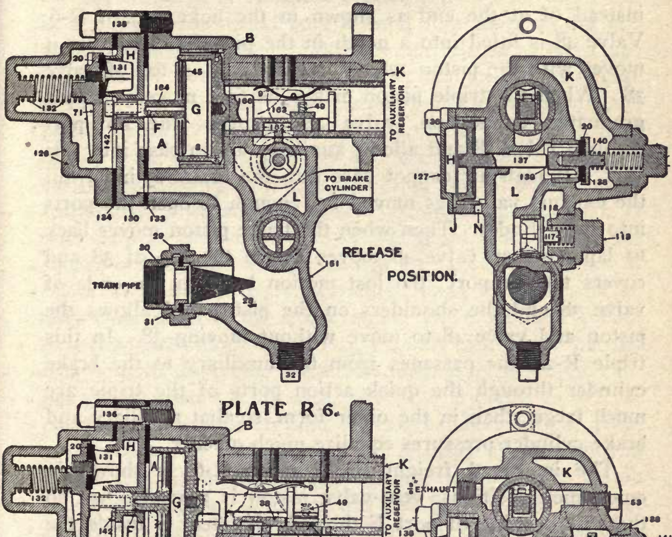
This type of triple valve does not send any train pipe air to the brake cylinder; the brake cylinder pressure is the same with either a full service or an emergency application; so that the same increase of train pipe pressure is required to move the triple valve to release position. When train pipe pressure is restored so that it is greater than auxiliary pressure, or the auxiliary pressure has leaked down, or been bled out, train pipe air passing through port F into chamber G moves piston 128 and valves 38 and 48 to release position; this closes the service port, opens the exhaust port to release the air from the brake cylinder, and opens feed port B to recharge the auxiliary.

If the piston 128 is in lap position, the volume of air in chamber G is so small that in an emergency reduction of train pipe air, the pressures can equalize through port F and piston 129 will rarely move. If piston 128 is in *service* position, it is at the end of its travel and can not move any further. Therefore, after pistons 128 in the triples have responded to a service reduction, *no matter how light,* the quick action parts of these triples will not move and a sudden serial action of these triples will not take place; only a heavy service application. If the general rule to allow all the air to pass out of the train pipe at the brake

IMPROVED QUICK ACTION TRIPLE VALVE.

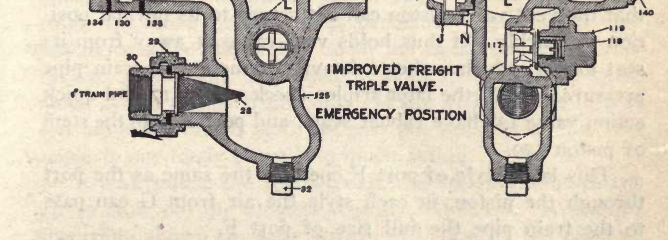
FOR 12 AND 14 INCH PASSENGER CYLINDERS.

PLATE R 24.



RELEASE POSITION.

PLATE R 6.



IMPROVED FREIGHT TRIPLE VALVE.

EMERGENCY POSITION

valve or conductor's valve in cases of emergency or danger is promptly obeyed, all brakes that operate will be applied with the greatest power and in the shortest time possible under the conditions.

The passenger car triple shown at the top of page 201 has the graduating valve 48 on top of the exhaust valve 38 instead of at the end as shown in the next cut, of R-6. Valve 48 is fitted into a notch in the piston rod so that it moves with the piston 128, having its seat on top of valve 38. When the triple piston makes its first movement in a graduated application, valve 48 uncovers the air port through valve 38 and allows auxiliary air to pass into this port, although air cannot pass into the brake cylinder till the exhaust valve has moved far enough to open the ports into the cylinder. Then when the triple piston moves back to lap position, valve 48 moves across the top of 38 and covers the air port; the lost motion between the ends of valve 38 and the shoulders on the piston rod allows the piston and valve 48 to move without moving 38. In this triple R-24, the passages from the auxiliary to the brake cylinder through the quick action ports of the triple are much larger than in the older form, so that auxiliary and brake cylinder pressures equalize much quicker.

The improved freight triple valve, R-6, is shown in emergency positions, vent-valve piston is moved down so that the opening of port F through the stem is inside the bushing of the center piece 130. This covering of port F chokes and retards the flow of air out of chamber G so that the vent-valve piston can not return to its normal position so quickly. It thus holds vent-valve 71 away from its seat longer, which makes a heavier reduction in train pipe pressure. In all the later triples check valve 117 and quick action valve 138 have rubber seats, and port F is in the stem of piston 129.

This later style of port F operates the same as the port through the piston, in each style the air from G can pass to the train pipe the full size of port F.

DEFECTS OF QUICK ACTION TRIPLE VALVE.

If vent valve 71 leaks, or is held off its seat, there will be a blow at the round port M, and sometimes at the two square ports J; also, the brake may not release as train pipe pressure can not be raised enough to move triple to release position. If the vent valve piston stem 129 is bent or the piston sticks in the cylinder of 128, valve 71 will be held open. This piston stem 129 and the cylinder of 128 are easily damaged by improper handling, and should be carefully handled when taken apart. A small leak at valve 71 will show at the round hole M. If there is a blow at the square ports J in the triple shown on page 196, and not at M, or at N in the triples shown on page 201, air is probably coming from the quick action valve 138 and thence past the stem of 137, which is not an air tight fit in the cast iron body of the triple. If the air passing by valve 138 can not go by stem 137, it will, when the triple is in release position, pass check 117 and out the exhaust port or pressure retainer, or leakage groove. A leaky packing ring in piston 128 will affect the prompt movement of this piston to release position, as the air can leak by this defective ring and equalize the auxiliary with the train pipe without moving the triple piston. A leak by this ring will not affect the quick action operation of piston 129. If either of these rings are fitted too tight, this particular triple piston may not move when the others do in the initial reduction of a service application, and when it does move it may cause quick action at this triple only. If the packing ring in piston 129 leaks, the air in G can pass out by this ring and this triple is not likely to go into quick action.

A leak under the seat of valve 38 will allow auxiliary air to blow out the exhaust steadily. If under valve 48 in the triple shown on page 196, it will blow at the exhaust when the triple is in release position. With the triple shown on page 201 it will leak in lap position only, and then into the brake cylinder. If the packing ring in either piston 128 or 129 is too tightly fitted or gritty, the triple may work slower than the others, and get quick action with a moderate service reduction; this will vent a little train pipe air to the atmosphere at that triple, but will not cause any other New York triples to work quick action. If the stem 129 is bent or cylinder of 128 is bent or damaged, it may produce the same effect. This defective triple can usually be located by the flash of air from ports M and J towards the ground which will blow the sand or dust. This brake may release at once if the pressure in the train pipe is not reduced at that time below that at which that auxiliary and brake cylinder equalizes.

Sand works into the ports M, N and J and may cause the quick action piston 137 to stick after a quick action application; this will hold valve 138 open so auxiliary air will leak away.

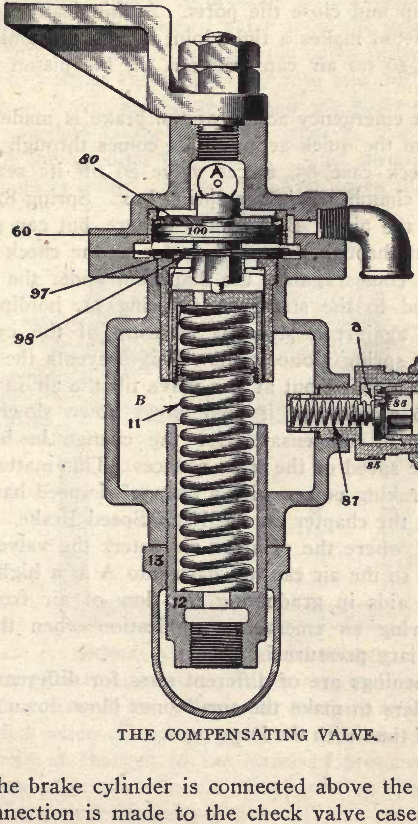
Leaks by the gasket between the triple and the auxiliary on a freight brake, or the triple and the cylinder head on a passenger brake allowing auxiliary air to pass to the cylinder, will give a steady blow at the exhaust port while the triple is in release position.

If the port F has been enlarged or the packing ring in piston 129 is a poor fit, so it leaks, this triple may not go into quick action when the sudden train pipe reduction is made.

The Compensating Valve is used in high speed service and is designed to reduce gradually the high brake cylinder pressure in an emergency application with 110 pounds in the train pipe and auxiliary to 60 pounds, when the valve will close and allow no more air to escape through it from the cylinder.

It consists of a piston, 100, that moves in a cylinder or bushing with several small ports in its side, in normal position the piston covers them so no air can pass out the ports. Below this piston is a diaphram and plate fastened to the piston that prevents the passage of air either way.

The piston is held up in normal position by a stiff spring 11, the tension of the spring is adjusted by the nut 12, a cap nut 13 makes an air tight joint at the bottom of the spring box, screwed into the side of the spring box is a check valve 85, containing a valve 86 with a small port *a* drilled through it.



THE COMPENSATING VALVE.

The brake cylinder is connected above the piston at A; a connection is made to the check valve case 85 from the passage H in the side of the New York quick action triple valve. At any application of the brake air from the cylinder comes into A and gives its pressure to the piston, if this pressure is any greater than the resistance of spring 11 piston 100 will move down and uncover the air ports in the side of the bushing; this allows cylinder air to escape and reduce its pressure till spring 11 has power to force piston 100 up and close the ports. A thin leather gasket on top of piston makes a tight joint against a shoulder of the bushing so no air can leak out till the piston moves down.

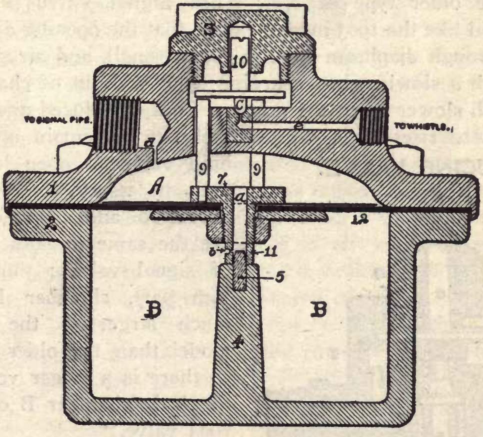
When an emergency action of the brake is made, train pipe air from the quick action triple comes through a pipe into the check case 85, forces valve 86 off its seat and equalizes in chamber B in the spring box. Spring 87 seats valve 86 so the air in B is confined there, but can gradually flow out through the small port *a* in the check valve. Its pressure comes against the diaphram under the piston and is added to the strength of spring 11, holding piston 100 up against a stronger pressure of the cylinder air than the spring alone could. This prevents the cylinder air from blowing out at this valve till the air in B has had time to escape and it then blows down slowly. In this manner it compensates for the change in braking power as the speed of the train reduces. This matter of a change in braking power with a change of speed has been discussed in the chapter on the High Speed Brake.

The port where the cylinder air enters the valve at A is restricted so the air can not flash into A at a high pressure, which aids in graduating the flow of air from the cylinder during an emergency application when the 110 pound auxiliary pressure is used.

These openings are of different sizes for different sized brake cylinders to make the small ones blow down at the same rate of time with the large ones.

NEW YORK AIR SIGNAL VALVE.

The Air Signal Valve shown in section on this page has two chambers, A and B, in the upper and lower parts of the valve, separated by a rubber diaphram 12. Air from the main reservoir reduced in pressure at the reducing valve to 40 pounds enters the signal valve from the signal pipe and passes into chamber A through the small opening *d* which serves to restrict the flow of air into and out of chamber A. From A air passes up around the posts 9 which are firmly attached to the diaphram stem 7. Air also passes through the opening *a* in stem 7, and through the very small hole at *b* into chamber B. The lower end of stem 7,

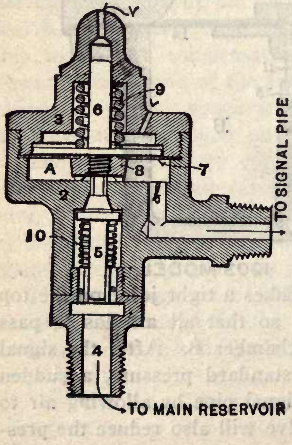


SIGNAL VALVE 1903 MODEL.

when in its normal position, makes a tight joint on the top of post 4 around the plug 5, so that all air has to pass through *b* when charging up chamber B. After the signal equipment is charged to the standard pressure, a sudden reduction of pressure in the signal pipe by allowing air to escape at the car discharge valve will also reduce the pressure in chamber A. The air in B cannot equalize through *b* fast enough; so pressure in B will raise diaphram 12, also raising disc valve 10 off its seat at *c*; air then passes from A to the whistle through *e* and gives a blast. When diaphram 12 raises, the lower end of stem 7 at 11 raises off the post 4, air from chamber B can then pass up through 11 past plug 5, which is taper at its upper end, through passage *a* in stem 7 and equalize quickly with the air in chamber A. The diaphram at once drops to its normal position with stem 7 resting on post 4, seating valve 10 so no more air passes into the whistle. Air then feeds into A and B till the pressures are equalized with the signal pipe when another reduction can be made at the car discharge valve and again operate the signal valve.

The older type of New York Signal Valve is constructed like the 1903 model, except that the opening *a* passing through diaphram stem 7 is very small, and air passes through *a* slowly when charging up B and out of chamber B much slower when the pressure in A is reduced and diaphram 12 rises; this causes diaphram to remain up and hold valve 10 open longer than necessary. The disc valve 10 and chamber A are the same in both types of signal valves; the bottom part, chamber B is much larger in the 1903 model than the older type, so there is a larger volume of air in chamber B of the 1903 valve.

REDUCING VALVE.



The 1903 model charges up chamber B slowly; when diaphram 12 raises, air equalizes from B into A very quickly, thus giving a quick closing of disc valve 10.

The reducing valve used with the New York signal apparatus is shown in section on this page. Diaphram plate 6 is held down by a regulating spring 9 when there is less than standard pressure in A. This in turn holds supply valve 5 off its seat so that main reservoir air entering at 4 can pass into A and through *b* into the signal pipe, charging it. A rubber diaphram 7 makes an air tight partition between the air in A and the outside air. The small holes *v* in the spring cap 3 are to allow any air that may leak past 7 to escape to the atmosphere. When the pressure in A reaches the standard amount, usually 40 pounds, diaphram 7, stem 6 and nut 8 are raised by the air pressure against the stiffness of spring 9. This allows spring 10 to close supply valve 5 so that pressure in A will not raise any higher. When the opening of a car discharge valve or a leak in the signal pipe or its connections reduces the air pressure, spring 9 forces the diaphram down, opens the supply valve; this allows main reservoir air to feed into the signal pipe again.

The object of a reducing valve is to maintain signal pipe pressure lower than that used in the operations of the brake, so that operating either the brake or signal will not interefere with the work of the other. The opening past the supply valve is made small so air will pass into the signal pipe slowly in order that a sufficient reduction can be made at the car discharge valve of any car to operate the signal valve. This could not be done if the reducing valve supplied air as fast as the car discharge valve took it out. See pages 126 and 127.

OPERATING THE EQUIPMENT.

When making the initial or first service reduction in train pipe pressure, to apply the brakes lightly on a train having both kinds of triple valves in operation, no change in the manner or amount of reduction is needed, as both Westinghouse and New York triples, if in good order, will apply their brakes alike. The initial reduction should be from 5 to 7 pounds, depending on the number of air brake cars operated; the length of the entire train and the speed at which it is running. A short train will not need so heavy an initial reduction as a longer train. There will not be so many triple valve feed ports to pass air from the auxiliaries to the train pipe, which tends to prevent movement of the triple piston, and the volume of train pipe air is less in a short train than in a long one; so the reduction through the brake valve is made quicker, which moves the triples quicker. This in turn passes air into the brake cylinders faster, so the pistons move over the leakage grooves with less loss of air through the grooves.

On a long train the first reduction may be 7 to 9 pounds without giving serious shocks, unless the speed is very slow, in which case it is best to make a lighter reduction. A 5 pound initial reduction will give a cylinder pressure of less than 5 pounds on an 8-inch travel piston which will not give any shock to a train. If the train is moving fast, the initial reduction can be much heavier; especially in the case of a passenger train. It is advisable to apply the brakes with considerable force when at high speed, the retarding force of the shoes on the wheels is less in proportion than at slow speeds.

With freight trains, at whatever speed, allow the slack to even up after shutting off steam before applying the brake, then apply it lightly in the case of slow speeds to bunch the train evenly and follow up with other reductions as may be necessary to control the train. Always wait at one reduction till the air has stopped flowing from the train pipe exhaust of the brake valve and the triples have had a chance to act and the slack to even up before making another reduction.

When operating the 1902 model New York brake valve, move the handle to first service position notch with a short train, and the air will at once begin to discharge from the train pipe through an opening in the main slide valve, as the pressure reduces, the cut-off valve will close the opening, it will entirely close when the pressure is reduced the proper amount for that notch; it is not necessary to return the handle to lap position. Succeeding reductions may then be made by moving the handle to the next service notches and allowing the valve to graduate the flow of train pipe air and stop its discharge, or the handle can be stopped between the notches. When the last graduating notch is reached it is expected that a reduction of 20 to 23 pounds will have been made in the train pipe pressure. With a long train it may be necessary to go to the second or third notch in order to get a proper initial reduction on a long train. If quick action is desired at the triples, move the handle to the emergency position for the first reduction and leave it there till the train has stopped or the necessity for the quick stop has passed. This is a general rule for all brake valves and all triples in cases of emergency or danger which must be observed.

With the older type of New York brake valve, the Vaughn-McKee valve, in order to have the valve cut off the discharge of train pipe air automatically in a graduated application, the valve must have been placed in full release position long enough to discharge all air from the supplementary reservoir to allow train pipe pressure to move the equalizing piston and the cut-off valve to their normal positions. It must then be moved to running position to recharge the supplementary reservoir from the train pipe air till it equalizes, after which the piston would operate the cut-off valve in a graduated application. If the valve was only placed on running position to release brakes and moved to service application, the cut-off valve might be over the graduated reduction port so no air could pass out of train pipe and it would be necessary to go farther back towards the emergency notch to discharge any train pipe air. When operating the brake with this valve be sure to go to full release when releasing brakes, then stop on running position an instant if you expect the piston to operate the cut-off valve in a graduated service reduction. The 1902 model brake valve will graduate the flow of train pipe air in a service application, as it automatically discharges and recharges the supplementary reservoir when at lap position or towards release. As the only proper position for the brake valve at the moment of releasing all brakes on any kind of a train or engine is full release, this precaution can be observed.

With a short train or lone engine the brake valve of whatever type can be moved from full release to running position in a few seconds and thus avoid overcharging the train pipe in case there is a high main reservoir pressure.

With a long train pipe, leave the valve in full release about a half second for each car or until the black and red hands of the gauge have equalized at less than the standard train pipe pressure, usually 70 pounds, then move to running position and leave it there till the next application, unless the train is a very long one, when it is not unusual for a few of the brakes on the head end of the train to apply from overcharged auxiliaries, the head ones charging higher than those on the rear when main reservoir air is flowing rapidly into the train pipe. If any set they can be kicked off by going to full release for an instant. The New York brake valve has an excess valve to maintain a difference of pressure between the main reservoir and train pipe so the instructions about carrying excess pressure with the Westinghouse D-8 brake valve, found in the previous pages of this book, will apply to the New York brake valve. Questions 20, 21 and 65 refer to this matter. Always use full release position to release brakes with any valve, and it is a vital point in quick recharging of auxiliaries, as when on a hill, to keep the valve in full release as long as possible.

Many railroads have imperative, iron-clad rules about certain air brake work which are made to prevent careless or unskillful air brakemen from doing considerable damage. While only a very few of the men handling the brake may be in the class mentioned, yet the rule must be observed by the skillful as well as the careless ones. One of these rules is: "Do not release the brakes on a long train when running at a slow speed, but come to a full stop first." This speed is usually below eight miles an hour. This rule is made because the shocks to the train caused by the slack running in or out of the train quicker than all the brakes can release, is usually certain to break the train in two or more parts. With the use of an additional engine and tender brake, either the Straight Air or the E. T. brake; retaining valves on engine and tender brakes or cocks so arranged as to hold the engine and tender brakes applied, the train brake can be released at a slow speed without serious shocks. Retainers depend on tight piston packing and tight joints for their value. If the joints or packing leathers leak, retainers are useless for this purpose. This "iron-clad rule" applies as well to long passenger trains, when consisting of over twelve coaches, a release at slow speed without the use of some device on the engine to hold the slack is almost certain to break the train in two parts. The size of the main reservoir and amount of excess pressure have considerable to do with the ease and certainty of releasing all brakes quickly on a long train. large volume and high excess make the operation sure on a long train. You should remember that there is more difference in the reservoir and train pipe pressures after a 20-pound reduction than after a 5-pound reduction. This may explain the reason for stuck brakes on a long train after a light application. This matter is treated of on pages 50 and 107. One prominent railroad handling long trains of air braked ore cars allows the release of a few brakes at a time when running at a slow speed, instead of coming to a full stop. After a full application or nearly so, when necessary to release a few of the brakes at a time and allow the train to keep moving during releasing, the brake valve is moved from lap to running position for an instant to raise the train pipe pressure a very little, not over a pound, when a few brakes, usually those near the head end of the train will release. The next time the valve is placed in running position for an instant, brakes will release in various parts of the train; this operation can be repeated till the train pipe pressure is raised about five pounds in all. Between each release allow the slack to even up. If this work is skillfully done and the triples are in good order, very few brakes will remain applied after the 5-pound raise in pressure. Then with good stiff excess go to full release and quickly charge the train pipe up its entire length to ensure that all triples are moved to release position. This process has a much different effect on a train at slow speed from releasing all triples with the same recharge of train pipe. It also operates better on a train of ore cars which are either all loaded or all empty, than on an ordinary freight train having loads and empties mixed up in the train; for this reason it takes great skill to handle a freight train in this manner. A full release of all triples from one movement of the brake valve at slow speed, usually breaks the train in two; for that reason all roads condemn the practice. In releasing brakes an engineer should know the grades and how they affect the bunching or stretching of a train.

One of the questions usually asked in an air brake examination is " trace the air through the air brake system; tell where it goes and how it operates the various parts of the equipment." Some air brake instructors ask this question at the beginning of their examination. As a complete answer to this question requires a good knowledge of the entire equipment, in this book it is left till the last.

With the Westinghouse equipment (see general arrangement of brake, facing title page), air from the atmosphere, enters at the inlet or receiving valves of the air pump, when the piston moves in the air cylinder, filling the space left by the piston. As the piston makes a stroke the air in the cylinder that is compressed passes by the discharge valves into the main reservoir and form there to the brake valve, where it is above the rotary valve. In full release position it passes through the direct supply port in rotary into the pocket in the rotary seat, around the partition, up into the large cavity in the lower side of the rotary, then into the train pipe. At the same time it passes through the feed port in the rotary and the preliminary exhaust port into chamber D also through the equalizing port into chamber D; main reservoir air goes to red hand of the duplex gage and pump governor and warning port to atmosphere. From chamber D, air goes to the black hand of gage.

In running position air passes through the running position or feed port into the feed valve and, until the supply valve closes, on into the train pipe. In this position air passes from the train pipe up into the cavity in the rotary and then to chamber D through the equalizing port. With the D-8 or 1899 valve in running position air passes through feed port in rotary to the excess valve; by the excess valve into train pipe. With D-8 valve train pipe air goes to the governor, with the other valves, main reservoir air operates the governor. When the governor operates air flows past the diaphram valve in over the air piston and some air passes out the vent port.

The air in chamber D flows into the brake valve reservoir with all types of brake valve. Train pipe air flows back until it reaches an angle cock or stop cock that is closed. It flows into every triple valve that is cut in and connected to the train pipe, pressing against the bottom or train pipe side of the triple piston. When this piston is in release position air flows through the feed groove around the triple piston into the auxiliary reservoir till the pressures are equalized. Air also passes up the pipe to the conductor's valve. When the pressures in the train pipe and auxiliary have equalized at 70 pounds the brake is ready for an application; we will explain a service application first.

Moving the handle of the rotary to service position first laps the port that admits main reservoir air to the train pipe, closes the equalizing port between chamber D and the train pipe and opens the preliminary exhaust port so chamber D air escapes to the atmosphere. This reduces chamber D pressure over the equalizing piston train pipe pressure then raises this piston, which opens the train pipe exhaust valve so train pipe air flows to the atmosphere, reducing the pressure at each triple valve. The triple piston moves towards the reducing pressure, closing the feed port, moving the graduating valve to open its port in the slide valve, the slide valve moves so the exhaust port is closed, next opening the air port to the brake cylinder so that auxiliary air flows into the brake cylinder and pushes out the brake piston which sets the brake.

To release the brake the brake valve is placed in full release position; main reservoir air passes into the train pipe as already described. This moves the triple valves to release position, closing the air ports to the brake cylinder, opening the exhaust port so the air can flow from the cylinder to the atmosphere and opening the the feed groove so train pipe air can flow into the auxiliary. Air also flows into chamber D and brake valve reservoir.

If a retaining valve is used, brake cylinder air, after leaving the exhaust port, passes through a pipe to the retainer, when this valve is in release position the air passes directly out. If the valve is in retaining position air pressure raises the valve and passes up into the case of the retainer and then out through the small opening in the case till the pressure drops to 15 pounds, when the valve seats and holds the air in the brake cylinder till the retainer is turned to release position.

When making an emergency application of the brake the brake valve is placed in emergency position. Train pipe air passes out very rapidly through the direct exhaust port at the same time chamber D air passes out at the preliminary exhaust port of the 1892 brake valve. Air passes out of the train pipe so rapidly that the triple valve cannot reduce auxiliary pressure as shown in service application, auxiliary air pressure moves the piston full stroke at once, auxiliary air passes by the removed corner of the slide valve through emergency port and on top of the emergency piston, pushing it down, this opens the emergency valve and allows train pipe air to pass into the brake cylinder, which sudden reduction of train pipe pressure operates the next triple quick action and so on throughout the whole train. At the same time auxiliary air passes through the tail port in the slide valve; also some air passes by the emergency piston into brake cylinder till the pressures equalize. When the brake is set by opening the conductor's valve or by the train breaking in two, the operation is the same.

In releasing brakes after an emergency application, the flow of air is the same as with a service application. We will add to this answer the signal equipment: The main reservoir air flows through the reducing valve till it reaches a pressure of 45 pounds; if the reducing valve is adjusted for that pressure. Air flows into the air signal pipe back to each car discharge valve. On the engine it passes from the signal pipe into the upper part of the signal valve (see page 125), over the rubber diaphram into A, it also passes down to the lower part of the valve, up by the stem 10 slowly into chamber B until the pressure equalizes there with the signal pipe. When the whistle is to be operated from the train, the car discharge valve on the car is opened, air passes out of the signal pipe to the atmosphere. This reduces signal pipe pressure, when the reduction affects the pressure over the diaphram in the signal valve, the pressure under the diaphram not being reduced so quickly, air under it in B raises the diaphram and with it the valve 10, so that air flows out there to the whistle, giving a blast. When the valve 10 is raised, air in B flows past the flattened sides of this stem to the whistle; this quickly reduces the pressure in B and the diaphram drops, pushing valve 10 to its seat so no more air passes to the whistle. As soon as the train pipe pressure falls below 45 pounds the reducing valve opens and begins to feed main reservoir air into the signal pipe slowly, as the opening through the valve is restricted or choked. If the air could pass into the signal pipe at the reducing valve as fast as it can pass out at a car discharge valve, no reduction would be made in the signal pipe pressure.

With the New York brake (see page next Index), the course of the air is a little different. Air flows from the atmosphere through the receiving valves into the air cylinders as the air pistons move up and down. The air in the high presure air cylinder goes direct to the main reservoir when it is compressed. The air in the low pressure air cylinder, when compressed, passes into the high pressure air cylinder and from there into the main reservoir, thence to the brake valve around and on top of the main slide valve; main reservoir air goes to the red hand of the gage and train pipe air to the black hand. If a single governor is used it is operated by train pipe air; if a duplex governor one side by train pipe air and the other by main reservoir air. When in release position it passes directly into the train pipe and from the train pipe into chamber D and the supplementary reservoir with the 1902 model valve. With the old style brake valve on release position the air in the supplementary reservoir and chamber D passes out through a small cavity in the slide valve to the atmosphere; this allows train pipe pressure to move the equalizing piston to its normal position. On running position the main reservoir air passes by the excess valve and then into the train pipe; train pipe air passes into the supplementary reservoir with the brake valve in this position.

The train pipe air passes back through the train pipe to each triple valve that is cut in. At the triple valve the air passes through the port F in the vent valve piston and if the main piston is not already in release position, moves it there. Air then passes through the feed groove into the auxiliary until the pressure there has equalized with the train pipe.

With a service application, the slide valve in the brake valve is moved till the service port is open, train pipe air then flows direct to the atmosphere until its pressure is reduced so the presure of the air in the supplementary reservoir can move the piston, closing the cut-off valve and stopping the escape of train pipe air.

This reduction of train pipe pressure extends to each triple, auxiliary air pressure moves the triple piston, graduating valve and slide valve; first closing the feed groove, next the exhaust port and then opening the air port so air passes from the auxiliary to the cylinder. The air in the space G, between the main triple piston and the vent valve piston passes out through port F so the vent valve piston does not move in a service application.

In an emergency application the slide valve in the *brake valve* is moved to emergency position. Train pipe air passes rapidly out through the large ports in the slide valve, reducing train pipe pressure so rapidly that the triple pistons make a quick stroke. As the air between the two pistons cannot pass through port F quickly enough, the vent valve piston moves with the main piston, unseats the vent valve; this allows train pipe air to flow to the atmosphere. The air also pushes against the quick action piston, moving it over and with it opens the quick action valve, which permits auxiliary air to flow through the passages into the cylinder, the check valve preventing this air from flowing back from the cylinder. Auxiliary air also flows into brake cylinder through the service port at the graduating valve. In releasing the brake the flow of air has already been described.

The course of air through the signal equipment is the same as described with Westinghouse signal, except that air passes from chamber A to chamber B through a small port *b* when charging up the signal valve, and out of B around the plug 4 to chamber A when the signal valve operates.

AIR BRAKE EXAMINATION QUESTIONS.

1. What are the essential parts of the automatic brake? What does each part do?

2. Can you trace the course of the steam through the steam end of the air pump? Can you trace the course of the air through the pump?

3. How should the pump be started and lubricated?

4. If the pump stops after working good for a time, where is the trouble likely to be?

5. If it makes a quick stroke one way and a slow stroke the other where is the trouble likely to be?

6. What are the principal causes for a pump running hot?

7. What damage does it do to a pump if it gets very hot?

8. If the main reservoir is partly filled with water which will it affect the most, setting or releasing the brake? Why? How often should it be drained?

9. What might prevent the governor shutting off the steam and stopping the pump when maximum pressure is obtained?

10. Where would you look for the trouble if governor stops the pump at much less than standard pressure?

11. If too much oil is used in the air end of pump is it likely to gum up governor so it will not work accurately?

12. Should you test the engine and tender equipment for leaks?

13. How do you test for leaks in main reservoir and pipes from pump to brake valve?

14. What other parts of the equipment gets air from the main reservoir besides the train pipe?

15. How do you test for a leak in train pipe? In signal line?

16. How do you locate a leak that lets off the brake?

17. What pressure should you have before testing?

18. What controls the excess pressure with the H-5 brake valve? With the F-6 valve?

19. How many kinds of engineers brake valves have we in service on this road?

20. Can you trace the air through each of them?

21. Explain the principle of operation of the engineers equalizing discharge brake valve?

22. Describe its operation to apply the brake with service or emergency applications, and in releasing the brake.

23. Where is the excess valve, and the feed valve located in the engineer's brake valve?

24. Why is it necessary to keep these valves clean and regulated for the proper pressure? How is this done?

25. Why is excess pressure necessary? Do you need the most with a large main reservoir or a small one?

26. Is more excess needed to release all the brakes on a long train than on a short one?

27. How do you regulate the excess pressure with a D-8 brake valve? With the 1892 model or F-6 valve?

28. Name the different positions of the brake valve.

29. What ports are open and what ports are closed in each position?

30. Where does main reservoir pressure begin and end?

31. Where does train pipe pressure begin and end?

32. Where does auxiliary pressure begin?

33. What is the equalizing port for? Is it open in all positions of the brake valve?

34. Do leaks in the brake valve affect the operation of the brakes? Explain how.

35. Do you consider a cut rotary valve or seat dangerous?

36. Will using the valve in emergency instead of service application cause this cutting any quicker? Why?

37. With the D-8 valve does the black hand show the same pressure when valve is in emergency position? Why?

38. Does the 1892 model valve show the pressure this way? Why?

39. If the equalizing piston becomes gummed or sticks, how will it affect its operation in applying the brakes?

40. What is the purpose of the small reservoir connected to the equalizing discharge valve?

41. If the pipe leading from valve to small reservoir is broken off or leaking badly, what will you do?

42. Where is the first air taken from in making a service stop?

43. What port does it blow out of?

44. Where next does it come from? Where next?

45. Does air ever blow out of train pipe exhaust when releasing the brake? Why?

46. Do you hear it when releasing brake on engine and tender only? Do you hear it with a train of over two cars?

47. If you are connected to more than two air cars and heard that blow, what would it indicate?

48. How do you know that the brake valve is working properly?

49. When applying the brakes can you tell about how many cars are connected with air to the brake valve by the amount of air escaping from the train pipe exhaust?

50. How much do you reduce the train pipe pressure form seventy pounds to set the brake as tight as possible?

51. Why will this reduction do that?

52. Does the length of travel of brake piston have anything to do with the pressure when brake is full set? How? Explain fully.

53. In making a service stop why should the brake valve not be moved past the service application position?

54. Is this movement of the brake valve liable to kick off some of the head braks? Why?

55. What is the proper position to place brake valve in after releasing brakes if they are to be set again immediately? Why? Explain fully.

56. What are the functions or uses of the triple valve?

57. How many forms in use on this road? Describe each form.

58. Where does all the air come from that enters the brake cylinder through the plain triple when setting the brake?

59. Does all the air that goes into the brake cylinder of a quick acting brake come from the auxiliary

60. Please explain the action of the quick action triple when used in the emergency application.

61. Can you get the emergency action after a service application?

62. Does it take a sudden reduction of pressure right at the triple to work the quick action valves or will a slow, heavy reduction do this? Why?

63. If three or four cars at the head end of the train do not have quick action triples working, can you get the emergency application behind these cars by a reduction at the brake valve?

64. What is the function of the graduating valve?

65. Where is it located and how does it operate?

66. If the graduating valve leaks on its seat is the brake connected to that triple liable to release on a partial application? On a full application? Why is this?

67. How will the quick action triple work if the graduating pin is broken? How will you locate the defective brake?

68. What is the function of the graduating stem and spring?

69. If this spring is very weak or missing how will it affect the work of the triple valve?

70. How does the air get from the train pipe into the auxiliary?

71. Why is this port so small? Could the brakes be set and released as certainly on a long train if this port was much larger? Would auxiliaries charge evenly?

72. In what position of the triple valve is the port open?

73. How rapidly does an empty auxiliary charge up to seventy pounds with seventy in the train pipe?

74. How rapidly from fifty pounds up to seventy pounds?

75. What regulates the time of charging each different sized auxiliary?

76. If one auxiliary is charged up higher than another is the brake likely to creep on? Is it liable to take place when coupling up an air brake train? Explain why.

77. Why is it dangerous to apply and release the brake repeatedly in making one station stop?

78. Does this apply to a release and second application at a slow speed on slippery track? With a passenger train? With a freight train?

79. Do you understand that brake cylinders have leakage grooves? Where are they located and how long are they? What are they for?

80. Do you allow for them when setting the brake? How?

81. As a rule how much reduction in train pipe pressure is necessary to ensure that brake piston goes past the leakage groove?

82. Does a long train require more than a short train? Why?

83. What should be done after coupling to an air brake train before pulling out?

84. What pressure should you have in train pipe and auxiliaries before testing the brake?

85. How do you know when you have seventy pounds in the auxiliaries?

86. What tests of air equipment are called for by our rules?

87. Explain fully how these tests should be made.

88. Are you required to test retaining valves? How is this done?

89. If a brake is broken or disabled how will you prevent it working on that car and let the brakes work on other cars?

90. How do you cut out the brake on engine or tender?

91. Is it necessary to release the brake before cutting it out?

92. How does the length of the piston travel affect the work of the brake? If it is too long? If it is too short?

93. What is the proper piston travel? For passenger cars? For freight cars? For engine brakes?

94. How is the slack taken up to secure this adjustment?

95. Should the triple be cut out before adjusting the levers to avoid injury to the workman in case brake goes on?

96. At what travel should the driver brake piston be adjusted?

97. How is the slack of a six wheel brake taken up?

98. What is necessary in order to have all the brakes work alike?

99. When brakes go on suddenly and are not operated by the engineer what should you do? To what causes would you assign this?

100. If an air brake train breaks in two how do you proceed to get train ready to go ahead again?

101. How do you proceed in case of a bursted hose? How can you help trainmen to locate it?

102. Would it be necessary in these cases to make a terminal test?

103. After releasing the train brake there is a steady leak from the exhaust port of the triple, what is the trouble?

104. What precautions must be observed in making a stop with a "part air" freight train? What with a long, "full air" train?

105. In making a stop with a freight train when would you let off the brakes to make a smooth stop? Why?

106. When with a passenger train? Why?

107. What is the pressure retaining valve, what is its use and how is it operated?

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

109. Does the brake release any slower till it gets down to this pressure, and how is it done?

110. Can you get the emergency action of the brake with the pressure retainers holding fifteen pounds?

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

112. When two or more engines are coupled together which one should do the braking?

113. Can both engineers use the brakes at the same time safely?

114. How will you proceed to give the leading engineer complete control of the train? What should the second engineer do?

115. If there is no cut out cock on second engine under the brake valve what should be done?

116. How does the air signal equipment operate?

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

118. What causes the whistle to blow each time the brake is released? What makes it repeat the signal?

119. Will a leak in the train signal pipe affect the working of the whistle? Explain.

120. Explain the meaning of the signals given by one, two, three and four blasts of the signal whistle.

121. What changes do you make in the engine equipment to carry 110 pounds train pipe pressure instead of 70, for the high speed brake?

122. How many pounds train pipe reduction in a service application will give a fully applied high speed brake?

123. Is it safe to use the emergency application of the high speed brake when running less than 30 miles an hour? Why?

124. Explain the action of the high speed reducing valve in service, and in emergency.

125. What pressures should be in the brake cylinders on the engine and tender when the Straight Air brake is fully applied?

126. How is this pressure regulated?

127. Does long piston travel have any effect in reducing this pressure?

128. What valve closes the exhaust from the brake cylinder to the triple when the Straight Air is applied, and vice versa?

129. Is it good practice to use the automatic while the Straight Air is full set on the engine and tender brake? Why?

130. Should the Straight Air brake valve be left on lap position while operating the automatic? Why?

131. How many air pipe connections at the Distributing valve? Explain where the air comes from and goes to at each of these connections.

132. Explain the effect of leaks from each of these pipes and tell what you would do in each case, if any of them break off.

133. What is the duty of the equalizing piston and its slide valves in the Distributing valve, and what air pressures operate it?

134. What is the duty of the application piston and its valves and what air pressures operate it?

135. Why does the engine brake creep on when either brake valve is lapped? How will you locate this defect?

136. Will the engine brake stay applied if both brake valves are in running position? Why? Will it creep on from leaks?

137. Which brake valve is used to apply the automatic brake on train and engine? Which brake valve should be used to operate the engine brake only?

138. What is the difference in the operation of the engine brake by the Independent brake valve and by the Straight Air brake valve?

139. Does the safety valve on the Distributing valve control the application chamber pressure when the Independent brake valve is used? Or in an automatic application only?

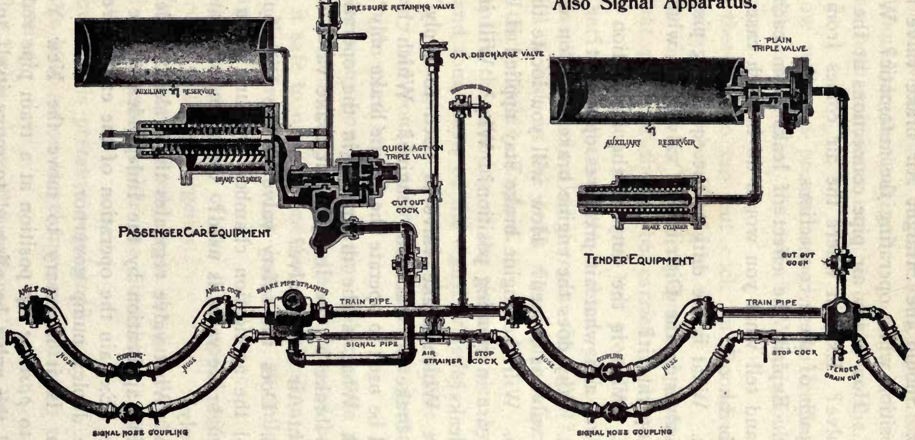
140. What valve regulates the brake cylinder pressure in a full application by the Independent brake valve?

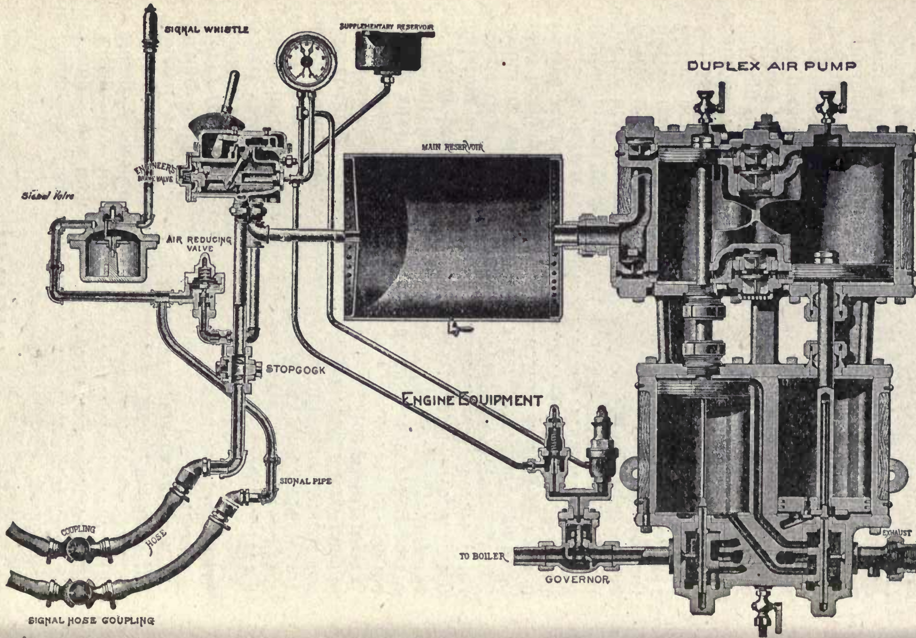
141. Explain the operation of the excess pressure side of the duplex pump governor.

142. Is it necessary to move the New York brake valve to *positive lap* position at a train pipe reduction, or should the valve be allowed to move itself to *automatic lap?* Why?

143. Trace the course of the train pipe air in the Westinghouse quick action triple in release, service and emergency positions. Also do the same for the New York quick action triple valve.

The New York Quick-Action Automatic Air Brake.
Also Signal Apparatus.




DUPLEX AIR PUMP
ENGINE EQUIPMENT
SIGNAL WHISTLE
SUPPLEMENTARY RESERVOIR
MAIN RESERVOIR
ENGINEERS BRAKE VALVE
Signal Valve
AIR REDUCING VALVE
STOPGOCK
SIGNAL PIPE
COUPLING
HOSE
SIGNAL HOSE COUPLING
TO BOILER
GOVERNOR
EXHAUST

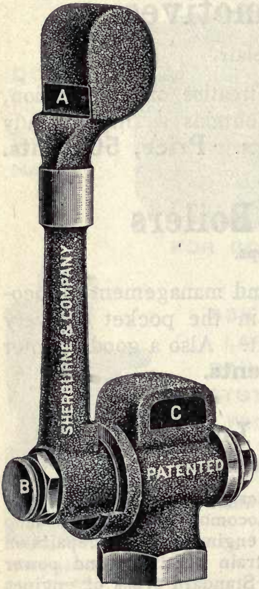
INDEX.

PAGE

BRAKEMAN'S
AIR BRAKE AND SIGNAL COCK

For Controlling from Rear of Trains When Backing.

THE methods of handling trains at terminals and passenger yards have entirely changed within a few years and it is now a universal practice that trains be **backed** into the station and from there to the yards. This makes it necessary to have them positively controlled from the rear end. It is also necessary to have a substitute for the engine bell, as a warning in passing into stations and yards.



The cut shows a device which is designed to fulfill these requirements. It is a combined plug-cock and alarm whistle (A) attached by a short length of hose or pipe to the "train pipe" of the rear car. The whistle is blown by pressing the button (B) shown in the cut, which allows air to pass through the hollow handle of the cock to whistle, which is shown on the end of the handle, blowing the same and giving the necessary alarm. **The air used for this purpose, on account of the design of the whistle valve, POSITIVELY does not affect the brake system.**

By moving the handle of the cock in either direction exhaust is made from the train pipe, through opening C, the brake set, and consequent positive control of the train given.

The device is also valuable in switching of freight trains, especially during the night or in thick weather, as the train by its use is under complete control from both ends.

SHERBURNE & CO.,

Sole Manufacturers.

53 Oliver Street, BOSTON, MASS., U. S. A.