DEVELOPMENT OF THE FREIGHT TRIPLE VALVE

1. The original idea of providing a system of brakes that could be applied to all the cars of a train and be under the direct control of the engineer was suggested to George H. Westinghouse in 1866 by a collision between two freight trains. In its beginning, therefore, the brake was regarded merely as a safety device and as such it was brought into use and developed.

The first air brake, namely, the straight-air brake, was applied to a train consisting of a locomotive and four cars. On the first run of this train, the engineer, by a prompt application of the brakes, prevented what would likely have been a serious accident had the train been equipped with any other brake then in existence, thus demonstrating the value of the air brake as a safety device. The control of the train equipped with the straight-air brake was so superior to the control that could be obtained by means of any other brake then in use that the idea of using the brake to control a train made up of more than four cars suggested itself. Accordingly, in September, 1869, a six-car Pennsylvania Railroad train was equipped with the air brake, and in November of the same year a ten-car train was thus equipped. As the brake in most general use at that time was a cumbersome "chain" brake applicable to only four- or five-car trains, the success of the air brake in handling ten-car trains...
at once made it valuable as a dividend earner. The earning power of the air brake consisted in its ability to handle longer, heavier trains at higher safe speeds than was possible with other brakes then in existence.

2. The adoption of the straight-air brake by a number of the leading railroads, on which it was pressed into general service, eventually brought out the serious defects of the air brake and made a further development of it necessary. This resulted, in 1872, in the invention of the plain automatic brake, the triple valve of which made possible the automatic brake of the present day.

The automatic brake was developed during the years 1872 and 1873, and it was so superior to all other forms of brake that it was adopted as the standard for passenger-train service. Up to that time no power brake was in use in freight service, and the attempts to increase the length of freight trains led to numerous accidents and break-in-twos, caused chiefly by lack of proper train control. These accidents led to the belief that the automatic brake could be successfully used in handling long freight trains. To find out whether or not this could be done, the Westinghouse Air Brake Company, in 1882, fitted up a fifty-car train with the plain automatic air brake and took it over the Alleghany Mountains. Tests made on this trial trip clearly demonstrated that the controlling power of this type of brake was sufficient to control the speed of the train even on the heaviest grades.

3. The success of the automatic air brake brought several competitive brake systems into the field, and in 1885 the Master Car Builders' Association appointed a committee to investigate the relative merits of these brake systems as well as to report on the feasibility of controlling a fifty-car freight train by means of a continuous power brake, a point much in controversy at that time. A series of tests with fifty-car trains, known as the "Burlington tests," was begun in 1886 and completed in 1887. The Westinghouse brake and three others were entered in these tests, which clearly demonstrated that none of the brake systems could be
successfully used in every-day service on trains of fifty cars. The Westinghouse brake worked satisfactorily in service applications, but in applying it in emergency the interval between the application of the brake on the first car and last car was so long that the shock caused by the rear cars running into the front cars was terrific.

This necessitated a modification of the plain triple valve for fifty-car freight-train service. Accordingly, in 1887, the quick-action triple valve was brought out. This triple was applied to the fifty-car train, which had been left at Burlington. Tests were made to try out the triples and they were found to be so satisfactory by the railway officials and by the persons conducting the tests that the train was sent on a tour through the Middle West and the East. This tour established the quick-action brake as the standard for both freight and passenger service.

4. As will be noted, the straight-air brake and the plain triple valve were developed for passenger service, whereas the quick-action triple valve was developed for freight service, although eventually it was adopted as standard for both freight and passenger service; also, the quick-action triple was designed and developed for use on trains of fifty cars or less, the fifty-car train to be the maximum. From the very beginning, the length, weight, and speed of trains have been limited by the capacity of the brake for the safe and efficient control of the train. The hauling power of the locomotive has always been a step or two in advance of the brake control; consequently, when the length of the train was limited to fifty cars by the brake control, the tonnage of the train was increased to the hauling power of the locomotive by increasing the capacity of the cars. As the capacity of the cars increased, the braking power on the car was necessarily increased in proportion, as was also the hauling power of the locomotive.

The desire to haul trains of more than fifty cars led to the "part-air train" practice, which consisted in using a sufficient number of the head-end brakes to control the train, the rear-
car brakes not being used. This practice was quite successful, and under it the length of the train gradually increased from fifty to eighty and ninety cars. As fifty or fewer than fifty brakes were in use on such trains, the brake system operated without difficulty and engineers soon learned to control the slack of the non-air cars so as to prevent severe shocks and break-in-twos.

5. Next came the rule to increase the percentage of air-braked cars from time to time, until now it is customary to run all-air trains. As sixty- to eighty-car trains have become a fixed practice, and one-hundred-car trains are not uncommon, the air-brake manufacturers have been kept busy experimenting and improving their apparatus in the endeavor to keep the brake up to the requirements of the service. To control an all-air train of eighty to one hundred cars by means of the brake is a vastly different proposition from controlling an eighty-car part-air train. The length as well as the volume of the brake pipe is practically twice that of the original fifty-car train. Therefore, the difficulty experienced in 1887 in emergency applications with the plain automatic brake is now experienced in service applications of the automatic brake; that is, the interval between the application of the brake on the first car and that on the last car is so great in service applications that if a heavy reduction is made without taking due precautions a terrific shock will be caused by the rear cars running in the amount of the slack and colliding with the front cars held by a good application of the brake. In addition, the recoil of the rear cars after the shock, aided by the action of the compressed springs and the application of the brake taking hold on them, tends to snap the train in two. Another serious difficulty, due to the increased brake-pipe volume (which is twice as great as with a fifty-car train) and to the increased back flow of air into the brake pipe from the auxiliaries, due in turn to the slower reduction, is that the time necessary to make a given brake-pipe reduction is doubled. This makes the time of application twice as long, which makes the application of the rear brakes
more uncertain and very materially lengthens the distance required to make a stop. Every second lost at high speed in getting the brake fully applied adds many feet to the length of the stop.

In releasing brakes, the interval between the release of the first brake and the last brake is so great that the brakes on a good portion of the train release and the slack runs out before the brakes on the rear portion release, tending to break the train in two. Also, the brake is slow in releasing, and the rear brakes are especially slow on account of the increased brake-pipe volume to be discharged and the increased size of the auxiliary reservoirs of the large capacity cars that are taking air from the brake pipe during recharge. As the brakes are slow in applying and releasing, both the danger and the time of making a stop and a start are increased.

The difficulty of brake control increased with the length of the train above the limit of fifty cars. However, the brake manufacturers, profiting by their past experience, foresaw the difficulties ahead and bent their energies to improve the brake apparatus so that it would correct the defects of the quick-action brake. Their efforts were along the lines of a uniform application and a uniform release and recharge of all brakes, for if that object could be attained the brake would safely and efficiently control trains of any practical length. The result of the experiments and tests conducted resulted in an improved type of freight triple valve called the type K triple valve.
DESCRIPTION AND OPERATION

DESCRIPTION OF TYPE K FREIGHT TRIPLE VALVE

6. The Type K freight triple valve is used only in freight service and, as already stated, was designed to meet the conditions brought about by the increase in train speeds, in length of trains, and in car capacities that obtain at the present time. It is made in two sizes, which can be distinguished by the mark K-1 or K-2 on the side of the valve body. The K-1 triple is used with 6- and 8-inch brake cylinders, and the K-2 triple with 10-inch brake cylinders. Another difference between the K-1 and K-2 triples is that the K-1 triple has but two bolt holes while the K-2 triple has three bolt holes in the reservoir flange. The K-1 triple and the F-36 triple are made to bolt to the same reservoir; the K-2 triple and the H-49 triple are to bolt to the same reservoir.

The old type H triple valve that is in general use in freight service was designed for maximum trains of fifty cars of 30-ton capacity. The practice of running trains of greater length and weight necessitated a quicker serial action of the brake in service applications, a retarded release of the head brakes, and a uniform recharge of the head and rear auxiliaries to permit the train to be handled successfully. The K triple valve embodies these additional features as well as all the features of the type H triple.

7. In Figs. 1 and 2 are two side views of the K triple valve that show plainly its outward appearance. Fig. 3 is a vertical section through the valve. It shows half the triple-valve case, with the movable parts in the position they occupy when the triple is in release position, as well as most of the ports and passages.
Fig. 4 shows two views of the slide valve. View (a) shows the top of the slide valve that forms the seat for the graduating valve, and view (b) shows the face of the slide valve. These views represent the slide valve as transparent in order to bring out the relations of the ports, passages, and cavities in the valve.

Fig. 5 is a view of the face of the graduating valve 7, showing the cavity v in the face of the valve. The graduating valve 7 is moved back and forth on the back of the slide valve.

Fig. 6 is a view of the slide-valve seat, showing the ports p, r, t, and y.

Fig. 7 is a view of a portion of the triple-valve body so sectioned and broken away as to show how port y leads from chamber Y to the slide-valve seat.

Figs. 8 to 14, inclusive, are conventional views that show the various ports, passages, cavities, and movable parts on the same plane. Owing to the number of ports in the K triple and to their locations, it is difficult to illustrate the operation of the triple valve by means of true sectional views. Therefore, these conventional views are given to assist in explaining the operation of the triple as well as to simplify the tracing of the flow of air through it. They are not intended to represent the actual appearance of the triple valve.

8. Referring to Fig. 3, the names and numbers of the parts are as follows: 2, valve body; 3, slide valve; 4, triple piston; 6, slide-valve spring; 7, graduating valve; 8, emergency piston; 9, emergency-valve seat; 10, emergency valve; 13, check-valve case; 14, check-valve-case gasket; 15, check-valve; 16, strainer; 17, cylinder cap; 20, graduating-stem nut; 21, graduating stem; 22, graduating spring; 23, cylinder-cap gasket; 24, cylinder-cap bolt and nut; 26, drain plug; 29, retarding-device body; 30, retarding-device screw; 31, retarding stem; 32, retarding-spring collar; 33, retarding spring; and 34, retarding-stem pin.

9. Duty of the Movable Parts.—The movable parts of the triple valve are the triple piston 4, the slide valve 3, the graduating valve 7, the emergency piston 8, the emergency
valve 10, the check-valve 15, the graduating stem 21 and spring 22, the retarding-device stem 31, and the spring 33. The duty of the triple piston 4 is to control the movement of the slide valve 3 and the graduating valve 7 as well as to open and close the feed groove 5.

The slide valve 3 controls the flow of air between the auxiliary reservoir and the brake cylinder, between chamber Y and the auxiliary, between the brake cylinder and the atmosphere, and between the auxiliary and the chamber above the emergency piston. The duty of the slide-valve spring is to hold the slide valve firmly on its seat and thus prevent foreign matter from getting under the valve when there is no air pressure in chamber C.

The graduating valve 7 measures the air admitted from the auxiliary reservoir into the brake cylinder during service applications of the brake; also, its cavity v connects ports o and q in the top of the slide valve and completes the connection for chamber-Y air to pass into the brake cylinder in quick-service position of the triple valve.

The duty of the graduating stem 21 and spring 22 is to prevent the triple piston from moving past full-service position during a service application of the brakes when only a few cars are handled in a train, or past quick-service position when conditions require it.

The duty of the retarding stem 31 and spring 33 is to govern the movement of the triple piston and the slide valve between release and retarded-release position. When the pressure on the brake-pipe side of the triple piston exceeds that on the auxiliary-reservoir side by about 3 pounds, the tension of the retarding spring will be overcome and the triple piston and slide valve will be moved to retarded-release position; as the auxiliary pressure increases and the difference of pressures on the two faces of the piston decreases, the retarding stem and spring will return the triple piston, slide valve, and graduating valve to their full-release position.

10. The duty of the emergency piston 8 is to unseat the emergency valve during an emergency application of the
brakes. It is made to fit loose enough in its bushing to allow the brake-pipe air from chamber \( Y \), after passing through port \( y \), the slide valve, graduating valve, and port \( l \) into the chamber above the emergency piston, to pass by the piston and enter the brake cylinder without forcing the piston downwards.

The duty of the emergency valve \( 10 \) is to prevent brake-pipe air from passing through chamber \( Y \) and chamber \( l \) into the brake cylinder, except when unseated by the emergency piston during an emergency application of the brakes. It is provided with a rubber seat better to prevent leakage past it. The check-valve \( 15 \) prevents brake-cylinder air from passing to the brake pipe whenever brake-cylinder pressure is the greater; also, it allows brake-pipe air to pass to chamber \( Y \) when the pressure in that chamber is reduced by air passing through port \( y \) when the triple valve is in quick-service or full-release position.

11. Duty of Ports and Cavities in Slide Valve and Seat.—Referring to Figs. 3, 4, 5, and 6, it will be seen that service port \( z \) extends through the slide valve; it conveys auxiliary-reservoir air to the brake cylinder through port \( r \) in the slide-valve seat when the valve is in service position. Ports \( z \) and \( r \) fully register when the slide valve is in full-service position, but only partly register when in quick-service position. The opening of the upper end of port \( z \) is controlled by the graduating valve.

Cavity \( n \) is the exhaust cavity, and when the slide valve is in full-release position it connects ports \( p \) and \( r \) in the slide-valve seat and allows the air from the brake cylinder to pass freely to the atmosphere. In retarded-release position, it registers with port \( r \) and conveys brake-cylinder air to groove \( m \) in the face of the slide valve by way of the restricted passage \( x \) in the interior of the slide valve.

Passage \( x \) in the interior of the slide valve connects the cavity \( n \) with the groove \( m \). In retarded-release position, the air, in exhausting from the brake cylinder, has to pass through port \( x \) on its way to the exhaust port. Port \( x \) is made small
so as to retard the escape of brake-cylinder air in retarded-release position sufficiently to make the head brakes on a long train release at about the same instant that the rear brakes release through the cavity \( n \) in the slide valve.

The emergency port \( s \) extends through the slide valve and conveys auxiliary-reservoir air to the brake cylinder during emergency applications, at which time it registers with port \( r \) in the slide-valve seat.

Port \( o \) extends directly through the slide valve and conveys brake-pipe air from port \( y \) in the slide-valve seat to cavity \( v \) in the graduating valve when both valves are in quick-service position.
Port \( q \) extends through the slide valve and conveys brake-pipe air from cavity \( v \) in the graduating valve to port \( i \) in the slide-valve seat, with which it registers in quick-service position.

12. The feed groove \( i \) in both the K-1 and the K-2 triple valve is the same size as that in the F-36 triple valve. Experience has shown this to be the proper size of feed groove to charge the auxiliary reservoir of an 8-inch brake cylinder in a proper manner. At the same time it is not so large as to permit an excessive amount of auxiliary air to feed back into the brake pipe during an application of the brakes before the feed groove is closed. The K-2 triple valve, however, is used with 10-inch brake cylinders; it must therefore have an additional charging port to enable it to take care of the enlarged capacity of the auxiliary that goes with the 10-inch brake cylinder. Port \( j \) is provided in the slide valve of the K-2 triple for that purpose. It conveys brake-pipe air from chamber \( Y \) through port \( y \) to the auxiliary reservoir when the slide valve is in full-release position, thus assisting in promptly recharging the auxiliary reservoir. The combined area of groove \( i \) and port \( j \) is just sufficient to charge the auxiliary reservoir of a 10-inch brake cylinder in practically the same time that feed groove \( i \) will charge the auxiliary of an 8-inch brake equipment.

The removed corner \( b \) extends diagonally across the corner of the slide valve. It is provided so that port \( t \) in the valve seat will be uncovered and thus allow auxiliary-reservoir air to pass to the emergency piston and operate the brake quick action when the slide valve is in emergency position.

Cavity \( v \) in the graduating valve, Fig. 5, connects ports \( o \) and \( q \) in the top of the slide valve to allow brake-pipe air to pass between these two ports on its way to the brake cylinder when the slide valve and the graduating valve are in quick-service position.

13. Port \( t \), Fig. 6, leads from the face of the slide-valve seat to the space above the emergency piston. It is uncovered
by the removed corner \( b \) in the slide valve and conveys auxiliary-reservoir air to this space to operate the emergency piston during emergency applications. In quick-service position, brake-pipe air passes from chamber \( Y \) through the slide valve and graduating valve and port \( t \) to the space above the emergency piston and then past the piston into the
brake cylinder. The emergency piston is not forced down in this position because the air is not supplied through port \( y \) at a rate greater than it can pass by the emergency piston into the brake cylinder.

Port \( y \) in the slide valve seat, Fig. 7, leads to the check-valve chamber \( Y \) and supplies brake-pipe air to the brake cylinder when the slide valve is in quick-service position and to the auxiliary reservoir when the valve is in full-release position.

Port \( r \) in the slide-valve seat is used in all positions of the triple except lap position. In full-service, quick-service, and emergency positions, it conveys auxiliary-reservoir air to the brake cylinder; in full-release and retarded-release positions, it conveys brake-cylinder air to cavity \( n \) in the slide valve on its way to the atmosphere.

14. The retarding device of a K triple when the triple is attached to an auxiliary reservoir extends into the auxiliary reservoir and cannot be seen. The triple then looks like an H triple and can be distinguished from it only by means of the letter K cast on the body of the valve, Fig. 1, and the fin-like lug that is cast on the top of the valve body; these serve as distinguishing marks for the K triples.

The emergency parts of a K triple valve are exactly the same as those of an H triple and are interchangeable with them. The service parts differ somewhat. The slide valve, seat, and graduating valve of the K triple are different from those of the H triple; also, the K triple has a retarding device and its valve body and check-valve case differ from the H triple valve.

In an emergency application of the brakes, the K triple valve operates exactly the same as the H triple. In service applications, however, the K triple valve includes the quick-service feature. Also, in releasing brakes it includes the retarded- or uniform-release, and the uniform-recharge features that the H triple does not possess.

15. Quick-Service Feature.—The object of the quick-service feature is to quicken the serial application of
the brakes on long trains, so as to reduce the interval between the application of the first and the last brakes. This is accomplished by each triple valve venting brake-pipe air momentarily through a restricted passage into the brake cylinder, thus producing at each triple a slight brake-pipe reduction that is quickly transmitted from car to car throughout the brake pipe in a manner similar to a quick-action application. With a train of all K triple valves, this feature reduces the time of application about one-half that required by H triples; applies the brakes more uniformly throughout the train; insures the application of all the brakes with light brake-pipe reductions; gives a higher brake-cylinder pressure, increasing the brake-cylinder pressure about 1 pound on equalization with standard piston travel; and effects a considerable saving in air. By venting brake-pipe air into the brake cylinders, the K triple reduces the time of discharge of brake-pipe air from the brake-valve exhaust for a given reduction about half the time necessary with H triples.

The quick-service feature operates only on trains of such lengths that the volume of the brake pipe is too large for brake-pipe pressure to be reduced at the proper rate through the brake-valve exhaust. If the reduction can be made at the proper rate, as with short trains, the quick-service feature automatically becomes inoperative.

16. Retarded- or Uniform-Release Feature.—To release the brakes, main-reservoir pressure is thrown into the brake pipe, so as to cause a wave of pressure to flow from the head end toward the rear. The head triples feel the impulse first and move to release position quite an interval before the rear triples. They cannot be prevented from going to release position first; therefore, the only way to get a uniform release of the brakes throughout the train is to restrict the exhaust port of the head triples and retard the exhaust of brake-cylinder air sufficiently to permit the head and rear brakes to let go at about the same instant.

The object of the retarded- or uniform-release feature is to retard the exhaust from the brake cylinders of the head
brakes so as to make the release of the brakes more uniform throughout the train. With H triples, the head brakes begin to release first. After a 15-pound reduction on an eighty-car train, they fully release 30 seconds before the rear brakes. With K triples, the head triples move to release position first, but about the first thirty triples are forced past normal release to retarded-release position and their brake cylinders release through a restricted port; only the rear triples move to normal release position and exhaust through the full size of the exhaust port. The relative sizes of the restricted and normal exhaust ports are such that the head and rear triples exhaust their brake cylinders in approximately the same time; consequently, the brakes release uniformly throughout the train and in less than half the time required by H triples. This results in much smoother operation and greatly reduces the shocks and consequent break-in-twos, slid flat wheels, and damage to equipment and lading.

To move a triple valve to retarded-release position, the brake-pipe pressure must be raised about 3 pounds above auxiliary-reservoir pressure. On a long train it has been found impossible to obtain this difference of pressure beyond about thirty cars back of the engine; consequently, the triple valves beyond that point do not go to retarded-release position.

17. Uniform-Recharge Feature.—The object of the uniform-recharge feature is to increase the rate of rise of brake-pipe pressure in the rear end and to make the auxiliary reservoirs throughout the train recharge at approximately the same rate, thus insuring a more prompt action of the rear-end brakes and preventing the head brakes from reapplying when the brake valve is moved to running position. When H triple valves are used, all the feed-grooves are of the same size; consequently, the head auxiliaries overcharge on account of the higher brake-pipe pressure they are subjected to with the brake valve in release position. Thus, when the brake valve is moved to running position, the pressure in the head end of the brake pipe drops until it equalizes with
the lower pressure in the rear end of the brake pipe and the head-end brakes reapply.

With K triple valves, the feed groove \( f \) (located in the ridge on the back of the triple piston) through which the auxiliary charges when the triple is in retarded-release position, is about half as large as the feed groove \( i \), used when the triple is in normal release position; consequently, the head-end auxiliaries charge through a restricted opening that compensates for the higher brake-pipe pressure in the head end and permits more of the air passing into the brake pipe to flow to the rear end of the train, charging the brake pipe to a higher pressure and releasing and recharging the brakes more promptly.

In releasing the brakes, the pressure in the head end of the train rises much more rapidly and to a higher pressure than in the rear end. This is due to the head end being nearer the supply of air, to the frictional resistance offered to the flow of the air by the brake pipe, and to the fact that each triple valve starts to recharge its auxiliary the moment it moves to release position. The primary object of the uniform-recharge feature, therefore, is to increase the rate of rise of brake-pipe pressure toward the rear end, thereby obtaining a quicker release and recharge of the rear brakes; this results in shortening the time necessary to release all brakes, in a more uniform release of all brakes, and in a more uniform and quicker recharge of all auxiliaries.

**OPERATION OF TYPE K FREIGHT TRIPLE VALVES**

18. Full-Release and Charging Position.—When the engineer's brake valve is placed in full-release or running position, the air entering the brake pipe raises the pressure in chamber \( B \) above that in the slide-valve chamber \( C \) and the auxiliary reservoir, and moves the triple piston, slide valve, and graduating valve to the right. If brake-pipe pressure in chamber \( B \) does not exceed the auxiliary-reservoir pressure in chamber \( C \) by 3 pounds, as is usually the case on all cars back of the thirtieth car of a long train, the retarded-release stem and spring will stop the triple piston and slide valve
in full-release position, as shown in Fig. 8. When in this position, the feed groove \( i \) in the triple-piston bushing is uncovered and brake-pipe air passes through it past the triple piston and charges the auxiliary reservoir; also, port \( j \) in the slide valve registers with port \( y \) in the slide-valve seat and conveys air from chamber \( Y \) to the slide-valve chamber, thus assisting in charging the auxiliary reservoir, the check-valve \( 15 \) being unseated by brake-pipe pressure while air is passing through port \( y \) to the auxiliary reservoir.

Cavity \( n \) in the slide valve fully connects ports \( r \) and \( p \) so that brake-cylinder air can escape freely to the atmosphere.

Air flows from the brake pipe through feed groove \( i \) into the auxiliary until the pressures equalize and the auxiliary reservoir is fully charged. Air flows through port \( y \) into the auxiliary until the pressures are equalized near enough for the check-valve spring to seat the check-valve, after which the auxiliary charges through the feed groove \( i \) alone.

19. Quick-Service Position.—When a service reduction is made in brake-pipe pressure at the brake valve, the pressure in chamber \( B \), on the brake-pipe side of the triple piston, is reduced faster than auxiliary-reservoir pressure can reduce through the feed groove \( i \). This produces a difference of pressure on the two faces of the piston, and when this difference becomes about 2 pounds per square inch, the auxiliary-reservoir pressure in chamber \( C \), being the greater, forces the piston forwards to application position, taking the graduating valve \( 7 \) with it and closing the feed-groove \( i \). This movement of the triple piston first causes the graduating valve to uncover port \( z \) and to connect ports \( q \) and \( o \) in the back of the slide valve through cavity \( v \); then the shoulder on the triple-piston stem engages the slide valve and moves it to application position. If the difference in pressure on the two faces of the triple piston is not sufficient to compress the graduating spring \( 22 \), these parts will be held in quick-service position, as shown in Fig. 9.

In this position, the triple piston is close to or against the graduating stem but does not compress the graduating spring.
The slide valve cuts off the connection between ports $r$ and $p$ so that brake-cylinder pressure cannot pass to the atmosphere; port $s$ in the slide valve partly registers with port $r$ in the seat, and ports $q$ and $o$ in the face of the slide valve register, respectively, with ports $t$ and $y$ in the seat. Auxiliary-reservoir air now flows through ports $s$ and $r$ into the brake cylinder and applies the brakes; also, brake-pipe pressure, raising check-valve 15, passes through ports $y$ and $o$ to cavity $v$ in the graduating valve, then through ports $q$ and $t$ to the chamber above the emergency piston, from which place it can pass the emergency piston, which fits loosely in its cylinder, to the passage $d$ and the brake cylinder. Ports $y$, $o$, and $q$ are so restricted that the flow of air through them, when connected, is not great enough to raise sufficient pressure above the emergency piston to force it down and cause an emergency action of the triple, but the air that passes to the brake cylinder reduces the brake-pipe pressure locally at each triple valve just enough to cause the next triple valve to operate promptly. This local reduction acts to transmit quickly and uniformly the brake-valve reduction from car to car in a manner similar to the serial action during an emergency application, only the amount of the reduction is not so great. As a result of this serial action, the time interval between the operation of the first and last brakes on a long train is only about half for the K triples that it is for the H triples; also, with a long train of K triples, the time required for the air to exhaust from the brake-pipe exhaust valve of the brake valve for a given reduction will be only about half the time required with a train of H triples. The venting of brake-pipe air into the brake cylinder results in a pressure on equalization that is about 1 pound higher.

After the triple piston has moved the slide valve to quick-service position, the slide valve does not move again until the brake is released or a sufficient reduction is made in brake-pipe pressure to move it to full-service or emergency position; the graduating valve controls the quick-service ports $o$ and $q$ in the slide valve, so that they are opened each time the graduating valve opens the service port $s$ and closed
each time the piston moves the graduating valve to lap position.

The quick-service feature of the K triple valve operates only when the brake-pipe reduction is being made at less than the proper rate, as when the train is long. With a short train, the brake valve can reduce brake-pipe pressure as fast as is necessary, and the local reduction is not desirable; hence, under such conditions, the quick-service feature automatically goes out of service by the triple valve going to full-service position.

The tendency of the triple to produce quick action during a service application is guarded against by proportioning the valves and locating the ports so that the service port $z$ will not fully register with port $r$ while port $o$ is connected to port $y$, and any movement tending to compress the graduating spring will increase the opening through port $z$ and decrease the opening through port $y$. This gradually increases the rate of discharge from the auxiliary reservoir, and decreases the rate of discharge from the brake pipe, until port $z$ is opened its full amount and port $y$ is entirely closed.

20. Full-Service Position.—The strength of the graduating spring 22 is such that when the reduction in the brake pipe is being made at the proper rate, the difference in pressure on the triple piston will be great enough to compress the graduating spring sufficiently to permit the slide valve to assume full-service position, as shown in Fig. 10. Thus, as the quick-service feature is not needed, it is automatically cut out of commission by the ports $o$ and $q$ being moved out of register with ports $y$ and $t$.

When the brake-pipe reduction is slower than it should be, as when the train is long, or during moderate reductions, the service port $z$ is opened sufficiently to prevent a difference of pressure from being formed that would compress the graduating spring 22.

With the triple valve in full-service position, ports $z$ and $r$ register fully. The quick-service port $y$ is blanked by the
slide valve so that no brake-pipe air can pass to the brake cylinder through port $\gamma$. The local reduction of brake-pipe pressure at each triple valve is thus prevented because the reduction is being made as fast as desirable at the brake valve, and any local reduction would cause undesired quick action of the brakes. However, the brakes will apply promptly because the service port $\zeta$ is fully open and auxiliary pressure reduces at the same rate as brake-pipe pressure.

21. Lap Position.—The lap position assumed by the triple valve from quick-service position is different from the lap position it assumes from full-service position, as will be seen in Figs. 11 and 12. This is due to the fact that the slide valve is not moved when the piston moves the graduating valve to lap the service ports.

The triple valve is held in service position as long as the brake-pipe reduction continues. When it ceases, auxiliary-reservoir air still flows into the brake cylinder until auxiliary pressure is reduced below brake-pipe pressure sufficiently to cause the triple piston to be moved toward release position and the shoulder of the stem comes in contact with the slide valve. The difference in pressure necessary to move the piston and graduating valve is not sufficient to overcome the friction of the slide valve, so that further movement of the piston is stopped by the slide valve.

When the piston starts to lap position from quick-service position, the parts come to rest in quick-service lap position. In this position the graduating valve $\gamma$ closes the top end of ports $\alpha$ and $\zeta$ so that no more air can pass to the brake cylinder either from the auxiliary reservoir through port $\zeta$ or from the brake pipe through port $\gamma$.

If the triple valve is in full-service position when the reduction of brake-pipe air at the brake valve ceases, it will assume lap position in the manner just explained, but the triple piston will be assisted in its movement to lap position by the graduating spring $22$, which was slightly compressed, and the piston will be stopped in full-service lap position, instead of in quick-service lap position.
22. Second Reduction During a Service Application.—When a second reduction is made by the engineer's brake valve, the triple piston will move from lap to service position and take the graduating valve with it. The slide valve, being already either in quick-service or in full-service position, will not move. This will again open the service ports and the auxiliary-reservoir air will pass into the brake cylinder. When the brake-pipe reduction has ceased, and the auxiliary-reservoir pressure in chamber C has reduced below the brake-pipe pressure in chamber B, the triple piston and graduating valve will be moved to lap position in the same manner as after the first reduction. These reductions may be continued until the brake is fully applied by the auxiliary-reservoir and brake-cylinder pressure equalizing. When this occurs, the triple piston will remain in service position and will not return to lap position. A further reduction in brake-pipe pressure will cause the piston to move to emergency position, but will not apply the brake harder and will only be a waste of brake-pipe air. A brake-pipe reduction of about 20 pounds from a pressure of 70 pounds will give equalization.

23. Retarded-Release Position.—If, when releasing the brakes, the brake-pipe pressure in chamber B is 3 pounds or more in excess of the auxiliary-reservoir pressure in the slide-valve chamber C of the triple valve, as is usually the case on the head cars of a train, the triple piston, instead of stopping when it strikes the retarding stem 31, will compress the retarding spring 33 and move to retarded-release position, Fig. 13, taking the slide and graduating valves with it.

When in this position, the ridge on the back of the triple piston is against the end of the slide-valve bushing, with which it makes an air-tight joint except at the feed groove j. Brake-pipe air from chamber B therefore passes the triple piston through the feed groove i, thence through feed groove j to chamber C and the auxiliary reservoir. As the feed groove j has only about half the area of feed groove i, the auxiliary reservoir will be recharged much more slowly.
when the triple valve is in retarded-release position than when it is in full-release position.

Port \( y \) in the slide-valve seat is covered by the slide valve in retarded-release position, so that the auxiliary reservoir can get no air from that source.

Cavity \( n \) in the slide valve registers with port \( r \) in the seat, and groove \( m \) in the slide-valve face, Fig. 4 (b), registers with the exhaust port \( p \), and since cavity \( n \) and the groove \( m \) are connected by the restricted passage \( x \) through the body of the slide valve, brake-cylinder air will escape very slowly to the exhaust port and the atmosphere. When the difference of pressure between the brake-pipe and auxiliary reservoir is less than the tension of the retarded-release spring by an amount sufficient to compensate for the friction of the parts, the triple piston and slide valve will be moved back to full-release position by the spring.

24. Emergency Position.—When a heavy and sudden reduction of brake-pipe pressure is made by the brake valve or in some other way, the pressure on the brake-pipe side of the triple piston also reduces suddenly and the greater auxiliary-reservoir pressure forces the triple piston forwards to emergency position, Fig. 14. The triple piston moves the slide valve 3 and the graduating valve 7 with it. The graduating spring 22 is compressed and the triple piston is forced tightly against gasket 23, making an air-tight joint with it. When the slide valve 3 is in this position, the service ports do not register. The removed corner \( b \) of the slide valve, Fig. 4, is over port \( i \) in the slide-valve seat, so that auxiliary-reservoir air flashes down on top of the emergency piston 8 faster than it can pass by the piston, and the piston 8 therefore is forced down and unseats the emergency valve 10. This allows the air in chamber \( Y \) to escape into the brake cylinder; then, brake-pipe pressure raises the check-valve 15 and brake-pipe air flashes into the brake cylinder. This creates a local reduction of brake-pipe pressure at the triple valve that causes the next triple valve to apply quick action, and so on throughout the train. The emergency port \( s \) in
the slide valve, Fig. 4, which is never covered by the graduating valve, now registers with port r in the slide-valve seat and conveys auxiliary-reservoir air to the brake cylinder. The check-valve 15 seats about the time that brake-pipe and brake-cylinder pressures have nearly equalized, and it thus prevents the escape of brake-cylinder air to the brake pipe. The emergency valve 10 is forced to its seat by the check-valve spring when the brake-cylinder and auxiliary-reservoir pressures have nearly equalized. The joint made by the triple piston being forced against the gasket 23 prevents any air that may pass by the triple-piston packing ring from escaping into the brake pipe.

DEFECTS AND CARE OF EQUIPMENT

DEFECTS OF THE K TRIPLE VALVE

25. Brake Applies Quick Action.—If the triple valve applies its brake quick action during a service application it may be due to: (1) a dirty condition of the triple valve or (2) to a weak or broken graduating spring 22.

1. Dirty Triple Valve.—A dirty triple valve is the most frequent cause of a brake applying quick action during a service application. The gum and dirt will hold the triple piston when the first brake-pipe reduction is made, but when the difference of pressure between the auxiliary and brake pipe is great enough to loosen the piston from the gum and dirt, it will travel rapidly to emergency position and apply its brake quick action, and the heavy local reduction of brake-pipe pressure at this triple valve will cause the others to apply quick action also, or at least cause them to apply in full.

2. Weak or Broken Graduating Spring 22.—A weak or broken graduating spring 22 will cause trouble on a short train but may not cause any trouble on a long one. When the train is short, the brake-pipe volume is smaller than when the train is long, and its pressure can reduce through the brake-pipe exhaust port at the brake valve faster than
auxiliary-reservoir pressure can be reduced through the service port \( z \) in the triple valve. When this difference of pressure is great enough, auxiliary-reservoir pressure will force the triple piston and slide valve to emergency position and apply the brakes quick action. On a long train, where the brake-pipe volume is greater, brake-pipe pressure may not reduce faster through the brake-pipe exhaust port at the brake valve and the quick-service ports in the triple valves than auxiliary-reservoir pressure can reduce through the service port \( z \) in the triple valve; consequently, a weak or broken graduating spring may cause no trouble. But, if the train is not very long, a triple valve with a weak or broken graduating spring may assume full-service position that would otherwise assume quick-service position.

26. Blow at Triple-Valve Exhaust Port.—A blow at the triple exhaust port may be caused by either a brake-pipe or an auxiliary-reservoir leak. The brake-pipe leak may be due to a defective emergency valve or a leak past the gasket 14. An auxiliary leak may be caused by a leaky slide valve \( 3 \), a leaky gasket 25 allowing air to feed into passage \( d \), Fig. 3, or a leaky auxiliary tube \( b \).

To test for the leaks, proceed as follows: With the brake system charged, close the cut-out cock in the cross-over pipe, and if the brake applies, it indicates a brake-pipe leak. This may occur past the emergency valve 10 or the check-valve-case gasket 14. If the blow continues and the brake does not apply, it is probably due to a leak from the auxiliary. Open the cut-out cock, and apply the brake lightly; if the blow continues, it indicates a leaky slide valve. If the blow ceases, the slide valve is tight, and the cause of the blow should be sought elsewhere.

To test for an auxiliary-reservoir leak, leave the brake applied for a few minutes to see whether it will release or not. It probably will release; provided the leak from the auxiliary reservoir is greater than can be supplied by the leakage of air from the brake pipe into the auxiliary reservoir past the triple piston. If it releases, the source of the leak will usually
be found in the auxiliary tube or gasket 25. The gasket may be removed and examined and the auxiliary tube tested by first removing the auxiliary reservoir. Next, plug one end of the tube b, stand the reservoir on end, and fill the tube with water, allowing it to stand for several minutes. If the tube leaks, it will be indicated by the water lowering in the tube.

If the blow at the triple-exhaust port is caused by a brake-pipe leak, it may be due to a defective emergency valve or to a leak from passage a into chamber l past gasket 14. If either the auxiliary reservoir or the emergency valve leaks, it will be indicated by a humming noise within the valve after the auxiliary has become fully charged. This is caused by the rapid lifting and seating of the check-valve 15 in supplying the leakage from chamber Y through the emergency valve or through port y and the auxiliary leak. When a triple is found to be blowing at the exhaust port, first try jarring the triple lightly near the emergency valve. If this does not stop it, close the angle cocks on both sides of one of the hose connections, part the hose, and apply the brake in emergency by quickly opening the angle cock. If the blow cannot be stopped, and there is not time to make the necessary repairs, cut out that brake and bleed the auxiliary of all pressure.

27. Leaky Check-Valve Case Gasket 14.—If the check-valve case gasket leaks, it will cause a blow at the triple-valve exhaust port when the brakes are released and the triple is in release position, and when the brakes are applied with a light application, it will make them apply harder.

28. Graduating Valve 7 Leaking.—If the graduating valve 7 leaks, it is very apt to cause the brake to release when it has been applied with a light application. This valve controls the passage of air from the auxiliary reservoir to the brake cylinder, and in case it does not entirely close the service port when the triple piston assumes lap position, auxiliary-reservoir pressure will continue to pass to the brake cylinder until brake-pipe pressure exceeds auxiliary-
reservoir pressure sufficiently to move the triple piston to release position.

If the graduating valve leaks so that brake-pipe air can feed through the quick-service ports into the brake cylinder, when the triple is in quick-service lap position, it will permit the brake-pipe pressure to equalize with the brake-cylinder pressure; also, it will tend to delay the release of the brake.

29. Quick-Service Ports Blocked Up.—If the quick-service ports $o$ or $q$ in the slide valve or $y$ in the slide-valve seat should become blocked or obstructed, it would result in a failure of the triple thus affected to vent brake-pipe air into the brake cylinder during a service application, which, on the initial service reductions, would cause the loss of a slight amount of brake-cylinder pressure. In a long train, no material detriment to the action of the brakes will be observed if only a few of the triples in the train have their quick-service ports blocked, and no attempt should be made on the road to remedy such a defect. This defect may be detected while charging an empty auxiliary reservoir by the absence of the buzzing noise caused by brake-pipe air feeding past the check-valve 15.

30. Stopped-Up Exhaust Port.—If the port $x$, Fig. 4, or the restricted portion of the exhaust cavity in the slide valve in the K-1 triple valve, becomes stopped up with dirt, it will prolong unduly the release of its brake, provided the triple is located near the front of the train.

31. Dirty Strainer 16.—A dirty strainer 16 may cause the auxiliary reservoir to charge very slowly and may not allow its brake to apply on account of the reduction being made through it too slowly.

32. Check-Valve 15 Leaking.—A leaky check-valve 15 can do no harm until equalization takes place. When brake-pipe pressure is reduced below the brake-cylinder pressure, air from the brake cylinder feeds into the brake pipe until they equalize, thus reducing brake-cylinder pressure
and in some cases increasing brake-pipe pressure sufficiently to force some triples to release position and release their brakes. This is especially the case on cars on which the brake-piston travel is unusually long, permitting a low equalization between the auxiliary-reservoir and brake-cylinder pressures. In the event of a break in the brake pipe or of a burst hose, the brakes will apply quick action and all the brake-pipe air will escape to the atmosphere. Then, if the check-valve leaks, brake-cylinder air can pass to the brake pipe and the atmosphere and allow the brake to leak off.

33. Slide Valve 3 Leaking.—A leaky slide valve 3 will usually cause a blow at the triple-valve exhaust port whether the brake is applied or not, and will tend to release the brake when applied.

34. Emergency Valve 10 Leaking.—With brakes released, a leak in the emergency valve 10 will cause a constant blow at the triple-valve exhaust port, accompanied frequently by a buzzing noise in the triple valve. When the brakes are applied with a light application, such a leak will allow brake-pipe and brake-cylinder pressure to equalize, and this may cause wheels to slide, especially on a long train having a large volume of brake-pipe air with which to equalize. If the emergency piston becomes cocked, or stuck in its cylinder, it will hold the emergency valve from its seat and permit brake-pipe air to flow past the valve into the brake cylinder and then out through the triple exhaust port to the atmosphere, causing a constant blow and a large waste of air.

35. Gasket 25 Leaking.—Gasket 25 is located at the connection where the triple valve is bolted to the auxiliary reservoir. If it is leaking, auxiliary-reservoir air is apt to feed through the leak into passage $d$ and then to the triple-valve exhaust port and the atmosphere, provided the triple is in release position. When the brake is applied with a light application, this leak will tend to cause it to release.

36. Auxiliary Tube $b$ Leaking.—A leak in auxiliary tube $b$ will cause a blow at the triple-valve exhaust port when
the triple is in release position and will tend to release the brake after it has been applied by a light application.

37. Brake-Cylinder Packing Leather Leaking.—If the packing leather leaks, it will allow the brake to leak off. If it leaks badly, the brake may not apply in service applications but usually will apply in emergency. A brake with this defect should not be cut out, but should be left cut in in order that all available braking power may be had in case of an emergency.

38. Weak or Broken Retarded-Release Spring 33. If the retarded-release spring 33 is weak or broken, it will affect the free release of the brakes. The increase of pressure in the brake pipe when releasing the brakes will hold the triple piston and slide valve in retarded-release position too long if the spring is weak, and indefinitely if the spring is broken. This will also prevent the prompt recharge of the auxiliary reservoir. To remedy this defect, a spring of the proper tension should be applied.

CARE OF EQUIPMENT

39. Cleaning the Brake Cylinder.—To clean a brake cylinder remove the piston and thoroughly clean all parts with kerosene; special care should be taken to get the leakage groove clean. Remove the follower and expander ring and see that the packing leather is soft and in good order. The walls of the cylinder should be greased with a heavy lubricant, and a little lubricant should be put in the expander-ring groove before replacing the ring. Great care must be taken in replacing the expander ring, as it is very apt to get out of place.

40. Cleaning the Triple Valve.—To clean the triple valve, take it apart and immerse the triple piston, slide valve, and graduating valve in kerosene. Clean the emergency valve and piston and the check-valve without oil and examine these parts and see that they are in good condition. Remove
all dirt from the inside of the triple valve, and clean the triple piston and slide-valve bushings and all ports. Clean the strainer located at the connection \( W \) and the one in the branch-pipe tee. If the gaskets are not in good order, they should be replaced by new ones. See that the retarded-release device and the graduating stem and spring are in good order. Then remove the parts from the kerosene, thoroughly clean the triple-piston packing ring without removing it from the piston, and clean all ports, cavities, and passages in the slide and graduating valves. Lubricate the triple-piston packing ring and its bushing, the slide-valve face and seat, and the graduating-valve face and its seat, using oil especially prepared for this purpose. Too much oil will make the triple too sensitive and is apt to cause undesired quick action. After assembling all the parts, test the triple valve on the testing rack.
EXAMINATION QUESTIONS

(1) What important features are embodied in the K—2 triple that are not in the H triple valve?

(2) Where does all the air that enters the brake cylinder come from: (a) when the triple valve is in quick-service position? (b) when it is in full-service position? (c) when it is in emergency position?

(3) Trace the flow of air through the triple valve when it is in quick-service position.

(4) How is the auxiliary reservoir charged: (a) when the K—2 triple valve is in retarded-release position? (b) when it is in full-release position?

(5) What is the duty of the graduating valve?

(6) Trace the flow of air from the brake cylinder to the atmosphere: (a) when the triple valve is in retarded-release position; (b) when it is in full-release position.

(7) What is the duty of the triple-valve piston?

(8) (a) Does the slide valve move every time that the triple piston moves? (b) Can the triple piston move without moving the graduating valve?

(9) (a) With what size of brake cylinder is the K—2 triple valve used? (b) With what size of brake cylinder is the K—1 triple valve used?
(10)  (a) What port is provided in the slide valve of the K-2 triple valve that is not found in the K-1 triple valve?  
(b) Why is this port provided in the K-2 triple valve?  

(11)  (a) What is the duty of the retarded-release stem and spring?  (b) What effect will a broken retarded-release spring have on the operation of the triple valve?  

(12)  What effect will a leaky check-valve 15 have when the brake is applied in full and the brake-pipe pressure is reduced below the pressure at which the auxiliary reservoir and the brake cylinder equalize?  

(13)  What advantages are derived from the retarded-release feature of the triple valve?  

(14)  What are the advantages derived from the quick-service feature of the triple valve?  

(15)  (a) What would be the effect if the quick-service ports of the slide valve or its seat become obstructed?  
(b) How would this defect be indicated?
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