INSTRUCTION PAMPHLET No. 5045.
October, 1913.
(Superseding Issue of April, 1912.)

PC
Passenger Brake Equipment

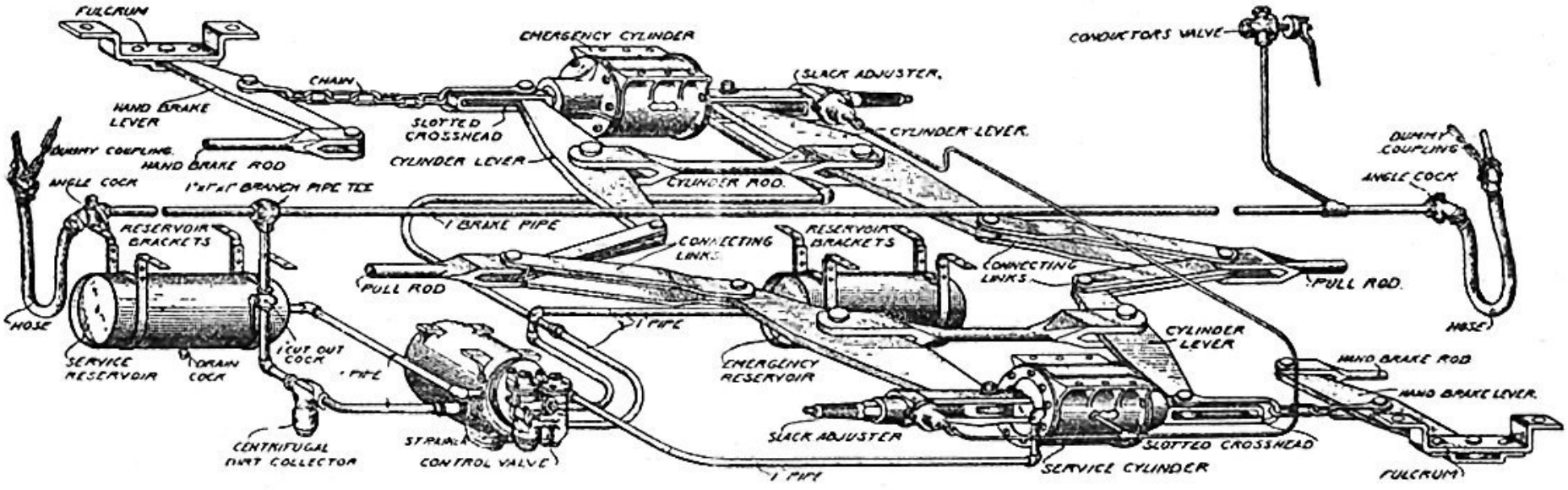

Fig. 1. PC Passenger Brake Equipment. Cylinders Pointing in Opposite Directions

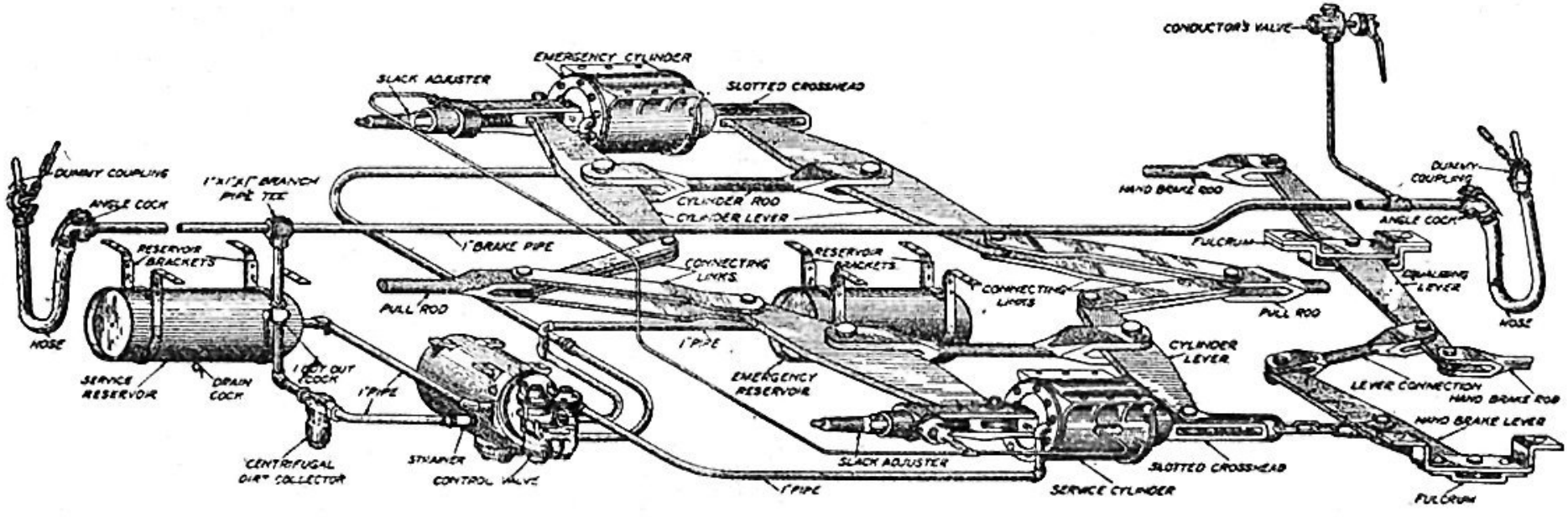

Fig. 2. PC Passenger Brake Equipment. Cylinders Pointing in Same Direction

WESTINGHOUSE AIR BRAKE CO.

Instruction Pamphlet No. 5045

October, 1913

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"PC" Passenger Brake Equipment

Note.—The reference numbers shown herein are for convenience only, and are not to be used when ordering repair parts. See Part Catalog giving Piece Numbers, Price, etc.

With the introduction of heavy (125,000 lbs. to 150,000 lbs.) passenger equipment cars in steam road service, the brake force required to control such heavy cars with approximately the same effectiveness as is obtainable with the apparatus used on lighter cars became so great as to exceed the capacity of a single brake cylinder even with the highest brake cylinder pressure and greatest multiplication of its power by leverage that could be permitted. The increased speed and weights of trains and the economy of time necessary for the highest operative efficiency under modern severe traffic demands, together with the increase in length of trains and the much greater volume of air which must be handled through the brake pipe, have imposed conditions which

the type of brake which was adequate for past conditions has been unable to meet satisfactorily.

While a high maximum emergency stopping power is required to insure the safety of passengers and rolling stock, the ordinary service functions and automatic safety and protective features became hardly secondary in importance.

Briefly stated, the requirements recognized as essential in a satisfactory brake for this modern service are as follows:

1. Automatic in action.
2. Efficiency not materially affected by unequal piston travel or brake cylinder leakage.
3. Certainty and uniformity of service action.
4. Graduated release.
5. Quick recharge and consequent ready response of brakes to any brake pipe reduction made at any time.
6. Maximum possible rate of recharging the brake pipe alone (rate of rise of brake pipe pressure when releasing limited only by length of brake pipe, not by necessity for recharging *reservoirs* as well as brake pipe, before rear brakes in train can be released).
7. Predetermined and fixed flexibility for service operation.
8. Maximum sensitiveness to release, consistent with stability, combined with minimum sensitiveness to the inevitable fluctuations in brake pipe pressure tending to cause undesired light service applications, brakes creeping on, etc., and yet guard against the attainment of too

high a difference of pressure between the brake pipe and pressure chamber (auxiliary reservoir).

9. Full emergency pressure obtainable at any time after a service application.

10. Full emergency pressure applied automatically after any predetermined brake pipe reduction has been made after equalization.

11. Emergency braking power approximately 100% greater than the maximum obtainable in service applications.

12. Maximum brake cylinder pressure obtained in the least possible time.

13. Maximum brake cylinder pressure maintained throughout the stop.

14. Brake rigging designed for maximum efficiency.

15. Adaptability to all classes and conditions of service.

That certain of these requirements demanded radical changes in the valve device used on the car is evident if a comparison of the above is made with the functions of previous types of brakes in general service. These considerations led to the development of the equipment known as the Westinghouse Improved Brake Equipment, Schedule "PC", employing what is known as a Control Valve in the place of a triple valve.

NOVEL FUNCTIONS

1st. *Graduated release and quick recharge*, obtained as with previous improved types of triple valves (*e. g.* Type L). The air supply to assist in recharging and to

accomplish the graduations of the release is taken from the emergency reservoir..

2nd. *Certainty and unifor nity of service action* secured by insuring that the valve parts move so as to close the feed grooves on the slightest brake pipe reductions, the design of the valves being such as to then require the necessary and proper differential to be built up to move the parts to service position as the brake pipe reduction is continued.

3rd. *Quick rise in brake cylinder pressure* provided for by insuring a prompt movement of the parts and direct and unrestricted passages from reservoirs to brake cylinders during applications.

4th. *Uniformity and maintenance of service brake cylinder pressure* during the stop, provided for in the same manner as by the application portion of the distributing valve.

5th. *Predetermined limiting of service braking power* fixed by the equalization of the pressure and application chambers of the control valve. This eliminates the safety valve feature of previous equipments and is both positive and uniform. After such equalization has taken place, any further brake pipe reduction causes the moving parts of the valve to travel slightly beyond the service position to the "over-reduction" position. Air then flows from the pressure chamber to the reduction limiting chamber until equalization takes place between these two chambers, if the brake pipe reduction is continued far enough. During this time the application chamber remains at the first equalization pressure and the brake cylinder pressure is maintained accordingly.

The maximum service brake cylinder pressure (service equalization) is fixed at 86 lbs., and the nominal braking power based on this pressure instead of 50 lbs. as with previous equipments. On this account it is possible to use a much lower total leverage ratio (which is necessary if the required efficiency of the foundation brake rigging for the classes of cars considered, is to be maintained). This equalization pressure corresponds to a reduction of 24 lbs. from 110 lbs. brake pipe pressure, which is the reduction required with high speed brake equipment to give maximum service brake cylinder pressure (60 lbs., corresponding to the opening point of the high speed reducing valve). *This insures uniformity of service operation of old and new equipments mixed in the same train.*

6th. *Automatic emergency application on depletion of brake pipe pressure.* If the brake pipe reduction is still further continued below the point at which the pressure and reduction limiting chambers equalize, the parts move to emergency position and cause both the quick action and emergency portions to operate, starting serial quick action throughout the train and obtaining emergency brake cylinder pressure.

7th. *Full emergency braking power at any time.* As the operation of the emergency and quick action portions just described is dependent only upon the movement of the parts to emergency position and as this can be caused at any time by making an emergency application with the brake valve, conductor's valve, etc., it follows that *full emergency braking power can be obtained at*

any time irrespective of a service application previously made.

8th. The *service and emergency features being separated* permits the necessary flexibility for service applications to be obtained without impairing in the slightest the emergency features of the equipment.

9th. *A low total leverage ratio*, with correspondingly greater overall efficiency, is made possible by the use of two brake cylinders per car, and also higher service equalization pressure.

10th. *Less sensitiveness to the inevitable fluctuations in brake pipe pressure*, which tend to cause undesired light applications of the brake. This insures against brakes creeping on or dragging, burning of brake shoes, delays to the train and so on.

11th. *Maximum rate of rise of brake pipe pressure* possible with given length of *brake pipe* with consequently greater certainty of brakes releasing when a release is made. With non-graduated release equipments or previous graduated release equipments operating with graduated release feature *cut-out*, the recharging of the brake pipe toward the rear end of a train of any length may become very slow due to the draining away of the air from the forward end of the brake pipe by the large reservoirs with large sized feed grooves which take their entire supply from the brake pipe only. The quick recharge feature of the "PC" equipment overcomes this difficulty, with graduated release cut in, by restoring the pressure to the pressure chamber on each car at as rapid a rate as the brake pipe pressure *alone* can be raised by the flow of air through the brake valve. Con-

sequently up to the point of equalization of the pressure chamber and the emergency reservoir under each car (about 5 lbs. less than normal brake pipe pressure), no air is being drawn from the brake pipe. This insures a *prompt* and *certain release* of the brakes, and a rapid recharge and prompt response to successive reductions which may be made, because (1) practically no air is drawn from the brake pipe; (2) pressure chamber and brake pipe recharge at the same rate; and (3) with graduated release cut-out, no air is supplied to pressure chamber except from brake pipe.

12th. *Greatly increased sensitiveness to release*, as demanded by the changed conditions already referred to, which tend to produce a very slow rate of rise of brake pipe pressure when releasing and recharging, especially toward the end of a long train of heavy cars having large reservoirs. It then becomes necessary to provide the maximum sensitiveness to an increase in brake pipe pressure, in order to insure all valves in the train responding as intended.

13th. *The elimination of the graduated release feature* is especially provided for in the construction of the valve. During the transition period when graduated release equipment is likely to be handled in the same train with cars not equipped with a graduated release brake, especially where long trains are handled and the air supplied from the brake pipe likely to be limited in any way from any cause, it is usually best to cut out the graduated release feature until all cars are furnished with this type of brake. All that is required to change the "PC" equipment from the graduated to a direct release brake or

vice versa, is the loosening of a bolt and turning of the "Direct and Graduated Release Cap" on the front of the control valve head until the desired position is indicated, the bolt being then retightened. (See Figs. 4 and 6.)

It should be further stated, that all the functions mentioned have been so combined that the requirements of interchangeability with existing equipments have been fully satisfied.

PARTS OF THE PC EQUIPMENT

The following is a list of the parts which make up the equipment with a short description of each:

1. The *control valve* which corresponds in a general way to the triple valve of the old style passenger equipment or more closely to the distributing valve of the "ET" locomotive brake. It operates to control the admission of air to and release of air from the brake cylinders.

2. *Two brake cylinders* (one for service and both for emergency applications) with pistons and rods so connected through the brake levers and rods to the brake shoes that when either piston is forced outward by air pressure, this force is transmitted through said rods and levers to the brake shoes and applies them to the wheels.

3. *Two supply or storage reservoirs* denoted as the *service* and *emergency* reservoirs respectively, according to the brake cylinders to which they are related.

4. A *centrifugal dirt collector*, connected in the branch pipe between the brake pipe and control valve as near the control valve as circumstances will permit, for the purpose of preventing pipe scale, sand, cinders or foreign particles of any kind from reaching the control valve.

5. A *branch pipe air strainer*, inserted in the branch pipe close to the control valve for further protection to this valve.

6. A *conductor's valve* placed inside each car by means of which the brakes may be applied by the conductor in case of accident or emergency.

7. A *branch pipe tee, various cut-out cocks, angle cocks, hose couplings, dummy couplings*, etc., the location and uses of which will be readily understood from the isometric views of the equipment, Figs. 1 and 2, and the descriptions which follow.

8. While not a fundamental part of the equipment, each brake cylinder is usually provided with an *Automatic Slack Adjuster*. This is a simple mechanism by means of which a predetermined piston travel and consequently a uniform cylinder pressure is constantly maintained, compelling the brakes on each car to do their full share of work, thus securing the highest efficiency and reducing the danger of flat wheels which are likely to accompany a wide range of piston travel. This device establishes the running piston travel; that is, the piston travel occurring when the brakes are applied while the car is in motion; and since this is the time during which the brakes perform their work, the running travel is most important.

LOCATION, ADJUSTMENT AND OPERATION OF PARTS

The *No. 3-E control valve* consists of four portions:

(1) Equalizing Portion.
(2) Application Portion.
(3) Emergency Portion.
(4) Quick Action Portion.

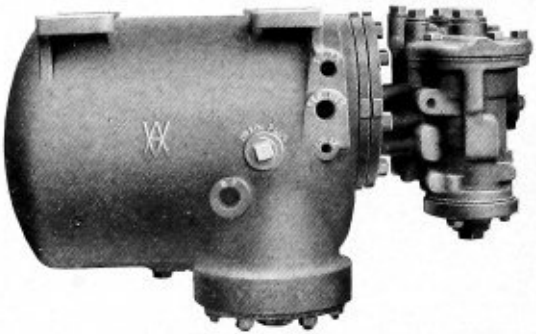

Fig. 3. No. 3-E Control Valve, Side View

These valve portions are supported upon the *compartment reservoir* which is bolted to the underframing of the car, all pipe connections being made permanently to this reservoir so that no pipe connections need to be disturbed in the removal or replacement of any one of the operating portions of the control valve.

The *compartment reservoir* is made up of the following chambers:

Pressure Chamber.
Application Chamber.
Reduction Limiting Chamber.

Fig. 4. No. 3-E Control Valve, Front View

The *equalizing portion* is si nilar, in a general way, to the equalizing portion of the distributing valve used with the "ET" equipment, or the plain triple valve of the old style brake. It is the portion which is directly affected by variations in brake pipe pressure and it controls (either directly or indirectly, through the medium of the other portions of the control valve), the desired charging of the reservoirs, the application of the brake,

whether in service or emergency, and the release of the brake.

The *application portion* corresponds to the application portion of the distributing valve used with the "ET" equipment. It controls the flow of air only from service reservoir to service brake cylinder and the release of same, and has nothing to do with the emergency reservoir or the emergency brake cylinder.

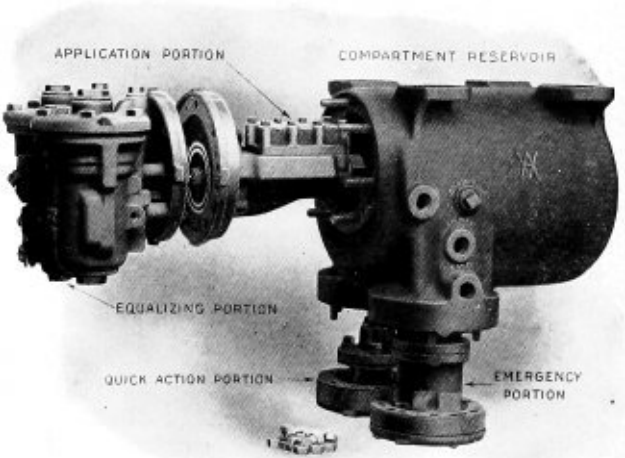

Fig. 5. No. 3-E Control Valve, Showing the Different Portions of the Valve

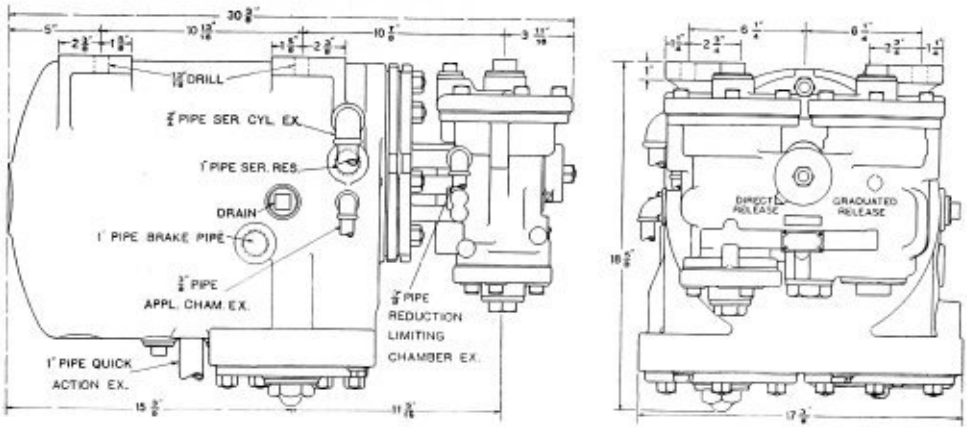

Fig. 6. No. 3-E Control Valve, Outline

The *emergency portion* contains a double piston and slide valve which controls the flow of air from the emergency reservoir to the emergency cylinder and the release of same to the atmosphere.

The *quick action portion* corresponds in general design and function to the quick action portion of a triple valve. It operates only when an emergency application of the brakes is made, vents brake pipe air to the at nosphere locally on each car and closes the vent to the atmosphere automatically after the desired brake pipe reduction has been made.

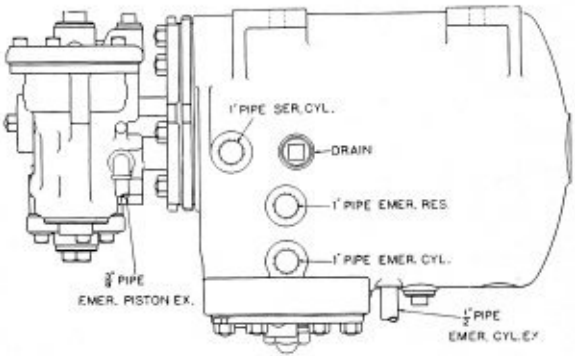

Fig. 6A. No. 3-E Control Valve, Outline

A full description of the functions and detailed operation of the control valve will be given later.

Fig. 3 is a view of the No. 3-E control valve assembled, complete, taken from the side on which the *quick action portion* is located.

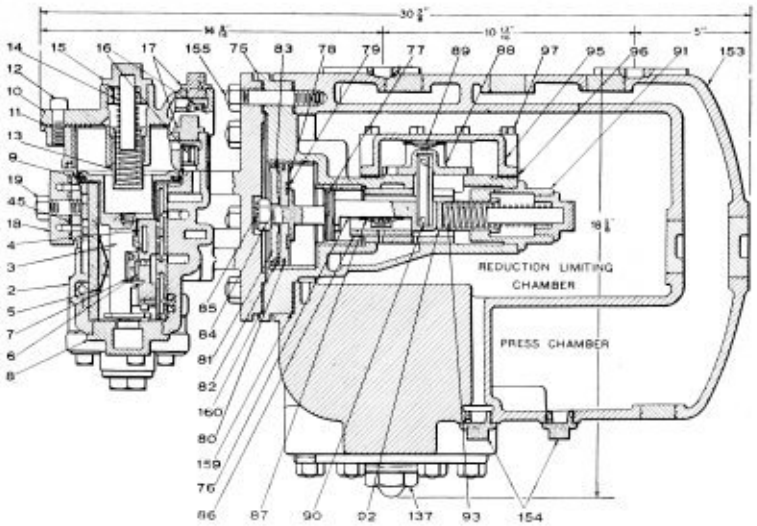

Fig. 7. No. 3-E Control Valve, Actual Section

Fig. 4 is a photograph of the equalizing portion mounted on the triple compartment reservoir, taken from directly in front. The direct and graduated release cap,

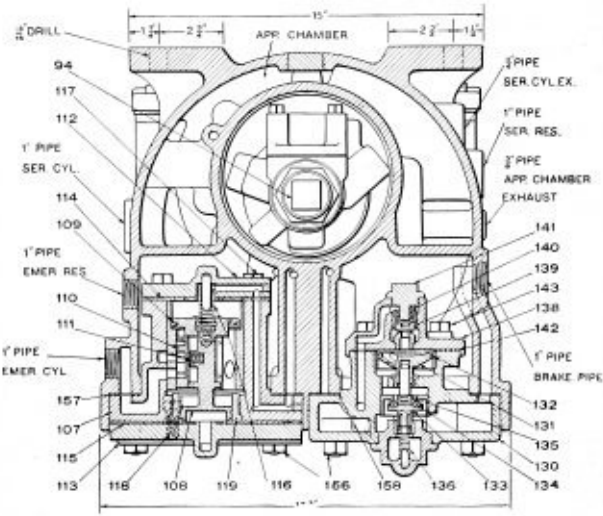

Fig. 7A. No. 3-E Control Valve, Actual Section

with its pointer and positions for cutting graduated release in or out, is clearly shown.

Fig. 5 is a photograph from the opposite side with the portions separated from each other to show their relative location and method of assembling.

Referring to Fig. 7, 7A and 7B, which show actual sections through the portions of the control valve and the triple compartment reservoir, the following are the names of the detail parts (*the numbers given are reference numbers only, to assist in identifying the names of the parts. These numbers should not be used in ordering new or repair*

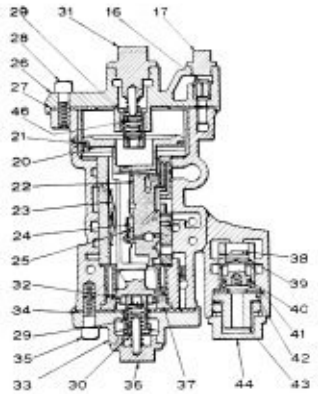

Fig. 7B. No. 3-E Control Valve, Equalizing Portion

parts. The proper parts can be furnished only when the order specifies the correct piece number, which is given in the regular part catalog price lists covering this device):

Equalizing Portion: 2, Equalizing Body; 3, Release Piston; 4, Release Slide Valve; 5, Release Slide Valve Spring; 6, Release Graduating Valve; 7, Release Graduating Valve Spring; 8, Release Piston Cap Nut; 9, Re-

lease Piston Ring; 10, Release Cylinder Cap; 11, Release Cylinder Cap Gasket; 12, Square Head Cap Screw; 13, Release Piston Graduating Sleeve; 14, Release Piston Graduating Spring; 15, Release Piston Graduating Nut; 16, Check Valve; 17, Check Valve Cap Nut; 18, Direct and Graduated Release Cap; 19, Stud and Nut for Direct and Graduated Release Cap; 20, Equalizing Piston; 21, Equalizing Piston Ring (Large); 22, Equalizing Slide Valve; 23, Equalizing Slide Valve Spring; 24, Equalizing Graduating Valve; 25, Equalizing Graduating Valve Spring; 26, Large Equalizing Cylinder Cap; 27, Large Equalizing Cylinder Cap Gasket; 28, Square Head Cap Screw; 29, Equalizing Piston Stop Sleeve; 30, Equalizing Piston Stop Spring; 31, Equalizing Graduating Nut; 32, Equalizing Piston Ring (Small); 33, Small Equalizing Cylinder Cap; 34, Gasket for Small Equalizing Cylinder Cap; 35, Square Head Cap Screw; 36, Cap Nut for Small Equalizing Cylinder Cap; 37, Small Equalizing Piston Bush; 38, Service Reservoir Charging Valve; 39, Charging Valve Piston Ring; 40, Charging Valve Piston Ring; 41, Charging Valve Seat; 42, Charging Valve Washer; 43, Internal Charging Valve Nut; 44, External Charging Valve Nut; 45, Gasket for Direct and Graduated Release Cap; 46, Equalizing Piston Stop Spring.

Application Portion: 75, Body; 76, Piston Stem; 77, Piston Ring (Small); 78, Piston Head; 79, Piston Seal; 80, Piston Ring (Large); 81, Piston Follower; 82, Piston Packing Leather; 83, Piston Packing Leather Expander; 84, Piston Nut; 85, Piston Cotter; 86, Exhaust Valve; 87, Exhaust Valve Spring; 88, Application Valve; 89, Application Valve Spring; 90, Application Piston Bolt;

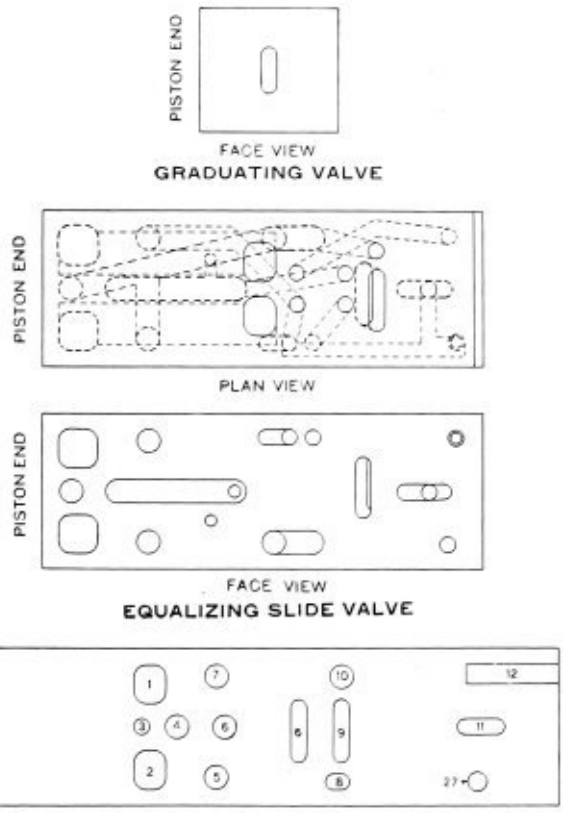

Fig. 8. Equalizing Graduating Valve, Slide Valve, and Slide Valve Seat

91, Spring Box; 92, Piston Spring Sleeve; 93, Piston Spring; 94, Graduating Nut; 95, Application Valve Cover; 96, Application Valve Cover Gasket; 97, Square Head Screw for Application Valve Cover.

Emergency Portion: 107, Body; 108, Piston complete; 109, Piston Ring; 110, Slide Valve; 111, Slide Valve Spring; 112, Small Cylinder Cap; 113, Large Cylinder Cap; 114, Small Cylinder Cap Gasket; 115, Large Cylinder Cap Gasket; 116, Piston Spring; 117, Square Head Cap Screw for Small Cylinder Cap; 118, Oval Fillister Head Cap Screw; 119, Emergency Piston Bush.

Quick Action Portion: 130, Body; 131, Piston complete; 132, Piston Ring; 133, Quick Action Valve; 134, Quick Action Valve Seat; 135, Quick Action Valve Nut; 136, Quick Action Valve Spring; 137, Quick Action Valve Cap Nut; 138, Quick Action Valve Cover; 139, Quick Action Closing Valve; 140, Quick Action Closing Valve Spring; 141, Cover Cap Nut; 142, Cover Gasket; 143, Square Head Cap Screw for Cover.

Reservoir: 153, Triple-compartment Reservoir; 154, Cap Nut; 155, Stud with Hex. Nut; 156, Stud with Hex. Nut; 157, Emergency Cylinder Gasket; 158, Quick Action Cylinder Gasket; 159, Large Reservoir Gasket; 160, Equalizing Cylinder Gasket.

Figs. 8, 9 and 10 show views of the seats and faces of the equalizing and release slide and graduating valves and of the emergency slide valve. The chambers, etc., to which the ports in the seats connect are as follows:—

Equalizing Slide Valve Seat: 1, Emergency Reservoir Check Valve (under side); 2, Brake Pipe; 3, Direct and

Graduated Release Cap (open only when cap is adjusted for graduated release); 4, Reduction Limiting Chamber Exhaust; 5, Small End (chamber G) of Service Reservoir Charging Valve; 6, Reduction Limiting Chamber; 7,

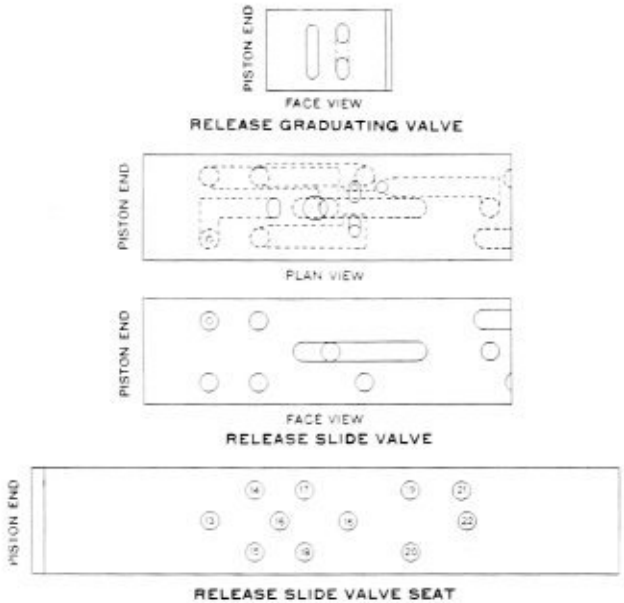

Fig. 9. Release Graduating Valve, Slide Valve, and Slide Valve Seat

Large End (chamber K) of Service Reservoir Charging Valve; 8, Release Slide Valve Chamber (chamber E); 9, Application Chamber and front of Application Piston

(chamber C); 10, Emergency Reservoir; 11, Pressure Chamber; 12, Slotted Port; 27, Small Equalizing Piston (chamber F).

Release Slide Valve Seat: 13, Large Emergency Piston (chamber P); 14, Small Emergency Piston (chamber S); 15, Direct and Graduated Release Cap (open only when cap is adjusted for graduated release); 16,

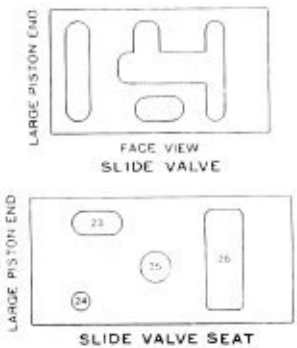

Fig. 10. Emergency Slide Valve and Slide Valve Seat

Emergency Piston Exhaust; 17, Direct and Graduated Release Cap (open only when cap is adjusted for direct release); 18, Application Chamber Exhaust, also Direct and Graduated Release Cap (the latter open only when cap is adjusted for direct release); 19, Application Chamber; 20, Quick Action Closing Valve; 21 Emergency Reservoir; 22, Small Equalizing Piston (chamber F).

Emergency Slide Valve Seat; 23, Service Brake Cylinder; 24, Back of Application Piston (chamber M); 25, Emergency Cylinder Exhaust; 26, Emergency Cylinder.

Fig. 11 shows the flanges of the different portions of the control valve and the seats on which these flanges fit, with all ports marked so as to assist in readily locating to what portions or chambers the openings are connected.

The diagrammatic drawings, Fig. 23, and those following, have been made up to assist in describing the different operations of the various parts of the control valve. They illustrate diagrammatically only those parts of the valve which come into play as the various operations are performed. For the sake of clearness, the actual construction of the parts has been disregarded. All ports and parts of the valve concerned in the performance of the particular function to be described have been shown as if located in the same plane, with the connections indicated as clearly as possible and without attempting to follow the actual construction of the valve.

Furthermore, it will be noted that all ports and passages which are not operative in the various positions, have been omitted in the corresponding diagrammatic views, so that in considering each successive position of the valve, the functions being performed by the valve will be more easily explained and understood by the reader than if those ports which exist but which are not operative in the position shown, were allowed to remain.

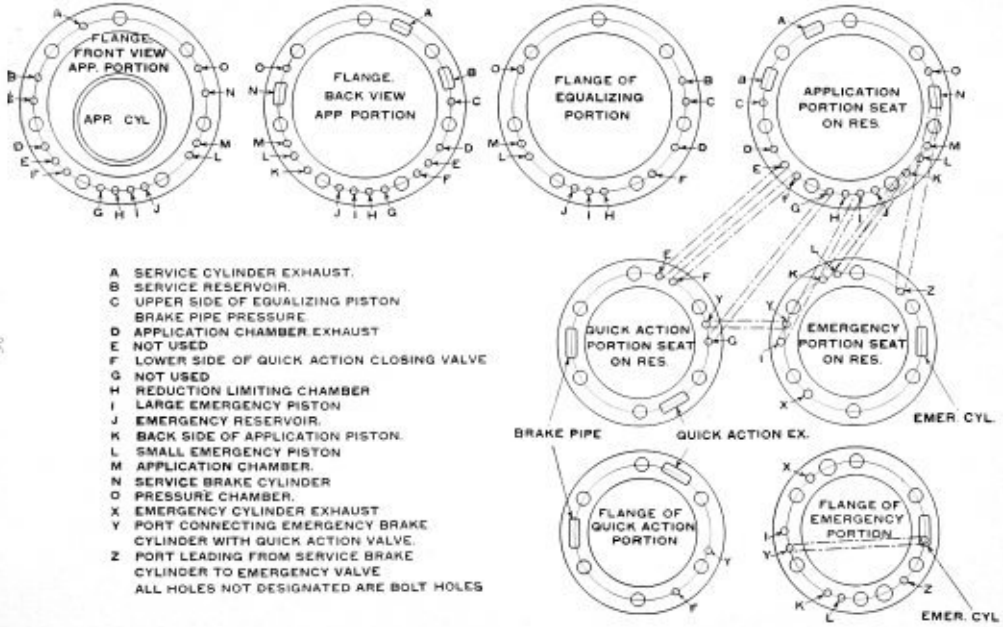

Fig. 11. Flanges of and Seats for No. 3-E Control Valve Portions

NORMAL POSITION

Before taking up the various positions assumed by the valve, reference should be made to Fig. 23, showing diagrammatically all of the ports and operative parts of the control valve in Normal Position. This is the position which the various parts of the valve would occupy with all parts properly assembled, but before any air has been admitted to the brake pipe, and is shown here in order to indicate the relation of all the ports and detail parts of the valve which will not be shown complete in any of the succeeding views.

All of the chambers, connections and detail parts of the valve are clearly indicated so that further explanation will be unnecessary. It will be noted that the various chambers, etc., have been designated either by name or by letter, but that the ports have not been designated. In describing the operation of the valve in detail, the portions from and to which the air moves in the various positions have been carefully explained but with only such references to the path pursued as will enable its course to be easily followed by reference to the illustrations. It should, therefore, be constantly borne in mind that the descriptive matter is incomplete without constant reference to the diagrammatic illustrations, and that only by a study of both the text and the diagrams can a clear understanding of the manner in which the functions of the control valve are performed, be obtained.

It will be noted that in Fig. 23, the direct and graduated release cap is shown in its *Graduated Release* position. Just below it is shown the position which the cap occu-

pies when adjusted for direct instead of graduated release. In all the succeeding views, except Fig. 35, the cap is considered to be adjusted for graduated release. Fig. 35 with the accompanying explanation, refers to the operation of the valve with the cap adjusted for direct release.

RELEASE AND CHARGING POSITION

Fig. 24 shows diagrammatically only those parts and ports which are operative while the brake is being released and the *pressure chamber* and *emergency* and *service reservoirs* are being charged.

In charging the empty equipment, air from the *brake pipe* entering the control valve at the point indicated, passes to *chambers B* and *A* and forces the equalizing and release pistons of the equalizing portion, with their attached valves, to *Release* position. Brake pipe air then passes from *chamber B*, lifting the equalizing check valve, and by way of the equalizing slide valve into *chamber D*. Air from *chamber D* then flows through the equalizing graduating and slide valve, (so shown in the diagrammatic drawing for the sake of clearness. In this and a number of instances following, this port in actual valves opens *past the end* of instead of *through* the graduating valve.), past the emergency reservoir check valve and thence in two directions, (1) to *chamber R* and to the *emergency reservoir* and (2) through the equalizing slide valve to two different ports connecting (1) to the *service reservoir charging valve*, thence to the *service reservoir* and

(2) by way of the direct and graduated release cap and through the release slide valve and past the end of the release graduating valve to *chamber E*.

Air from the *brake pipe* and *chamber B* also flows through *feed groove i* and charges *chamber E*.

From *chamber E*, the air flows by way of the equalizing slide valve in two directions, (1) to the *pressure chamber* direct (which is thus charged to brake pipe pressure) and (2) to *chamber K*. With substantially the same pressures (brake pipe pressure as explained) in *chambers G* and *K*, and a lower pressure (service reservoir pressure) in *chamber H*, the service reservoir charging valve remains in the position shown in Fig. 23, being held in this position until the recharging is completed, since *chamber K* is relatively small and the ports leading to it of ample capacity to charge it more quickly than the pressure can be built up in *chambers G* and *H*.

Referring to Fig. 23, it will be noted that the pressure chamber check valve prevents the air in *chamber E* from flowing directly to the *pressure chamber*. Consequently this check valve is not shown in Fig. 24. It allows, however, a free passage of air in the opposite direction. That is to say, when charging or recharging, air reaches the *pressure chamber* only by way of the equalizing slide valve but during an application of the brakes (to be explained later) the *pressure chamber* and *chamber E* are to all intents and purposes one and the same and may be then referred to as such.

Chamber F at the small end of equalizing piston is connected through the release slide valve to the emergency

piston exhaust and *atmosphere*, thus holding the equalizing piston and its valves positively in *Release* position.

Chamber S at the small end of the emergency piston is connected through the release slide valve to the emergency piston exhaust and the *atmosphere* in *Release* position, thus holding the emergency piston and its valve positively in the proper position.

The *reduction limiting chamber* is connected through the equalizing slide valve to the reduction limiting chamber exhaust and *atmosphere*.

The *application chamber* and *chamber C* are connected through the release slide valve and graduating valve to the application chamber exhaust port leading to the *atmosphere*.

The *service brake cylinder* is connected through the exhaust slide valve of the application portion to the service brake cylinder exhaust port leading to the *atmosphere*.

The *emergency brake cylinder* is connected through the emergency slide valve to the emergency cylinder exhaust port leading to the *atmosphere*.

It will be noted that Fig. 23 and some that follow show a small cavity in the release graduating valve. This cavity is connected to the emergency piston exhaust in all positions of the valve, but has no other connection. The purpose of this cavity is merely to insure that, under all conditions, there will be sufficient differential pressure acting on the graduating valve to hold it to its seat.

SERVICE APPLICATION

a. Preliminary Service Position

With the equipment fully charged as explained above, the result of a service reduction in brake pipe pressure will be to lower the pressure in *chambers A* and *B* below that in *chambers D* and *E*, thus creating a differential pressure on the equalizing and release pistons. Since *chamber F* is open to the *atmosphere* (see Fig. 24), the release piston will move on a much less differential than the equalizing piston. There is a small amount of lost motion between the release piston and release graduating valve and somewhat more between release piston and release slide valve so that during the first movement of the release piston, the release slide valve still remains in its *Release* position, thus keeping *chamber F* open through the emergency piston exhaust port to the *atmosphere*. The release piston, therefore, is the first to move when a brake pipe reduction is made and it carries with it the release graduating valve and finally moves the release slide valve to the position shown in Fig. 25, called *Preliminary Service* position. In this position the piston has closed the feed groove *i* (which is therefore not shown in Fig. 25) and just touches the release graduating piston sleeve.

The function of the valve in this position is to close the port leading from the *application chamber* to the *atmosphere* (which is therefore not shown in Fig. 25) to close the port connecting *chamber F* to the *emergency piston exhaust* and to open this latter port, connecting *chamber E* past the end of the release graduating valve and

through the release slide valve to *chamber F*. *Pressure chamber* air is therefore free to flow past the pressure chamber check valve to *chamber F*, thus balancing the pressures in *chambers F* and *D* on the opposite sides of the small end of the equalizing piston.

The other connections shown in Fig. 25, which remain as shown in Fig. 24, continue to perform the same functions as explained with reference to Fig. 13, and consequently do not need to be again referred to.

This position, it should be understood, is assumed only momentarily and should be regarded as the first stage only of the complete movement of the parts from *Release and Charging* to the *Service* position of the parts.

b. Secondary Service Position

The balancing of the pressures in *chambers F* and *D*, as explained, permits the equalizing piston to move in accordance with the difference of pressure already existing between *chambers D* and *A*. When the shoulder on the end of the piston stem comes in contact with the equalizing slide valve, as shown in Fig. 26, a connection is momentarily made from the *emergency reservoir* through the equalizing slide valve and past the end of (although shown as *through* in the diagrammatic view) the graduating valve to *chamber D*. The purpose of this connection (which is cut off, it will be observed, as soon as the equalizing piston is moved beyond the equalizing piston stop sleeve) is to prevent a drop in pressure in *chamber D* which would otherwise take place on account of the movement (displaced) of the equalizing piston. The displacement of the equalizing piston is sufficiently great,

compared with the volume of *chamber D*, to require the provision just explained.

At the same time, the *pressure chamber* is connected through the equalizing slide valve and graduating valve to *chamber D*, thus keeping the pressures in these two chambers equal.

The other connections remain as explained under the heading "Preliminary Service Position."

c. Service Position

The differential between the brake pipe pressure in *chamber A* and the pressure in *chamber D* (*pressure chamber* pressure as explained) is sufficient to move the equalizing piston and its valves past the intermediate secondary service position into *Service* position (Fig. 27) in which the equalizing piston just touches the equalizing graduating spring sleeve.

Chambers F and *D* are in communication by way of a feed port around the small end of the equalizing piston.

The *pressure chamber* is connected to *chamber D* through two channels, first, by way of the *pressure chamber* check valve to *chamber E* and thence past the end of the release graduating valve through the release slide valve to *chamber D* by way of a port past the end of (shown as *through* in cut) the equalizing slide valve, as well as through *chamber F*, and, second, the *pressure chamber* is also connected directly to the seat of the equalizing slide valve and past the end of (shown as *through* in cut) the slide valve direct to *chamber D*.

From *chamber D*, air from the pressure *chamber* can flow past the end of the equalizing graduating valve and

through the equalizing slide valve to the *application chamber* and *chamber C* on the face of the application piston.

The pressure of the compressed air thus admitted to *chamber C* causes the application piston to move to its *Application* position, compressing the application piston spring in so doing.

In this position the brake cylinder exhaust slide valve closes the brake cylinder exhaust ports (which, therefore, are not shown in Fig. 27) and the application slide valve opens the application port, permitting air from the *service reservoir (chamber N)* to flow to *chamber O* and the *service brake cylinder*, thus applying the brakes. The air flowing thus to the *service brake cylinder* also flows by way of the emergency slide valve to *chamber M*, in which the pressure is increased equally with that of the *service brake cylinder*. The flow of air from the *service reservoir* to the *service cylinder* continues, therefore, until the pressure in the *service brake cylinder* and in *chamber M* becomes substantially equal to that in the *application chamber* on the opposite side of the application piston. The application piston spring then returns the piston and the application slide valve back to *Lap* position (see Fig. 28), thus holding the brakes applied with a *service brake cylinder* pressure substantially equal to that put into the *application chamber*, as before mentioned.

It will be noted that in *Service* position, the *reduction limiting chamber* and *emergency brake cylinder* still remain connected to the *atmosphere*, as explained under the heading "Release Position."

d. Service Lap Position

In case that less than a full service reduction is made, that is to say that the brake pipe pressure is not reduced below the point at which the *pressure chamber* and *application chamber* pressures equalize, the flow of air from the *pressure chamber* to the *application chamber* as explained under the heading "Service Position" will finally reduce the pressure in *chamber D* to slightly below that to which the *brake pipe* pressure is reduced. The slightly higher brake pipe pressure in *chamber A* then causes the equalizing piston and graduating valve to return to their *Service Lap* positions (Fig. 28) and close communication from the *pressure* to the *application chamber* and holding whatever pressure was built up in *chamber C* and the *application chamber*.

It will be plain that any decrease in brake cylinder pressure, due to leakage, will not reduce the pressure in *chamber M* below that which is bottled up in the *application chamber* (*chamber C*). The differential pressure thus established on the application piston will cause it to move again toward its *Service* position and open the application valve port, as shown in Fig. 29, just enough to supply a sufficient amount of air from the *service reservoir* to the *service brake cylinder* to restore the depleted brake cylinder pressure to its original amount, following which the application valve will be again lapped as already explained. In this way, the *brake cylinder pressure will be maintained constant, regardless of leakage, up to the capacity of the service reservoir.*

The release piston and graduating valve may or may not return to their *Lap* positions at the same time as, and

in a manner similar to the movement of, the application piston and valves, but they perform no function in either case.

Otherwise the parts remain the same as in *Service* position.

e. Over Reduction Position

If the brake pipe reduction is carried below the point at which the *pressure* and *application chambers* equalize (86 lbs. when using 110 lbs. brake pipe pressure and 54 lbs. with 70 lbs. brake pipe pressure), such an over reduction results in lowering the pressure in *chamber A* below that in *chamber D* (*pressure chamber pressure*). The equalizing piston consequently moves beyond its *Service* position (Fig. 27) carrying with it the equalizing slide valve and graduating valve to what is called the "Over Reduction Position." (Fig. 29.)

The relative resistances of the release and equalizing graduating springs is such that the release piston and its valves still remain as in *Service*, although for the moment the same differential between *pressure chamber* and *brake pipe* pressure is acting upon the release piston as was sufficient to move the equalizing piston and its valves to the *Over Reduction* position.

The result is that air from the *pressure chamber*, (which is still connected to *chamber D* in substantially the same manner as explained under "Service Position") now flows past the end of the equalizing graduating valve and through the equalizing slide valve to the *reduction limiting chamber* instead of to the *application chamber* as in *Service* position.

The *reduction limiting chamber* being at atmospheric pressure, permits the pressure in the *pressure chamber* (and *chambers E* and *D*) to drop in accordance with the continued over reduction of brake pipe pressure, to the point of equalization of the *reduced pressure chamber pressure* and the *reduction limiting chamber pressure*. Otherwise the condition of the pressures in the reservoirs and brake cylinders controlled by the control valve is unchanged, except that in the movement of the equalizing slide valve to *Over Reduction* position, a connection is made from the *application chamber* and *chamber C* by way of the equalizing slide valve to the top (*chamber G*) of the service reservoir charging valve, and from *chamber D* (pressure chamber pressure) past the end of the equalizing graduating valve and through slide valve to *chamber K*. Since the pressure in the *pressure chamber* is being reduced, as already explained, while that in the *application chamber* and *service reservoir* is equalized, or practically so, at about 86 lbs. pressure, the service reservoir charging valve is not lifted, but is held down to its seat.

With the parts in this position, it will be noted that the *service reservoir* and the *application chamber* are separated only by the ring in the small end of the service reservoir charging valve. If there is any slight leakage which tends to cause a drop in *application chamber* pressure (which is relatively small compared with the *service reservoir* volume), the air in the *service reservoir* will gradually find its way around the ring in the small end of the service reservoir charging valve and prevent any material drop in *application chamber* pressure, thus

practically eliminating the possibility of the brakes gradually leaking off, due to *application chamber* leakage.

The application valve port is shown partly open, supplying brake cylinder leakage, as already explained.

f. Over Reduction Lap Position

Provided the brake pipe reduction is not carried below the equalizing point of the *pressure chamber* and *reduction limiting chamber*, a slight reduction of the pressure in the *pressure chamber* (and *chambers D* and *E*) below that held in the *brake pipe*, resulting from the continued flow of air from the *pressure* to the *reduction limiting chamber*, will cause the equalizing piston and graduating valve to be returned to *Over Production Lap* position (Fig. 30). This closes the port from the *pressure chamber* to the *reduction limiting chamber* and prevents further flow of air in this direction, but otherwise all parts and pressures are as explained above under heading "Over Reduction Position," except that the port connecting *chamber D* past the end of the equalizing graduating valve and through slide valve to *chamber K* is blanked by the movement of the equalizing graduating valve.

Should the brakes be held applied in *Over Reduction Lap* position for a sufficient length of time, with an *application chamber* leakage so great that the air from the service reservoir could not get past the ring in the small end of the service reservoir charging valve fast enough to supply such leakage (in the manner explained in connection with Fig. 29), the service reservoir charging valve

will finally be lifted, making wide open connection from the *service reservoir* to the *application chamber*.

From what has been said, it will be plain that if the brake pipe reduction is continued below the point at which the *pressure* and the *reduction limiting chambers* equalize, the pressure in the *pressure chamber* can no longer continue to reduce in accordance with the still falling brake pipe pressure. This results in a differential being established between the pressure in the *pressure chamber* (and *chambers D* and *E*) and the *brake pipe* pressure which, when the brake pipe pressure is reduced below 60 lbs. when carrying 110 lbs. brake pipe pressure or below 35 lbs. with 70 lbs. brake pipe pressure, is sufficient to cause the release piston to travel to its extreme (*Emergency*) position and produce quick action and an emergency application of the brakes as will be explained under the heading "Emergency Position."

RELEASING

a. Preliminary Release Position

Whether the parts are in *Service Lap* or *Over Reduction Lap* position, after an application has been made, an increase in *brake pipe* pressure above that in the *pressure chamber* (*chambers D* and *E*) will cause the equalizing piston and its valves to return to the release positions described below.

The equalizing piston moves before the release piston, the parts being designed to require a somewhat higher differential to move the release piston and its attached valves than is sufficient to move the equalizing piston.

In *Preliminary Release* position (Fig. 31), it will be noted that *chamber E* behind the release piston, is connected by way of the equalizing slide valve and graduating valve to the *reduction limiting chamber exhaust*. This connection is made but momentarily, in what may be considered the first stage of the movement of the parts to *Release* position. It plays a very important part, however, in the release operation of the valve, since by thus insuring a momentary but material drop in the pressure in *chamber E* below that in the *brake pipe* and in *chamber B*, the release piston is forced to return positively to its *Release* position shown in Fig. 32—*Secondary Release* position.

In *Preliminary Release* position, the *pressure chamber* is connected, by way of the equalizing slide valve to *chamber F*. The pressure thus acting in *chamber F*, in addition to the force of the equalizing stop spring, serves to insure that the equalizing piston and its valves hesitate in *Preliminary Release* position for a sufficient length of time to reduce the pressure in *chamber E* (as already explained).

It will be observed that the application piston is still in its *Lap* position, holding the pressure in the service brake cylinder. This continues until the release of air from the *application chamber* and *chamber C*, which does not take place until the parts move to the next stage in the release movement, called *Secondary Release* position, Fig. 32.

In the movement of the equalizing slide valve to *Preliminary Release* position, the *reduction chamber* is con-

nected to the reduction chamber exhaust port and the *atmosphere* and so remains until the parts again move to *Over Reduction* position or beyond.

Although there are other connections made in the *Preliminary Release* position as shown in Fig. 31, they perform no particular function other than has already been described, and consequently do not need to be again referred to.

b. Secondary Release Position

In the movement of the parts to *Release* position, the next stage, following the *Preliminary Release* position, is called the *Secondary Release* position and is shown in Fig. 32. It will be seen from the illustration that the venting of the air from *chamber E* through the equalizing slide valve and graduating valve to the *reduction limiting chamber exhaust* has resulted in the relatively higher brake pipe pressure moving the release piston and its valves to their *Release* positions, although for an instant the equalizing piston and its valves still remain as shown in Fig. 31—*Preliminary Release* position.

With the release piston and its valves in the position shown in Fig. 32, a connection is made from *chamber F* through the release slide valve to the *emergency piston exhaust*. At the same time the *pressure chamber* is connected by way of the equalizing slide valve to the same port which connects *chamber F* to the *atmosphere*. This tends to maintain the pressure in *chamber F* temporarily so as to insure the connection from *chamber E* to the *atmosphere* being held open, as explained above, until

the release piston and its valves are entirely back in their *Release* positions. In so moving, however, the release slide valve is gradually increasing the size of the opening from *chamber F* to the *atmosphere*, until a point is reached where the pressure in *chamber F* is lowered sufficiently to permit the differential pressure already acting on the equalizing piston to start this piston toward its *Release* position. The resulting movement of the equalizing slide valve restricts and finally stops entirely the flow of air from the *pressure chamber* to *chamber F*, the pressure in which is, therefore, rapidly exhausted to the *atmosphere* through the ports already mentioned and the equalizing piston and its valves are then held positively in their *Release* position as shown in Fig. 33.

Comparing Fig. 31 and Fig. 32, it will be noted that the movement of the release piston, slide valve and graduating valve from the position shown in Fig. 31 to that shown in Fig. 32, opens communication from *chamber E* past the end of the release graduating valve, through the release slide valve and direct and graduated release cap and through the equalizing slide valve to the reduction limiting chamber exhaust and *atmosphere*. This outlet from *chamber E* to the *atmosphere* is simply additional, it will be noted, to that already existing as explained in connection with Fig. 31, and, like it, is but momentary. In the succeeding position (Fig. 33) both these connections from *chamber E* to the *atmosphere* are cut off.

The movement of the release graduating and slide valves to their *Release* positions opens the *application chamber* and *chamber C* by way of the valves mentioned

to the application chamber exhaust and *atmosphere*. The resulting reduction of pressure in *chamber C* below that exerted by the application piston spring and the air pressure in *chamber M* causes the application piston, with its attached valves, to move back to *Release* position (Fig. 32), opening the *service brake cylinder* through the exhaust valve to the service cylinder exhaust and *atmosphere*. The release of the brake is, therefore, commenced as soon as the release piston and its valves are returned to their *Release* positions.

While there are other connections shown in Fig. 32 besides those just explained, they perform no particular function, so far as the momentary position of the parts in *Secondary Release* position (Fig. 32) is concerned, and will, therefore, not be referred to until all can be explained together under the heading "Graduated Release Position" (Fig. 33).

c. Graduated Release Position

As already stated, the movement of the release slide valve to its *Release* position connects *chamber F* to the emergency piston exhaust and *atmosphere*, causing the equalizing piston and its valves to be moved to and held positively in their *Release* positions, as shown in Fig. 33.

It should be clearly understood that a very slight increase in brake pipe pressure (about 1½ to 2 lbs.) above that remaining in the pressure chamber, is sufficient to move the parts through the successive momentary positions of *Preliminary* and *Secondary Release* as just explained, until they reach their final positions shown in Fig. 33—*Graduated Release* position.

In this position (graduated release being assumed to be cut in), the *application chamber* and *chamber C* are open through the release slide valve and graduating valve to the application chamber exhaust and *atmosphere*. So far as this connection is concerned, the release would be complete provided the parts did not move, but it will be noted that in this position also the *emergency reservoir* is connected by way of the equalizing slide valve, and the direct and graduated release cap (which is adjusted to give graduated release) through the release slide valve and past the end of the release graduating valve to *chamber E*. The pressure in the *emergency reservoir* is substantially that to which it was originally charged, namely, normal brake pipe pressure. The pressure in *chamber E*, it will be remembered, was reduced equally with the pressure chamber pressure when the brake application was made. Air from the emergency reservoir, at the higher pressure, will therefore flow into *chamber E* and, from *chamber E*, by way of the equalizing slide valve, to the *pressure chamber*, at the lower pressure, and tend to increase the pressure in *chamber E* and the *pressure chamber* at the same time that the brake pipe pressure in *chamber B* is being increased. If the pressure in *chamber E* rises faster than that in *chamber B*, the higher pressure which will soon be built up in *chamber E* will tend to move the release piston and graduating valve over toward *Graduated Release Lap* position (Fig. 34) and either partially restrict or wholly stop the flow of air from the *application chamber* to the *atmosphere*, and from the *emergency reservoir* to *chamber E*. If the brake pipe

pressure is increased very slowly, the relatively rapid increase of pressure in *chamber E* may cause the release piston and graduating valve to graduate the release as explained in connection with Fig. 34. If the rate of rise of brake pipe pressure is not slow enough to permit this action, the parts will move toward the position shown in Fig. 34 sufficiently to so restrict the flow of air from the *emergency reservoir* to *chamber E*, as to adjust the rate of rise of pressure in *chamber E* to correspond to that of the brake pipe and *chamber B*, in which case the release of air from the *application chamber* will be correspondingly prolonged.

The escape of air from the *application chamber* and *chamber C* to the *atmosphere* as already explained in connection with Fig. 32, results in the application piston spring and brake cylinder pressure acting in *chamber M*, moving the application piston with its valve back from their *Lap* positions, as shown in Fig. 31, to their *Release* position, as shown in Figs. 31 and 33, in which position air from the *brake cylinder* is exhausted to the *atmosphere* by way of the exhaust valve and service cylinder exhaust port. Whether the brake cylinder pressure is entirely or only partially released depends upon whether the exhaust of air from the *application chamber* and *chamber C* is partial or complete. This has already been referred to and will be further mentioned in connection with Fig. 34. It will be noted that in Figs. 31, 32 and 33, the *reduction limiting chamber* is connected to the reduction limiting chamber exhaust and *atmosphere* through the equalizing slide valve, and that in Figs. 32 and 33 *chamber S* is connected through the re-

lease slide valve to the emergency piston exhaust and *atmosphere*, so that the air in these chambers is completely exhausted to the atmosphere when either a graduated or direct release is made.

Referring to Fig. 33, it will be noted that *chamber E* is connected to *chamber K* and that air from the *emergency reservoir* has access to *chamber G*. These connections being opened by the movement of the equalizing slide valve to its *Release* position whether or not the service reservoir charging valve will be opened and permit the recharging of the service reservoir to begin at once, will depend on the relative pressures in the pressure chamber, emergency and service reservoirs. With the ordinary manipulation of the brake, the service reservoir charging valve will remain closed, as shown in Fig. 33, preventing the air from the *emergency reservoir* reaching the *service reservoir* and the *pressure chamber* only will be recharged until its pressure has been increased to within about 5 lbs. of that in the *emergency reservoir*.

The other connections which are shown in Fig. 33 have been fully explained in what has preceded and require no further mention at this time since they are not concerned in the particular function under discussion.

As already indicated, if the brake pipe is fully recharged without a graduation of the release being made, the parts will remain in the positions shown in Fig. 33 and the release will be complete and without graduations. The only change which takes place while such a release is being made is the movement of the service reservoir charging valve from the position shown in Fig. 33 to that

shown in Fig. 24, which should properly be regarded as illustrating the final stage in the recharging of the equipment of which Fig. 33 illustrates the initial stage. That is to say, at first the *pressure chamber* alone is recharged and this recharge is accomplished (as has been pointed out) from the *emergency reservoir* only, without any air being drawn for this purpose from the *brake pipe*. The air which is supplied through the brake valve to the *brake pipe* is, therefore, given every possible advantage and opportunity to accomplish what is intended when the brake valve handle is moved to *Release* position, namely, to *release the brakes* by causing an increase of pressure sufficient to accomplish this, throughout the entire length of the *brake pipe*.

After the release has been thoroughly established in this manner, the recharging of the reservoirs to their original pressure takes place as explained in connection with Fig. 24. That is to say, when the pressure chamber has been recharged to within about 5 lbs. of the pressure remaining in the emergency reservoir, the service reservoir charging valve is lifted from its seat, opening the connection from the *emergency reservoir* to the *service reservoir* and as the brake pipe pressure continues to be increased, the *service reservoir*, *emergency reservoir* and *pressure chamber* are finally recharged to full brake pipe pressure by the air coming from the *brake pipe*, as already explained in connection with Fig. 24.

d. Release Lap Position

If, however, the brake pipe pressure is not fully restored, a graduation of release being made; that is, if the

brake pipe is partially recharged and the brake valve handle then returned to *Lap* position, the continued flow of air from the *emergency reservoir* to *pressure chamber* and *chamber E*, as previously explained, will tend to increase the pressure in the *pressure chamber* and *chamber E* above that of *chamber B* which is now stationary, causing the release piston and graduating valve to move over until the shoulder on the end of the release piston stem comes in contact with the release slide valve as shown in Fig. 34. This closes the exhaust from the *application chamber* to the *atmosphere* and prevents further flow of air from the *emergency reservoir* to the *pressure chamber* and *chamber E*.

The flow of air from the *service brake cylinder* to the *atmosphere* (continuing as explained in connection with Fig. 33), will at once reduce the pressure in *chamber M* below that now retained in *chamber C* by the small amount which is sufficient to cause the application piston to move over to the position shown in Fig. 34, in which the exhaust valve is closed, thus preventing further release of air from the service brake cylinder. The other connections remain as already explained.

e. Release and Charging Pressure Chamber and Emergency and Service Reservoirs

The gradual release of brake cylinder pressure may be continued as explained above (Fig. 34) until the pressures in the *emergency reservoir* and *pressure chamber* have become equal. On account of the relatively large volume of the *emergency reservoir* compared with that of the *pressure chamber*, this equalization will not take

place until the *pressure chamber* has been recharged to within about 5 lbs. of the brake pipe pressure carried. Beyond this point, whatever small amount of pressure may remain in the *service brake cylinder* is released entirely and the *emergency* and *service reservoirs*, as well as the *pressure chamber*, are recharged from the *brake pipe* as described in connection with Fig. 34.

f. Direct Release and Charging Position

Up to this point, the direct and graduated release cap has been assumed to be in the position for graduated release. Fig. 35 corresponds to Fig. 33, except that the direct and graduated release cap is adjusted for direct release. It will be noted that there is now no connection from the *emergency reservoir* to the *pressure chamber* or *chamber E*. Consequently the *pressure chamber* is being recharged only by air from the *brake pipe* going through feed groove *i* to *chamber E*, and thence by way of the equalizing slide valve, to the *pressure chamber*. The pressure in *chamber E* cannot, therefore, increase above that in *chamber B* and the release piston, graduating valve and slide valve remain in the position shown in Fig. 35.

With the direct and graduated release cap adjusted for direct release, it will be noted from Fig. 35 that the *application chamber* and *chamber C* are open through the release slide valve to a port connecting through the direct and graduated release cap to the application chamber exhaust and *atmosphere*. This affords an outlet from the *application chamber* to the *atmosphere* which cannot be closed as long as the release slide valve remains in the

position shown, even though the release piston and graduating valve, should, from any cause, be moved back so that the release graduating valve would partially or entirely restrict the application chamber release port, which is also shown to be open through the release graduating valve in Fig. 35. Moreover, it will be noted that there are *two* outlets from the *application chamber* to the *atmosphere* when the valve is adjusted for *direct release* as compared with *one* when *graduated release* is cut in. This, together with the fact that the direct release port is of greater capacity than the graduated release port, results in a more rapid rate of release being obtained with the direct than with the graduated release adjustment of the equipment, as is desirable. As the other connections shown in Fig. 35 are the same throughout as explained in connection with Fig. 33, it will be unnecessary to make further reference to same.

EMERGENCY POSITION

a. Quick Action Valve Venting

When the brake pipe pressure is reduced faster than at the predetermined rate for service applications, or if the brake pipe reduction should be continued below the point at which the *pressure* and *reduction limiting chambers* equalize (as explained above under the heading "Over Reduction Position") the differential pressure acting on the release and equalizing pistons becomes sufficient to move them to their extreme or *Emergency* positions as shown in Fig. 36.

In this position, air from the *emergency reservoir* flows directly to *chamber E* and from *chamber E* to the under

side of the quick action closing valve. *Chamber T*, above the quick action closing valve, is connected to the emergency brake cylinder port, in which there is no pressure, even though a full service application of the brakes may have just preceded the emergency application.

The higher pressure on the under side of the quick action closing valve therefore raises this valve and air flows to *chamber W* above the quick action piston, forcing the latter down and opening the quick action valve against brake pipe pressure in *chamber Y*. As soon as the quick action valve is unseated in this manner, air from the *brake pipe* flows past the quick action valve to the quick action exhaust and *atmosphere*, causing a local venting of brake pipe air and transmitting the quick application serially throughout the train.

Air from the *emergency reservoir* flowing to *chamber E* also flows directly to the application chamber and *chamber C* which forces the application piston and its valve over into their extreme positions, opening the *service reservoir* through the application slide valve and *chamber O* to the *service brake cylinder*, thus permitting the pressures in the *service reservoir* and *service brake cylinder* to equalize.

At the same time *chamber P*, above the large emergency piston, is connected through the release slide valve to the emergency piston exhaust and *atmosphere*, permitting the emergency reservoir pressure in *chamber R* to force the emergency piston and its slide valve upward to their *Emergency* positions.

In this position of the emergency parts, the *emergency reservoir* is connected past the end of the emergency

slide valve to the *emergency brake cylinder*, thus permitting the pressures in the *emergency reservoir* and *brake cylinder* to equalize. *Chamber R* is also connected through the emergency slide valve to the *service cylinder port* which permits equalization of the service and emergency reservoirs and brake cylinders.

It will be noted that in this position the emergency slide valve opens a port which connects *chamber M*, behind the application piston, through the emergency slide valve to *emergency cylinder exhaust*. This, in connection with the admission of air from the *emergency reservoir* to the *application chamber* and *chamber C*, as already explained, still further insures a quick and positive movement of the application piston and its valves to *Emergency* position.

In this position the *pressure chamber* is connected through the equalizing slide valve to *chamber D*. The *pressure chamber* is also connected past the pressure chamber check valve to *chamber E*, and *chamber D* is connected past the end of the equalizing graduating valve through the equalizing slide valve to the *reduction limiting chamber*. These connections perform no particular function except to insure pressure acting on all slide valves, graduating valves, etc., so as to hold them to their seats as well as to provide for the equalization of all chambers, reservoirs, etc., of the equipment when an emergency application is made.

b. Quick Action Valve Closed

The emergency brake cylinder pressure and that in *chamber T*, above the quick action closing valve, contin-

ues to rise and the pressure in the *emergency reservoir* and in *chamber W* below the quick action closing valve falls, as explained above, until these pressures become substantially equal. This equalization of the pressures on the opposite sides of the quick action closing valve permits its spring to return the valve to its seat, cutting off further flow of air to *chamber W*. *Chamber W* is connected through the leakage hole in the quick action piston to *chamber X* so that as soon as the quick action closing valve is seated, the pressure in *chamber W* expands through this leakage hole to *chamber X* and the *atmosphere*, through the quick action exhaust opening. The balancing of the pressures in *chambers X* and *W* thus permits the quick action valve spring to return the quick action valve to its seat, closing the outlet from the *brake pipe* to the *atmosphere*, as shown in Fig. 37. This insures against an escape of air from the *brake pipe* to the *atmosphere*, when a release is made following the operation of the quick action parts.

Except for the closing of the quick action valve and return of the quick action parts to *Normal* position, as explained in the preceding paragraph, the positions of the other parts of the valve and connections between the various reservoirs and cylinders, etc., remain as already explained in connection with Fig. 36.

When releasing after an emergency application, as soon as the brake pipe pressure in *chambers A* and *B* is increased above that which remains in *chambers D* and *E*, the parts will move to their *Release* positions, exhausting the air from the brake cylinders and recharging the reservoirs and pressure chamber as explained under

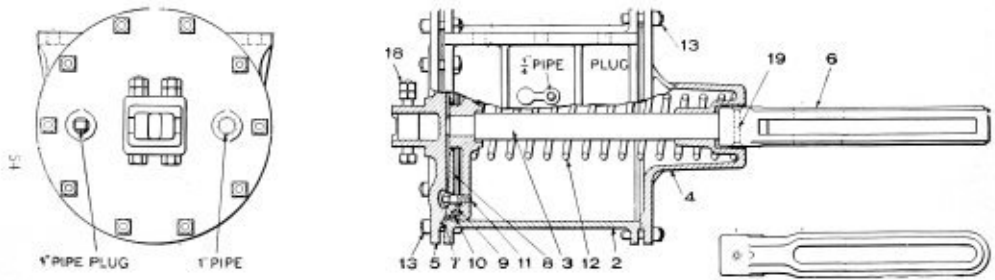

Fig. 12. Brake Cylinder

the heading "Release and Recharging." Figs. 31, 32 and 33.

BRAKE CYLINDERS

Two brake cylinders per car are used. (See Figs. 1 and 2.) Only *one* brake cylinder operates during service applications, but *both* are brought into play when an emergency application is made. This gives the necessary increased braking power for emergency applications, not by an increased pressure in one brake cylinder (as in previous equipments), but by bringing the same brake cylinder pressure to act upon the pistons of two brake cylinders instead of one. This means that *double* the maximum service braking power is obtained in emergency applications.

It will be noted that Figs. 1 and 2 differ in the arrangement of the brake cylinders and related parts. Fig. 1, with brake cylinders pointing in opposite directions, permits a somewhat simpler arrangement of the hand brake rigging, while the arrangement shown in Fig. 2 brings the slack adjusters and their connections into a more convenient location for some installations. Which of the two arrangements is to be recommended depends largely on the construction of the car underframing and the location of the apparatus under the car.

Fig. 12 illustrates the section and exterior of the type of brake cylinder used with this equipment. The piston 3 has a solid push rod which is connected to the levers of the foundation brake gear through the slotted crosshead; 12 is a release spring which forces piston 3 to release position when the air pressure is exhausted from the

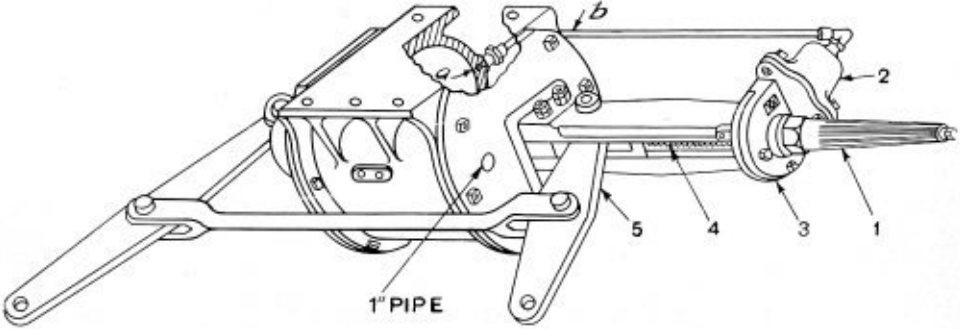

Fig. 14. Application of Slack Adjuster to Brake Cylinder

the prompt recharging of the equipment in service operation.

Enameled reservoirs are now strongly recommended on account of their durability and protection against corrosion, oxidation, etc., preserving a greater factor of safety than does the plain unenameled type. These reservoirs are enameled by a special process both inside and out.

Each reservoir is provided with a drain cock by means of which all residue may be drawn off at frequent intervals, as water or oil collecting will soon materially decrease the air storage capacity.

Following is a list of the standard sizes of reservoirs used with the various sizes of brake cylinders:

Service Reservoir		Emergency Reservoir		
Size, Inches	Capacity, Cu. In.	Size, Inches	Capacity Cu. In.	Cylinders Used With
16 x48	8577	16 x42	7436	2—14 in.
20½x36	10158	16 x48	8577	2—16 in.
20½x48	14003	20½x36	10158	2—18 in.

THE AUTOMATIC SLACK ADJUSTER

The automatic slack adjuster is illustrated in Figs. 14 and 15. The brake cylinder piston acts as a valve to control the admission and release of brake cylinder pressure to and from pipe *b*, Fig. 14, through port *a* in the cylinder, this port being so located that the piston uncovers it when the predetermined piston travel is exceeded. Whenever the piston so uncovers port *a*, brake

in the direction of the slack adjuster cylinder, thus shortening the brake cylinder piston travel and forcing the brake shoes nearer the wheels. As the pawl is drawn back to its normal position, a lug on the lever side strikes projection *a*, Fig. 15, on the cylinder, thus raising the outer end of the pawl, disengaging it from the ratchet wheel and permitting the screw to be turned by hand if desired.

To apply new shoes, turn casing 1 to the left, thus moving lever 5 toward the position shown in Fig. 14, until sufficient slack is introduced in the brake rigging. To bring the shoes closer to the wheels and shorten the piston travel, turn casing 1 to the right.

The screw mechanism is so proportioned that the brake shoe wear is compensated for at the rate of about $\frac{1}{32}$ of an inch for each operation of the adjuster, thereby removing the danger of *unduly* taking up false travel which would result in the shoes binding on the wheels.

The best results are obtained by the use of copper pipe from the brake cylinder to the adjuster cylinder, since this pipe is more flexible and does not corrode. It should always be firmly secured.

Every time the brake cylinder is cleaned and oiled, the slack adjuster should receive the same attention, and, after each cleaning and oiling, a test of the brakes should also include one of the adjuster.

CENTRIFUGAL DIRT COLLECTOR

The centrifugal dirt collector, as illustrated in Fig. 16, is so constructed that, due to the combined action of centrifugal force and gravity, all dirt and foreign material

cylinder air flows through pipe *b* into slack adjuster cylinder 2 where the small piston 19, Fig. 15, is forced outward, compressing spring 21. Attached to piston stem 23 is a pawl extending into casing 24, which engages ratchet wheel 27, mounted within casing 24 upon screw 4, Fig. 14. When the brake is released and the brake cyl-

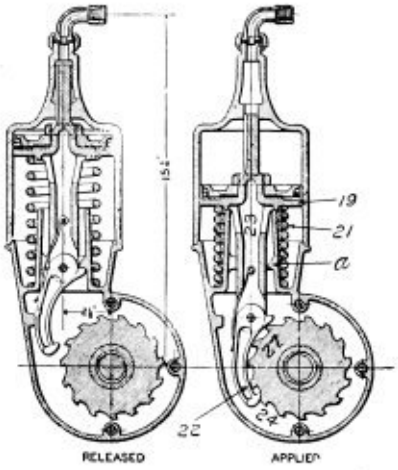

Fig. 15. Automatic Slack Adjuster Cylinder

inder piston returns to its normal position, the air pressure in cylinder 2 escapes to the atmosphere through pipe *b*, port *a* and the non-pressure head of the brake cylinder, thus permitting spring 21 to force the small piston to its normal position. In so doing, the pawl turns the ratchet wheel upon screw 4 and thereby draws lever 5 slightly

tached to its handle and running the length of the car; however, one valve may be placed at each end which will obviate the necessity of the cord. When this valve is opened, the air from the brake pipe flows directly through

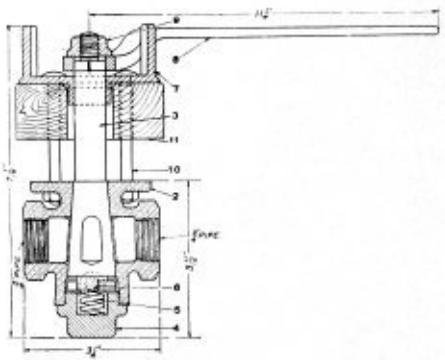

Fig. 17. C-3 Conductor's Valve

it to the atmosphere, setting the brakes in emergency. It should therefore be used only in case of actual danger and should then be opened as wide as possible and left open until the train stops.

PIPE FITTINGS

The purpose of the *Branch Pipe Tee*, Fig. 18, is to prevent moisture that may be deposited in the brake pipe, from any cause, draining into the branch pipe connection and from thence into the control valve. While the centrifugal dirt collector has proved very efficient in collecting

is *automatically* eliminated from the air flowing through the collector—as when the brakes are applied or released —*without reducing the area of the opening in any way.* The efficiency of this method of keeping dirt out of the brake system is remarkable and the importance of this fact will be appreciated by those who are familiar with the troubles which result from the entrance of dirt, pipe scale, etc., into the brake system and especially the triple valves. The design of the collector is such that the dirt

Fig. 16. Centrifugal Dirt Collector

and foreign matter eliminated falls into the bottom chamber and by means of a plug may be removed at intervals without breaking any pipe connections whatever.

CONDUCTOR'S VALVE

The conductor's valve, Fig. 17, may be located at any convenient point in the car, preferably with a cord at-

The *cut-out cock*, Fig. 19, of which there is one 1-inch in the branch pipe, should be placed where it can be easily reached but protected from accidental closing.

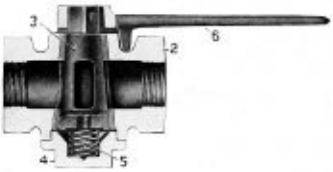

Fig. 19. Cut-Out Cock

The handle should be in such position that, as affected by vibration, it would tend to jar open instead of shut.

The *self-locking angle cock* has been developed to prevent any accidental movement of the handle from either

Fig. 20. New and Old Angle Cock Handle

open or closed position by flying missiles, loose brake rods, swinging check chains or other causes. In all details except the handle the self-locking type is the same

moisture and dirt from the piping of the air brake system thereby protecting the triple valve, the use of the branch pipe tee illustrated in Fig. 18 will materially assist in preventing the *excessive* deposit of moisture in the branch pipe sometimes occasioned in charging and testing trains from poorly designed yard plants, or because the locomotive has insufficient reservoir capacity or cooling pipe to insure precipitation of the water before passing to the brake system. This fitting has the interior coring so de-

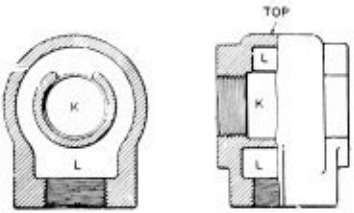

Fig. 18. Branch Pipe Tee

signed that the outlet from the brake pipe to the branch pipe is at the top. Thus, as air enters at K from the brake pipe it is deflected upward and made to pass through the outer chamber L and thence through the pipe opening at the bottom of the branch pipe, the moisture and heavy particles of dirt passing on through the brake pipe.

These fittings are made in two forms, one having the branch pipe connections at the side and the other having the connection at the bottom. Unless otherwise specified the latter, as illustrated in Fig. 18, will be furnished.

GENERAL HINTS

The brake should be handled by the engineers in the same manner as with cars equipped with quick-action triples, the only difference being that an emergency application will be obtained should a service reduction of the brake pipe pressure be continued below 60 lbs. when carrying 110 lbs. pressure or below 35 lbs. with 70 lbs. brake pipe pressure.

When it is found necessary to cut out the brake, close the cut-out cock in the crossover pipe and bleed both the service and emergency reservoirs.

Should it become necessary to bleed the brake when the engine is detached, or air connection is not made, first bleed the brake pipe and then bleed both the service and emergency reservoirs.

The two sets of cylinder levers are connected to the same truck pull rods as stated above. Therefore, when a service application of the brake is made, the push rod end of the emergency cylinder lever will move the same distance as the push rod end of the service cylinder lever, but the cross head being slotted, the piston of the emergency cylinder will not move. Consequently, the fact that the *emergency cylinder* cross head is in release position does *not* indicate that the air brakes are released. To determine this, look at the ends of either the service or emergency cylinder levers.

Whenever it is necessary to change the adjustment of the automatic slack adjuster, it is imperative that the cross heads of the two adjusters be left at the same distance from their respective brake cylinder heads, in order

as the old style angle cock; the upper illustration, Fig. 20, shows the self-locking handle while the lower represents the old form. In the case of angle cocks now in service it is necessary to supply only the improved handle to secure advantages which the self-locking angle cock provides.

Fig. 21. Hose Coupling

Hose couplings, Fig. 21, make the brake pipe continuous throughout the train. When cars are being separated, as in switching, the hose should be uncoupled by hand, to prevent rupture or damage.

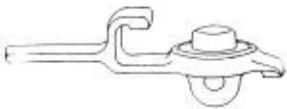

Fig. 22. Dummy Coupling

Dummy couplings, Fig. 22, are provided at each end of the car to which the hose couplings should be attached when not coupled up, to protect against injury to the hose couplings or dirt entering the pipes.

should be substituted. If the blow does not cease, it indicates a defective equalizing portion and a new one, or one that has been repaired, should be substituted.

Should there be a blow at the Emergency Piston Exhaust ($\frac{3}{8}$-inch exhaust on the right hand side of the equalizing portion) make a 15-lb. brake pipe reduction and lap the brake valve. If the blow ceases, it indicates that either the emergency portion or seal on the small end of the equalizing piston is defective and a new portion, as found to be needed, or one that has been repaired, should be substituted. If the blow does not cease, it indicates that the equalizing portion is defective and a new one, or one that has been repaired, should be substituted.

A hard blow at the service Brake Cylinder Exhaust (tapped for $\frac{3}{4}$-inch pipe and located on the left side of the control valve reservoir) with the brakes applied, indicates that the application portion is defective and a new one, or one that has been repaired, should be substituted. This portion is located back of the equalizing portion inside the reservoir. If this blow occurs when the brakes are released it indicates either a defective application or emergency portion and a new one or a repaired portion, as found to be required on investigation, should be substituted.

A hard blow at the Emergency Cylinder Exhaust (tapped for $\frac{1}{2}$-inch pipe and located on the bottom of the control valve reservoir) with the brakes either applied or released, indicates a defective emergency portion and a new one, or one that has been repaired, should be substituted.

that the piston travel of the two cylinders in emergency application will be the same.

The various exhaust openings referred to in the following are plainly marked on the outline drawings, Figs. 6 and 6A.

The Quick Action Exhaust is the one-inch opening in the bottom of the control valve reservoir. Should there be a continual blow at this opening, make an emergency application and then release; if the blow continues, remove the quick action portion and substitute a new or repaired portion or repair the quick action valve seat which will be found defective. The quick action portion is at the left hand when facing the equalizing portion.

There are three control valve exhaust openings, two on the equalizing portion and one on the side of the control valve reservoir, all tapped for $\frac{3}{8}$-inch pipe.

Should there be a blow at the Application Chamber Exhaust ($\frac{3}{8}$-inch exhaust opening on side of the control valve reservoir) with the brakes applied or released, it indicates a defective equalizing portion and a new one or one that has been repaired, should be substituted.

Should there be a blow at the Reduction Limiting Chamber Exhaust ($\frac{3}{8}$-inch exhaust on left side of equalizing portion) in release or service position it indicates a defective application portion and a new one, or one that has been repaired, should be substituted. This portion is located back of the equalizing portion, inside the reservoir. If the blow occurs only after 30 lbs. brake pipe reduction, it indicates a defective emergency reservoir check valve (the middle check valve in the equalizing portion) and a new one, or one that has been repaired,

The following is the method of lubricating the equalizing portion:

After the bearing surfaces have been properly rubbed in by a free use of oil, this oil should be wiped off with a soft cloth or some soft material. All oil, gum or grease should be thoroughly removed from the slide valves and seats. After this has been done, rub a high grade of very fine, dry (not flake) graphite, of the highest obtainable fineness and purity, on to the face of the slide valves, their seats, the face of the graduating valves, their seats, and the upper portion of the bushings where the slide valve springs bear, in order to make as much as possible adhere and fill in the pores of the brass and leave a very thin, light coating of graphite on the seats. When this is completed, the slide valves and their seats must be entirely free from oil or grease. Care must be taken when handling the slide valves, after lubricating, that the hands do not come in contact with the lubricated parts, as moisture will tend to remove the thin coating of graphite.

To apply the graphite, use a stick, suitable for the purpose, about 8 inches long, on one end of which a small pad of chamois skin has been glued. Dip the skin covered end in the dry graphite and rub the latter on the surfaces specified. A few light blows of the stick on the slide valve seats will leave the desired light coating of loose graphite. After the pistons and slide valves have been replaced in the equalizing portion, they should be moved to *Release* position and a little good oil or lubricant applied to the circumference of the piston bushings, and the pistons moved back and forth several times to insure proper distribution of this lubricant on the walls of the cylinders.

If the trouble described in the five paragraphs immediately preceding is not overcome by the remedies therein suggested, remove the application portion and examine its gasket, as a defect in same may be the cause of the difficulty.

When removing the application, emergency and quick action portions, their respective gaskets should remain on the reservoir. On removing the equalizing portion, its gasket should remain on the application portion, except when the application portion is shipped to and from points where triple valves are cared for.

When applying the different portions the gaskets should be carefully examined, to see that no ports are restricted, and that the gasket is not defective between ports. See also that all nuts are drawn up evenly to prevent uneven seating of the parts.

On the front and at the center of the equalizing portion is located the direct and graduated release cap (held by a single stud) on which is a pointer. (See Fig. 4.) The position of this pointer indicates whether the valve is adjusted for direct release or graduated release. This cap should be adjusted for either direct or graduated release according to the instructions issued by the railroad.

LUBRICATION

No. 3-E Control Valve

The control valve parts should be lubricated as follows:

EQUALIZING PORTION. All equalizing portions should be lubricated with dry graphite instead of oiling.

a proper distribution of the oil. Apply the large cover to the emergency portion.

QUICK ACTION PORTION. No parts of the quick action portion require lubrication but, if desired, the closing valve piston and cylinder bushings may be sparingly lubricated with triple valve oil. After lubricating, work the piston a few times, making sure that it moves freely.

Brake Cylinder

In cleaning the brake cylinder and piston, special attention should be given to removing lint, freeing the leakage groove of any deposit, and thorough cleansing of the expander ring, packing leather and piston. In lubricating the cylinder, special attention should be given to the thorough lubrication of the top of the cylinder and the inside of the packing leather where the expander ring rests. We have adopted as standard shop practice and recommend to customers the use of the Emery Brake Cylinder Lubricant as providing very satisfactory and economical lubrication and effectively preserving the piston packing leather and reducing brake cylinder leakage to a minimum. It should be particularly observed that the follower nuts are tight, since they are frequently found to be loose.

The bush in which the service reservoir charging valve moves should also be sparingly lubricated with a good grade of oil.

When oiling, as just directed or in the cases which follow, only a thin coating of oil is necessary and care should be taken not to leave any free oil on the parts.

APPLICATION PORTION. The exhaust valve and seat and application valve and seat of the application portion should be cleaned, rubbed in and sparingly lubricated with graphite grease.

Before applying the piston to application portion, clean the application cylinder and piston. Lubricate the walls of the cylinder and piston ring, using Emery Brake Cylinder Lubricant.*

EMERGENCY PORTION. After the bearing surfaces have been properly cleaned and rubbed in and before applying the slide valve to the emergency portion, remove the top cover and take out the loose fitting cylinder bushing. Lubricate the large piston with a few drops of a good grade of triple valve oil and apply the same oil sparingly to the slide valve, then enter the slide valve into the portion. Lubricate the slip bushing for the small emergency piston, applying a few drops of triple valve oil to inner circumference. Apply the bushing to the portion and bolt on top cover. Move the slide valve to *Release* position and put a few drops of triple valve oil on the walls of the large cylinder bushing. Move the slide valve and piston back and forth several times to insure

*NOTE.—The Emery Brake Cylinder Lubricant is manufactured by the Emery Pneumatic Lubricator Company, 1932 North Broadway, St. Louis, Missouri.

Westinghouse Air Brake Company

Pittsburgh, Pa., U. S. A.

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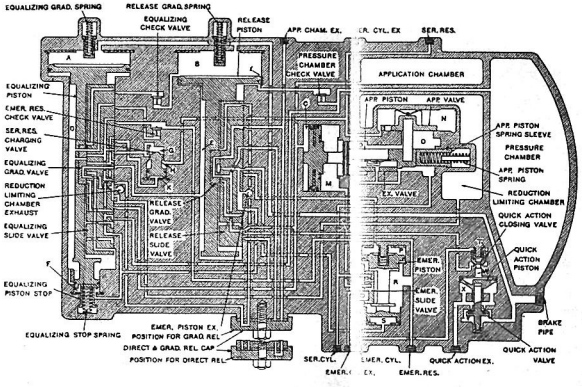

Fig. 23. Normal Position

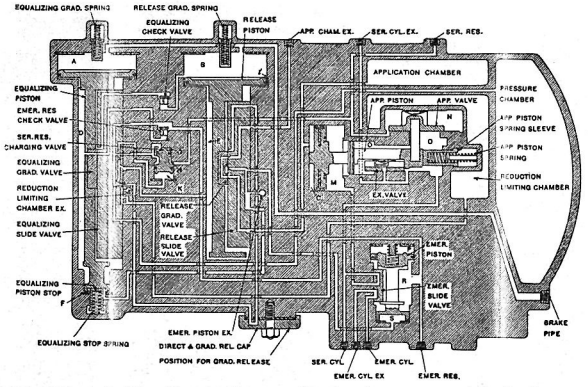

Fig. 24. Release Position, Charging Pressure Chamber, Emergency and Service Reservoirs

DIAGRAMMATICS OF THE No. 3-E CONTROL VALVE

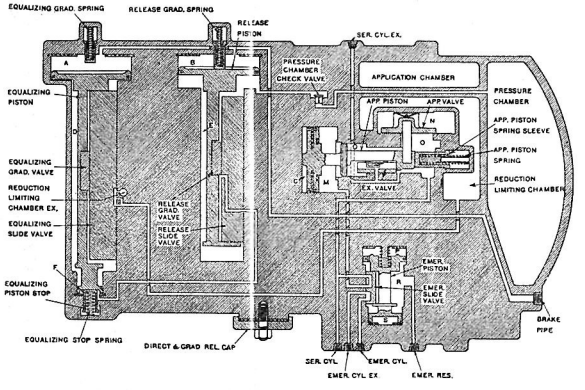

Fig. 25. Preliminary Service Position

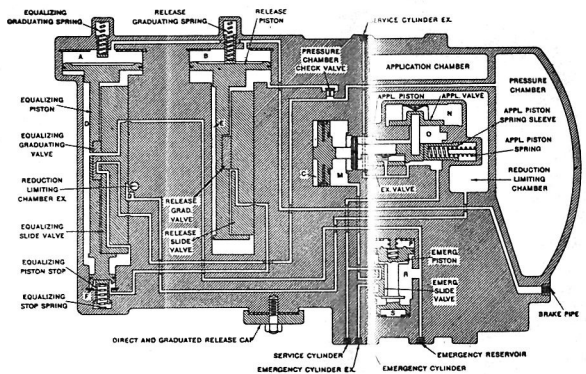

Fig. 26. Secondary Service Position

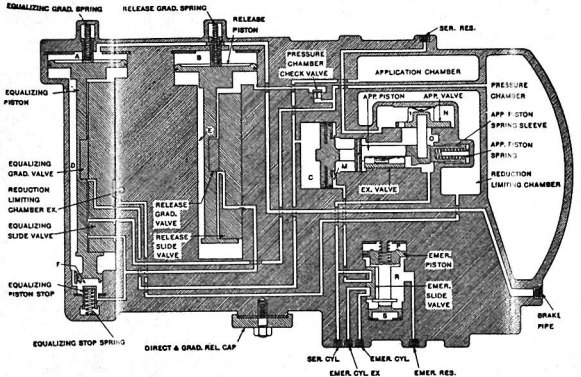

Fig. 27. Service Position

DIAGRAMMATICS OF THE No. 3-E CONTROL VALVE

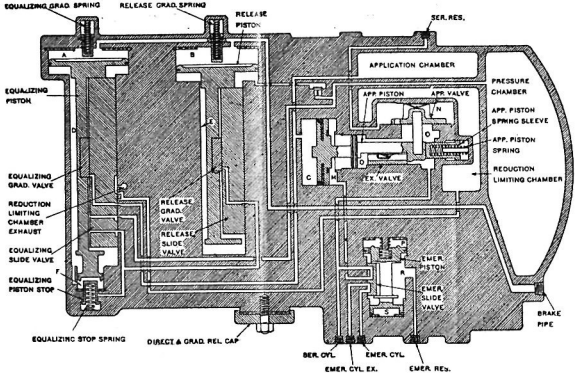

Fig. 28. Service Lap Position

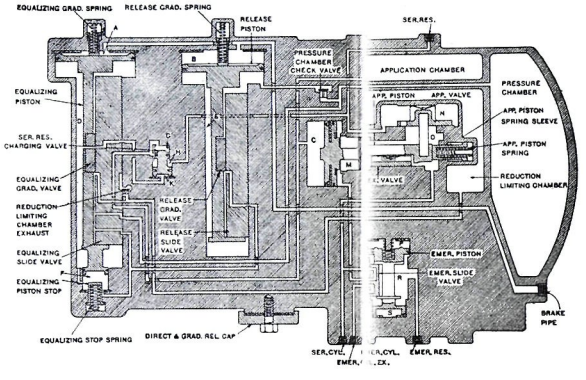

Fig. 29. Over Reduction Position

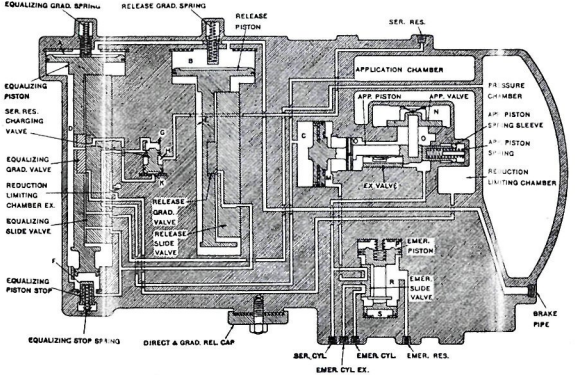

Fig. 30 Over Reduction Lap Position

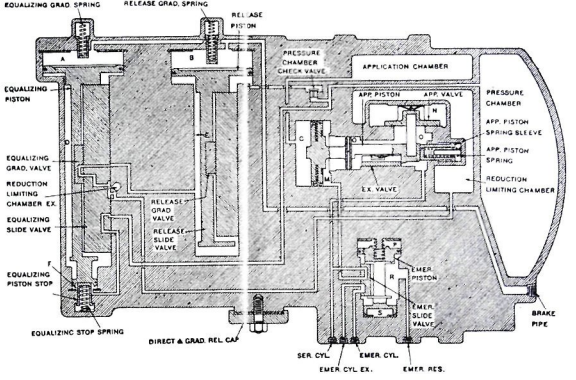

Fig. 31. Preliminary Release Position

DIAGRAMMATICS OF THE 3-E CONTROL VALVE

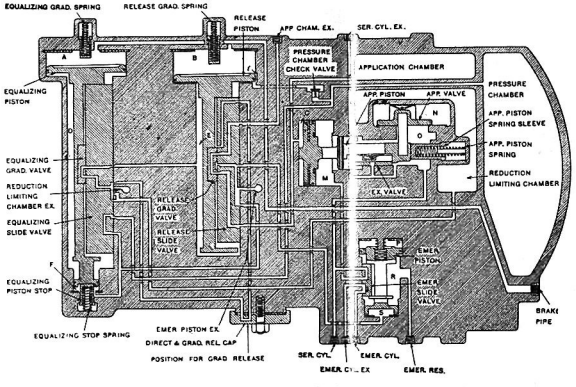

Fig. 32. Secondary Release Position

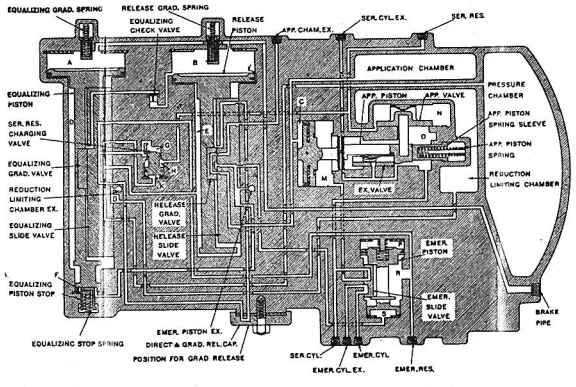

Fig. 33. Graduated Release and Release, Charging Pressure Chamber Only

DIAGRAMMATICS OF THE No. 3-E CONTROL VALVE

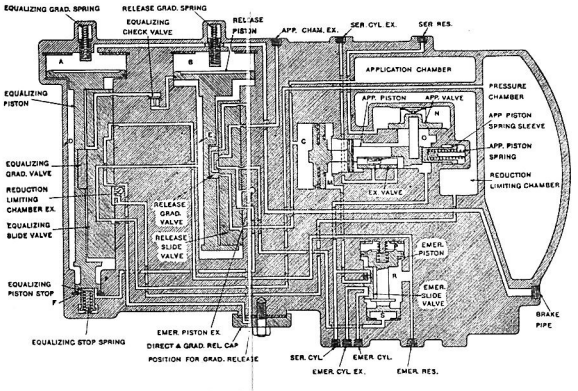

Fig. 34 Graduated Release Lap Position

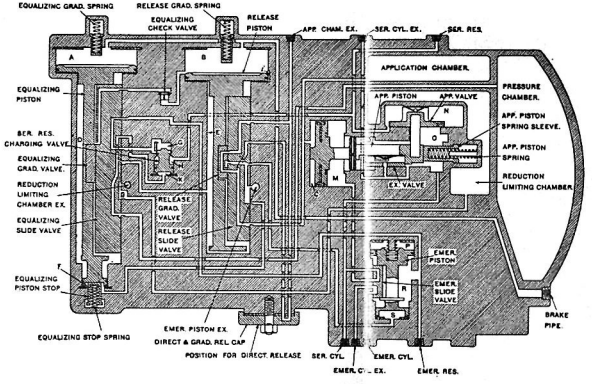

Fig. 35. Direct Release, Charging Pressure Chamber Only

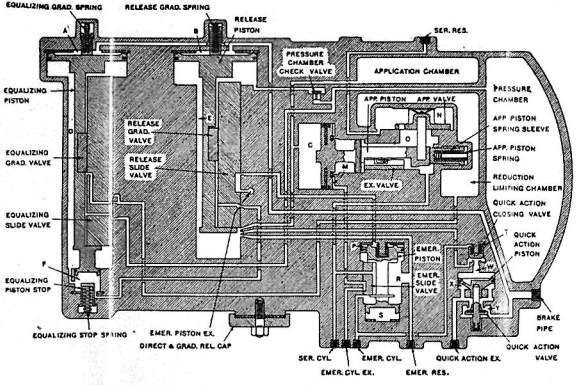

Fig. 36. Emergency Position, Quick Action Valve Venting

DIAGRAMMATICS OF THE No. 3-E CONTROL VALVE

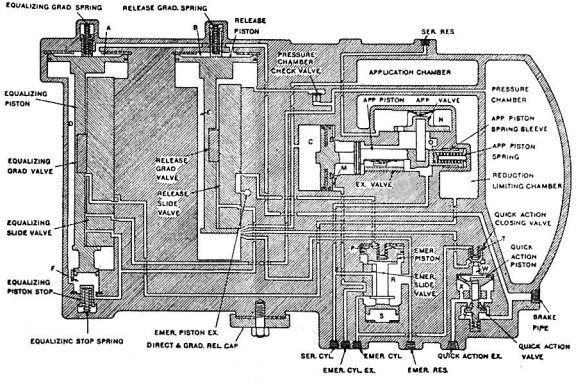

Fig. 37. Emergency Position, Quick Action Valve Closed