MODERN LOCOMOTIVE BRAKE EQUIPMENT

Performance and Characteristics

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Modern Locomotive Brake Equipment

Performance and Characteristics

Sixty years ago a 50-car freight train having a weight of 2000 tons and running at a speed of 20 mph was considered an outstanding event. The progress made since those days is due to continuous research: research in the fields of motive power, of control, of signals and of track. The contribution of the air brake as a means of train control has been remarkable because every increase in length, weight or speed introduces problems that are magnified out of all proportion with the change. For this reason it has been necessary to periodically engineer entirely new car and locomotive brakes to anticipate and meet the changing conditions of rail transportation.

The full value of improved car brakes can only be obtained if they harmonize with those of the locomotive and tender. By the same token, the benefits provided by modern engine equipments cannot be realized to their maximum extent unless used with car brakes designed for present day operating conditions.

The purpose of this publication is to discuss the features of the No. 8-ET and No. 24-RL locomotive equipments in relation to car brakes and to train handling.

DEVELOPMENT OF THE NO. 8-ET EQUIPMENT

The development of the No. 8-ET equipment extended over a period of years and was introduced in 1934. Some of its features were included in experimental valves installed on locomotives used during the road tests of the AB brake.

The No. 8-ET equipment was designed, not only to meet the same requirements that led to the development and adoption of the AB brake, but also to match the operation of this valve and to improve the braking of conventional passenger trains. We shall find, therefore, that some of the features of the No. 8-ET equipment are beneficial in freight service only, while others are of equal advantage in both passenger and freight service.

NO. 8-ET EQUIPMENT AS COMPARED TO NO. 6-ET EQUIPMENT

The fundamental principles of operation of the No. 8-ET equipment are similar to those of its predecessor the No. 6-ET. All functions of the No. 6-ET are retained in the No. 8-ET altho several have been modified to improve some phase of train handling. In double heading operation the No. 6-ET and No. 8-ET equipments can be used indiscriminately. Charts, that form part of this publication, show relative performance of the two equipments. Specific reference to these charts will be made in the following paragraphs where the special features of the No. 8-ET schedule are discussed.

First Service Feature

This feature is one of the most important because it is so widely used and appreciated in train handling. The principal advantage derived by using the first service position of the brake valve is better slack control, which results in smoother and easier handling of long freight trains, especially in the presence of heavy brake pipe leakage. First service can be divided into three stages: (a) limited reduction at standard rate, (b) continued reduction at a materially reduced rate, (c) maintenance of brake pipe pressure to prevent excessive head end reduction caused by leakage.

The initial brake pipe reduction is automatically limited to about 6 lb from 70 lb brake pipe pressure by connecting the equalizing reservoir into a calibrated volume known as the Reduction Limiting Reservoir. This reduction is just sufficient to start quick service action of the train brakes. If the cars in the train are equipped with AB brakes a minimum application will then propagate thru the train at a speed of about 500 feet per second and a pressure of approximately 10 lb, subject to slight increase in presence of brake pipe leakage, will be obtained in the brake cylinders of each car. If the train is made up of "K" cars the propagation speed would be much slower and a lower and non-uniform brake cylinder pressure would be received. During quick service of the AB valve a small but rapid brake pipe reduction into a measured chamber supplements the brake valve reduction and insures prompt propagation of quick service from one car to the next throughout the train. Further reduction of brake pipe air takes place by momentarily venting the brake pipe into the brake cylinder until the uniform and moderate pressure of about 10 lb is reached. This reference to detailed AB brake performance has been made purposely to show how the operation of the valve interlocks with that of the No. 8-ET equipment and enhances its advantages.

The initial reduction is the opening phase of first service and, by closing the feed groove between each auxiliary reservoir and the brake pipe, it conditions the train for the second stage, in which the brake pipe pressure is reduced at a much slower rate (20 lb in 2 minutes from an initial 70 lb brake pipe pressure). The slow rate of reduction is necessary to limit the rate of brake cylinder pressure development on the front end of the train which, in turn, prevents high differential between front and rear end brake cylinder pressures.

The third stage of first service becomes effective in the presence of substantial brake pipe leakage within permissible limits, or when heavy false gradient is present. Under these conditions the tendency of leakage to produce an excessive reduction is offset by the maintaining feature. More specifically, if the rate of brake pipe pressure drop exceeds the controlled rate of reduction of the equalizing reservoir, feed valve air will be fed into the brake pipe to the extent of holding the drop of brake pipe pressure to the desired, pre-established rate. In this way the natural tendency of brake pipe leakage to increase the brake valve reduction is prevented and the brake cylinder pressure development conforms to that intended by the engineman.

Chart 1 gives a graphic illustration of first service operation. After 14 seconds the curve of brake pipe pressure with respect to car position in the train for the No. 8-ET equipment still conforms to the initial gradient curve, while a 6 lb. reduction curve obtained with the No. 6-ET equipment has sagged due to the "run-away" of front end pressure to the rear. A glance at the brake cylinder curves shows how much more uniform is the braking force with the No. 8-ET as compared to that obtained with the No. 6-ET.

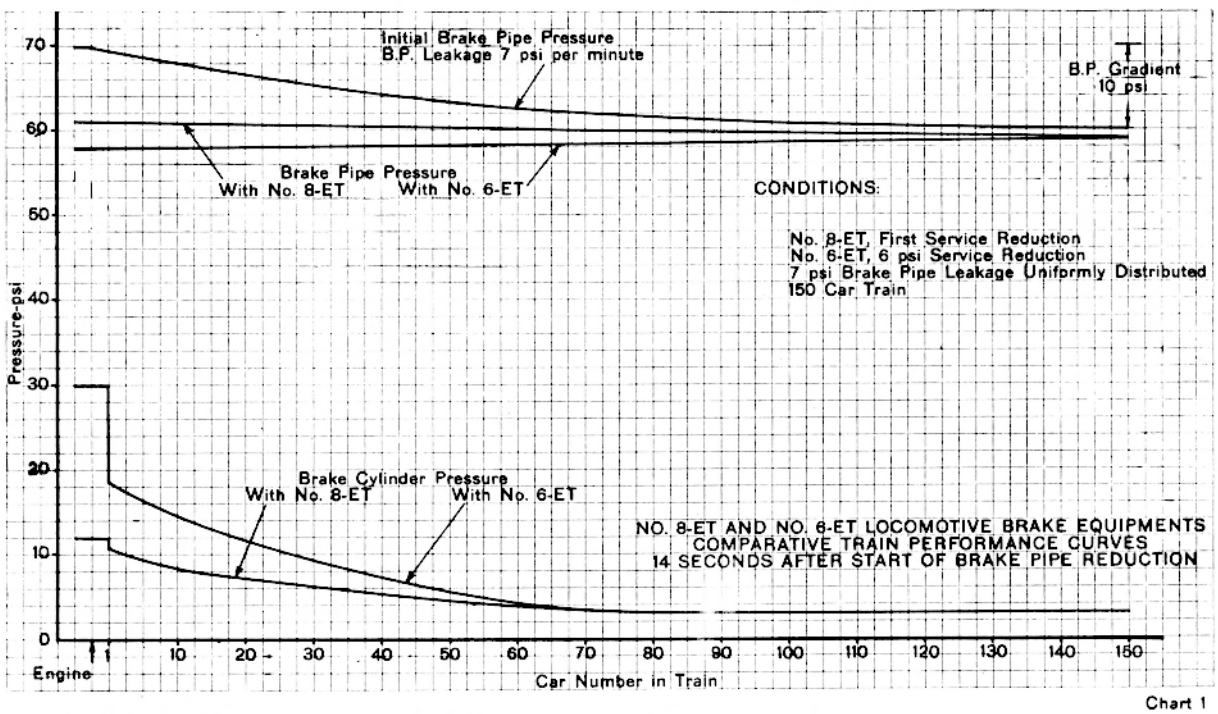

Chart 1

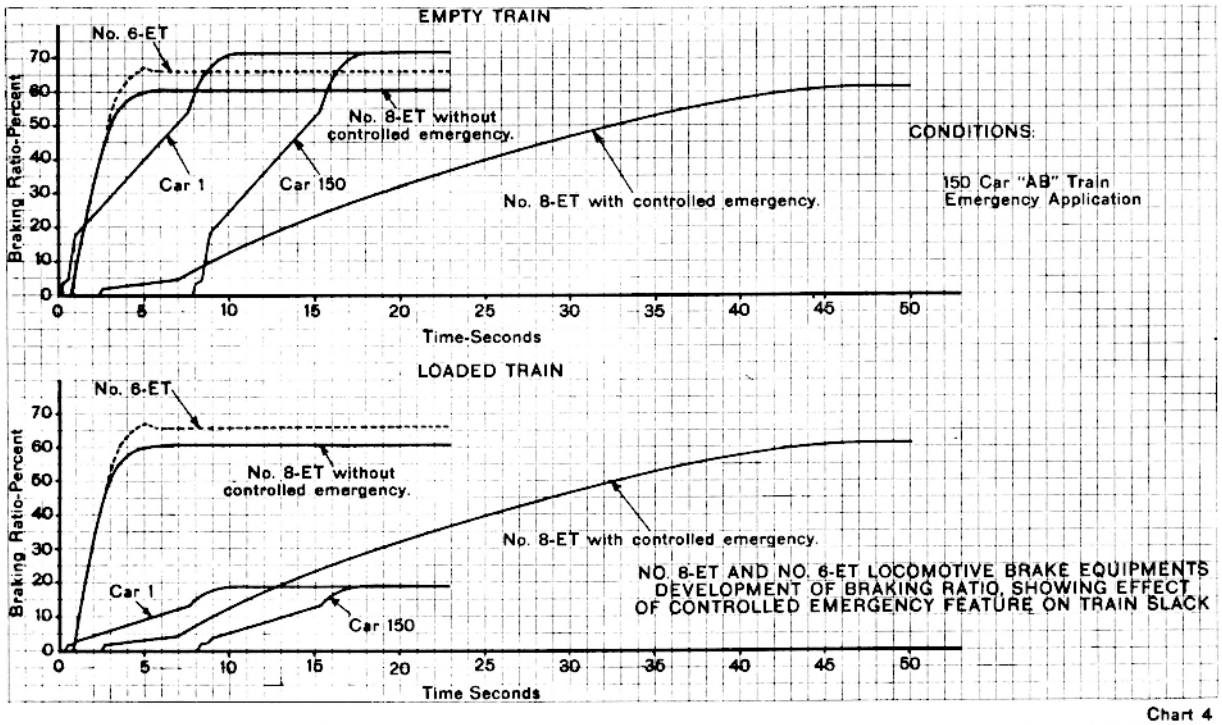

Chart 4

In passenger service and in the handling of short freight trains the problems resulting from slack closure are not nearly as exacting as in the case of long freight trains. It follows that the fast rate of brake cylinder pressure rise obtained in non-controlled emergency is permissible. The retardation of the locomotive and tender in this case is comparable to that obtained in the No. 6-ET equipment and closely parallels that of the front end cars. Chart 4, upper half, shows the development of the emergency braking ratio obtained on a locomotive and tender and on the first and last cars of an empty AB train. Note the difference between the controlled No. 8-ET card as compared to the non-controlled brake cylinder card. The curves which apply to braking ratio with respect to time correspond to the pressure development in the brake cylinders and to the retarding force actually obtained. A study of the chart clearly indicates the advantages resulting from controlled emergency in the case of long trains either empty or loaded. (For curves of loaded train see lower half of chart).

Chart 5 is the same as 4 but applies to a "K" equipped train. A comparison of the car curves illustrates the three stage AB card as opposed to the one stage "K" card and indicates the effective degree of control obtained by the combination of the AB equipment with the controlled emergency feature of the No. 8-ET equipment.

Retarded Recharge of the Pressure Chamber

The possibility of over-charging the pressure chamber and, therefore, dragging brakes during release of long trains is greatly reduced in the No. 8-ET equipment. This is due to the relatively large volume of the pressure chamber and to the slow rate at which this chamber is recharged when the retarded recharge cock is placed in freight position. In passenger service when over-charge is less likely to occur, the cock should be moved to passenger position, in which a faster rate for charging of the pressure chamber is effected. In both cases the charging rate is fixed by the capacity of the charging chokes. Ring leakage past the equalizing piston of the distributing valve cannot greatly affect this rate of charge because the piston seals against a gasket when in retarded recharge position. Further protection is afforded by the reduction chamber in permitting an over-charge of 4 lb before admission of air to the brake cylinders can take place.

Maintained Emergency Pressure

The brake cylinder pressure obtained in emergency is maintained and is under the control of the feed valve and will depend on the relationship between the setting of the feed valve and that of the safety valve. It follows that with higher brake pipe pressure a higher emergency brake cylinder pressure will be received. This condition corresponds with that obtained on the car brakes and, therefore, results in greater uniformity of braking in emergency.

Double Heading

The operation of the second engine of a double header or a helper locomotive is improved in two respects: (a) whenever the train brakes are applied the engineman is warned by an audible blow at the brake valve exhaust, (b) the relay brake pipe vent valve is operated independently of the double heading cock, therefore, to obtain an emergency application the engineman of a second engine merely moves the brake valve handle to emergency position without having to open the double heading cock.

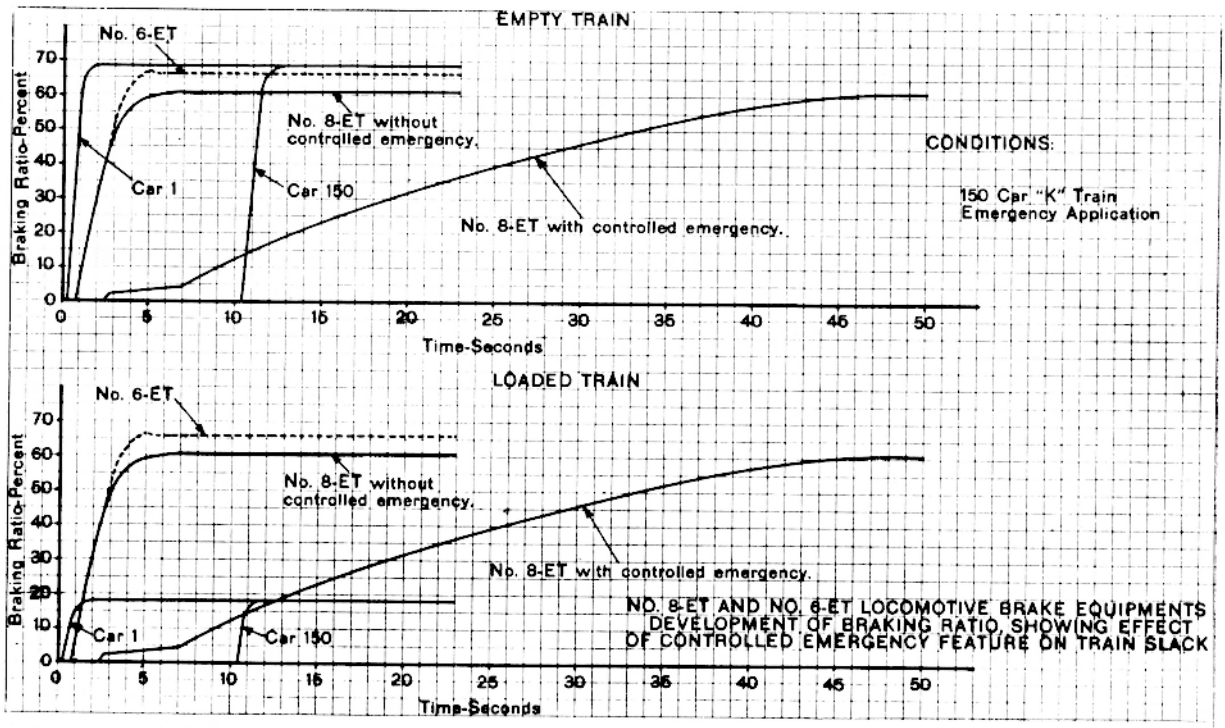

Chart 5

Structural Improvements—Distributing Valve

The application portion has large flow capacity sufficient to handle up to 4,500 cu. in. brake cylinder volume. The operation of this portion is reliable and sensitive to pressure changes due to: (a) the large application piston equipped with two rings, (b) a poppet type application valve which controls the flow of main reservoir air to the brake cylinders, (c) a low frictional load on the exhaust slide valve. Cost of maintenance is low and the trapping of brake cylinder pressure during release is minimized.

The same degree of sensitivity is found in the equalizing portion of the distributing valve due to the large equalizing piston and increased volumes of the pressure and application chambers which materially decrease the effect of piston ring leakage.

Reliability of valve operation and less frequent cleaning periods of the distributing valve are obtained by the use of filters and strainers that form part of the valve structure.

Pipe volume is not critical as it is in earlier equipments. The application and release pipes may be 75 feet long and the rate of the automatic application and release pressures and times remain the same regardless of the length of the application pipe, since they are controlled by chokes in the distributing valve. The release holding feature is not affected by pipe length because the application pipe is charged from the brake cylinder through a choke in the distributing valve.

Breakage of the application cylinder pipe of the No. 6-ET equipment causes failure of the locomotive brakes; breakage of the release pipe causes failure of the independent brake and nullifies holding position. On the other hand, the design of the No. 8-ET equipment reduces the extent of failure caused by the breakage of these pipes. In fact a broken application pipe only causes the loss of the independent brake application and of brake cylinder maintenance in emergency. A broken release pipe merely results in preventing the release of an automatic application with the independent brake valve.

The "dead engine feature" now forms part of the distributing valve. In so doing, a considerable volume of piping is eliminated.

The safety valve used in the No. 8 distributing valve is of the improved E-7 type and it is mounted in a protected location.

Structural Improvements—Brake Valve

The presence of feed valve pressure in the chamber above the rotary valve reduces the resistance of handle movement as compared to that of the earlier types of locomotive brake valves.

A pedestal type of pipe bracket, which forms part of this valve, not only reduces piping and fittings but also simplifies the installation of the auxiliary valves and their maintenance. Pipe leakage is materially reduced because of the pedestal and because of the Wabcotite fittings.

"HSC" LOCOMOTIVE BRAKE EQUIPMENT

The High Speed Control Equipment, as the name implies, was developed strictly for high speed passenger service. Its main characteristic is that it provides electro-pneumatic straight air brake operation and speed governor control in addition to the conventional automatic brake.

Experience has indicated that many advantages are derived by combining the features of the No. 8 and "HSC" equipments. The result was the development of the No. 24-RL equipment, which is discussed in the following pages.

MOST RECENT LOCOMOTIVE BRAKE DEVELOPMENT
NO. 24-RL EQUIPMENT

Reasons for Development

In the early days one locomotive brake equipment was sufficient to meet the needs of all classes of service. This condition had obvious advantages; interchangeability was not a problem, operation and maintenance were relatively simple. As railroad transport progressed and increased in efficiency it became apparent that brake equipments had to meet special requirements depending on the class of service. Their basic principle of operation was always similar but the necessity of additional features often forced the use of entirely new equipments. A typical case in question is the No. 8-ET equipment which was designed for freight and passenger locomotives, however, it is not adapted for the electro-pneumatic brake operation required for the more modern high speed passenger trains. For this type of service it was necessary to design a special equipment, namely, the "HSC", which uses an M-40-A brake valve with a D-22-ER control valve. Another case in question is that of automatic train control systems which usually require the use of a special brake valve although the distributing valve is not affected.

These widely varying conditions led to the design of an all-purpose locomotive equipment adapted to include any of the special features demanded by the various types of service. Such an equipment facilitates the task of the locomotive builders by making installation problems more uniform and more simple. At the same time the railroads benefit by being able to add valve portions to that part of the equipment that is in common to all, and which we refer to as the basic equipment. In so doing a railroad can adapt the brake equipment of a locomotive to whatever use they desire without being forced into an all-out change.

Apart from this most important feature, the No. 24-RL equipment includes essentially all those of the No. 8-ET and "HSC" equipments and others that will be discussed in the following paragraphs.

Controlled Release Position

This position corresponds to the full release position in the H-6 or No. 8 brake valves except that instead of connecting main reservoir pressure directly into the brake pipe, feed valve air is used for charging and recharging. The difference between running and controlled release position is mainly one of port capacity. In running position the amount of feed valve air flowing into the brake pipe is the same as obtained in the No. 8 brake valve for the same conditions. In controlled release position the port capacity is such as to provide 300% more air than in running position, which corresponds to about the same amount of air which flows through the No. 8 and the H-6 brake valves in full release position. It follows that charging and recharging times are not increased when using controlled release position in place of full release. The advantage provided by the former is that over-charge caused by the abuse of main reservoir full release position is eliminated. For the reasons just described the controlled release position will be found to be a decided improvement over the practice now followed by many railroads of using release nullifiers on the brake valve handle or special instructions forbidding the use of main reservoir full release position. The controlled release feature was made possible by the development of the new large capacity feed valve designed especially for this purpose and designated as the D-24 Feed Valve. In addition to large capacity, this valve is more sensitive, reliable and easier to maintain as compared to other feed valves.

The brake valve is furnished with a simple type of manual change-over that converts the

controlled release position into full release position, thereby permitting any railroad to use main reservoir pressure rather than the controlled pressure if they so desire.

Straight Air Operation

When a locomotive is segregated to freight or conventional passenger service the basic D-24 brake valve is used which, functionally, is the same as the No. 8 brake valve. However, when a locomotive may also operate in high speed passenger service a self lapping, pneumatic straight air portion is added between the rotary valve and the top cover to permit electro-pneumatic straight air operation and speed governor control. Thru the manipulation of a changeover lever it is possible to switch from straight air operation back to automatic operation. It follows that, if a locomotive leaves a terminal with a train of streamline cars, braking will be electro-pneumatic, but, if enroute one or more conventional cars are picked up, the engineman can switch over to automatic operation merely by turning the changeover lever. In addition to the straight air portion of the brake valve already mentioned, electro-pneumatic operation requires a master controller, a 21-B magnet valve and a B-3 relay valve or an "F" type relay valve, depending on whether or not the train is equipped with speed governor control. All these devices are separate units and are connected through the piping system to the brake valve and to the control valve, which takes the place of the distributing valve.

To summarize, the basic No. 24-RL equipment can be converted to streamline passenger operation by adding a portion to the brake valve and by the installation of other auxiliary devices without any change in the basic equipment piping.

Safety Control

Safety control will become more common because the No. 24-RL equipment is designed to include this feature with a minimum of extra piping. All that is required is an application portion, which is placed between the filling piece and the brake valve portion, and means to actuate the application portion either with the automatic brake valve handle or through the use of a foot valve. Two different application valves are available, one designed to produce a safety control service application, while the other is designed for emergency applications. The former has two advantages, namely:

1. It can be used as part of the over-speed and train control features, to be discussed later.
2. It will avoid the loss of time incident to the release of an emergency application.

A delay time with warning signal makes the likelihood of an inadvertent or unnecessary safety control application very remote. A 25-30 lb brake cylinder pressure suppresses a safety control application.

Over-Speed Feature

This feature operates in conjunction with a speed governor to limit the maximum train speed. The same service or emergency application portions used for safety control are also used for over-speed and the advantages of using the service portion are the same in this case as those described in the previous paragraph. A magnet and a relay portion form the balance of the equipment and constitute separate valve units. An over-speed application can be suppressed if during the 6 second warning period the engineman makes an application and holds it until the train has dropped below the speed limit.

Train Control

For the past twenty years many railroad divisions have been equipped with one of various types of automatic train control systems. A number of special brake valves were developed in the past for use on locomotives assigned to train

control territory. The No. 24-RL equipment can be readily adapted to receive this feature by adding the service application valve to the D-24 brake valve and by the use of a timing valve and an automatic and straight air suppression valve. The service application valve is the same as used for safety control and over-speed and will function to produce an automatic (non-manual) service application if the engineman fails to acknowledge a change in signal indication to a more restricted one within a specified warning period. The application is automatic in character (not straight air) even if the train is running under straight air brake operation.

Automatic Split Reduction

In stopping a long freight train the engineman usually makes a split reduction in order to better control train slack. Whenever a service application of the brakes takes place without the intervention of the engineman, as in train control, safety control or over-speed operation, the same split reduction can be obtained automatically. A Rotair valve, operated by the engineman, is used as a selector to make the proper port connections for either a split or a straight-away service reduction, depending upon whether the train is long or short. The reduction, either split or straight-away, is limited to full service if the engineman moves the brake valve handle to lap, otherwise an over-reduction is obtained. The valve structure which functions to produce the split reduction is included in the cover of the service application portion already referred to in previous paragraphs.

Self Lapping Independent Brake Valve

A self lapping type of independent brake valve is used with the No. 24-RL equipment instead of the rotary type valve. Many operators prefer the self lapping valve because a single movement increases or decreases the brake cylinder pressure without need of lapping the valve. The self lapping brake valve does not need a reducing valve, therefore, there is no interlock between it and the signal system. When making an independent brake application the self lapping brake valve sustains any drop in application chamber pressure that may take place due to leakage.

Release Reliability

The control valve, that takes the place of the distributing valve in the No. 24-RL equipment, is provided with a release insuring valve similar to the one used in the AB valve. Release insuring functions to release brake cylinder air whenever the brake pipe pressure reaches a value of 2 lb above that of the auxiliary reservoir. Failure to release due to ring leakage is minimized by the relatively large volume of the auxiliary reservoir that forms part of the No. 24-RL equipment. Release reliability is of great importance in multiple unit Diesel operation or whenever a helper locomotive is in the train. In these cases it is essential that the engineman of the leading locomotive be able to rely on the proper release of the brakes of the trailing Diesel units or of the helper locomotive because these may often lack the supervision of an operating crew. In other words, it is highly desirable to provide the locomotive brakes with a degree of release reliability which is as close as possible to that of the car brakes.

Improved Reapplication

A reapplication, such as may be used in a two-application stop, is made more effective with No. 24-RL equipment because the displacement reservoir is depleted together with the brake cylinder at a relatively slow rate. In the case of the No. 8-ET the condition is different because the reduction chamber is independent from the brake cylinder and therefore vents at a faster rate. It follows that in this latter case the reduction limiting reservoir must be replenished before the reapplication becomes effective.

Improved Service Performance

In freight service greater sensitivity to standard rates of brake pipe reduction is required because of the larger brake pipe volumes involved and because of the need to insure applications on helper locomotives at the rear of a long train. Increased sensitivity is provided by the large combined volume of the auxiliary and emergency reservoirs connected to the service slide valve chamber. On the other hand, protection against undesired applications originating from fluctuations of brake pipe pressure is provided by the use of the service piston spring which must be compressed before the feed groove is closed.

In passenger service the smaller brake pipe volume calls for greater service stability. This is obtained because in graduated release operation only the auxiliary reservoir is connected to the service slide valve chamber. Further protection against undesired service applications is afforded by the service piston spring previously referred to.

Dynamic Brake Interlock

The No. 24-RL equipment provides this feature for use on locomotives equipped with dynamic or regenerative braking systems. By the addition of a magnet valve to the control valve pipe bracket it is possible to release or prevent automatic or straight air applications on the locomotive when regenerative locomotive braking is effective. However, the dynamic brake interlock does not interfere in any way with the regular operation of the independent brake valve or of the train brakes.

CONCLUSIONS

We have reviewed the more important features and improvements of modern locomotive brake equipment. In discussing the No. 8-ET equipment frequent comparisons were made between it and the previous standard, the No. 6-ET. In the same way our analysis of the No. 24-RL equipment was based in large measure on the reasons for its development and on the characteristics that it has in common with the No. 8-ET and "HSC" equipments. To summarize the information given, we have listed on the following pages those points that were stressed in the body of the publication and which are, in effect, the essential elements of modern locomotive brake equipment.

NO. 8-ET EQUIPMENT

1. First Service	*Improved control of train slack*
2. Synchronization of locomotive and train brakes	*Smoother train handling*
3. Controlled emergency feature	*Elimination of objectionable shock during emergency applications*
4. Retarded recharge of pressure chamber	*Protection against dragging brakes caused by overcharge*
5. Maintained emergency feature	*Emergency pressure obtained in locomotive brake cylinders function of brake pipe pressure and maintained by feed valve*
6. Audible exhaust on second engine of double header or helper locomotive when train brakes are applied	*Improved train handling*
7. Emergency obtainable from helper locomotive without need of opening the double heading cock	*Increased safety*
8. Large capacity air passages in distributing valve	*Permits handling of greater brake cylinder volume*
9. Poppet valve type of application valve	*More responsive, greater uniformity of operation, reduced cost of maintenance*
10. Application piston equipped with two metallic rings	*Less friction*
11. Large pressure chamber volume	*Decreased sensitivity to equalizing piston ring leakage*
12. Individual strainers protect application and equalizing portions of distributing valve	*More reliable valve performance and reduced cost of maintenance*
13. Application and release pipes may reach 75 feet in length without affecting equipment performance.	*Greater flexibility of installation*
14. Rate of automatic release controlled by choke	*Pipe volume not critical*
15. Improved design so that breakage of application and release pipes do not cause major failure	*Safer train handling*
16. "Dead engine feature" built into distributing valve	*Simpler piping, less chance of leakage*
17. Use of E-7 safety valve	*More reliable operation and easier regulation of safety valve*

18. Feed valve pressure present in rotary valve chamber of automatic brake valve	*Less resistance to handle movement*
19. Pedestal type of brake valve	*Easier installation and minimizes leakage*
20. Use of Wabcotite fittings	*Eliminates pipe breakage and reduces leakage*

NO. 24-RL EQUIPMENT

In addition to the foregoing features the No. 24-RL equipment offers the following:

21. Adapted to all types of railroad locomotive service	*Aids locomotive builders in their design and installation problems and allows railroads to use locomotives for any class of service without change of basic brake equipment*
22. Controlled release	*Eliminates trouble due to improper use of full release position of brake valve*
23. D-24 feed valve	*Large capacity, increased reliability, reduced cost of maintenance*
24. Adapted to straight air electro-pneumatic braking and to speed governor control	*Locomotive can be used in freight service, conventional passenger, or high speed passenger service indiscriminately*
25. Safety control	*Safety control feature available by addition of a proper valve*
26. Over-speed	*Protection provided by addition of valve portions*
27. Train control	*Train control protection available by addition of extra valves*
28. Split reduction	*Automatic split reduction available in train control, safety control, or over-speed operation*
29. Self lapping independent brake valve	*Facilitates and improves independent brake control of locomotive*
30. Improved reapplication	*Greater effectiveness of second application*
31. Improved service performance	*Insures service application on helper locomotives with immunity from brake pipe pressure surges*
32. Dynamic brake interlock	*Interlock of standard locomotive brake equipment with regenerative or dynamic braking of locomotive*

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