RAILTOWN 1897
State Historic Park
Jamestown, California

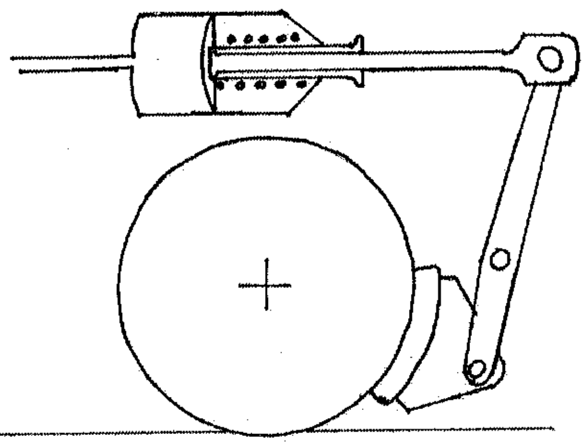
AIR BRAKE & TRAIN HANDLING

MANUAL

CALIFORNIA STATE PARKS SINCE 1864 ®

VERSION 1.1 JANUARY, 2016

AIR BRAKE FUNDAMENTALS



The railroad air brake is a combination of mechanical devices operated by compressed air and controlled pneumatically, which acts to press a brake shoe against a wheel. Its purpose in train handling is to control speed and slack, stop the train and to hold it stopped. It accomplishes this by dissipating the inertial energy of a moving train or locomotive by creating a frictional drag, or retarding force, on the wheels, thus preventing acceleration, reducing the train's speed, stopping its movement, or holding it stopped, as desired.

A BRIEF HISTORY

The first train air brake system was introduced in the mid-1800's, and was known as the "straight air brake". This system utilized an air pipe through the length of the train and flexible connections between each car, called the "brake pipe", which was connected directly to brake cylinders on each car. Using a valve on the locomotive, the Engineer controlled the braking force by raising and lowering air pressure in the brake pipe, and thus in each brake cylinder. This was a tremendous improvement over the previous practice of Brakemen jumping from car to car on a moving train to apply hand brakes. However, the straight air brake had one major limitation: if the train broke in two or if the brake pipe burst or leaked badly, the brakes simply failed to apply. George Westinghouse, inventor of the straight air brake, quickly realized this limitation and developed what he called the "automatic air brake", which functioned on the opposite principle: the brake pipe was charged with compressed air to release the train's brakes, and its pressure was reduced to apply them. The obvious advantage to this system was its fail-safe nature: if the brake system was charged, and brake pipe pressure was lost for any reason, the brakes would automatically apply, not fail. By the late 1800's, all railroads in the US were required by law to equip their trains with automatic air brakes. Though the reliability and features of the modern automatic air brake have improved significantly, it continues to operate on Westinghouse's same basic principle.

OVERVIEW OF SYSTEM FUNCTION

The air brake system on each car must be charged with compressed air in order to function. An air brake system that is not charged is said to be *dry*, and will not function.

The brake pipe is charged with compressed air from the locomotive. A control or "triple" valve on each car senses the increase in brake pipe pressure and charges the auxiliary reservoir and emergency reservoirs on the car from the air in the brake pipe. Any air pressure in the brake cylinder is released to the atmosphere. The brake system is fully charged when pressure in the reservoirs on each car is equal to the pressure in the brake pipe and the brake pipe is charged to the setting of the regulating ("feed") valve on the locomotive.

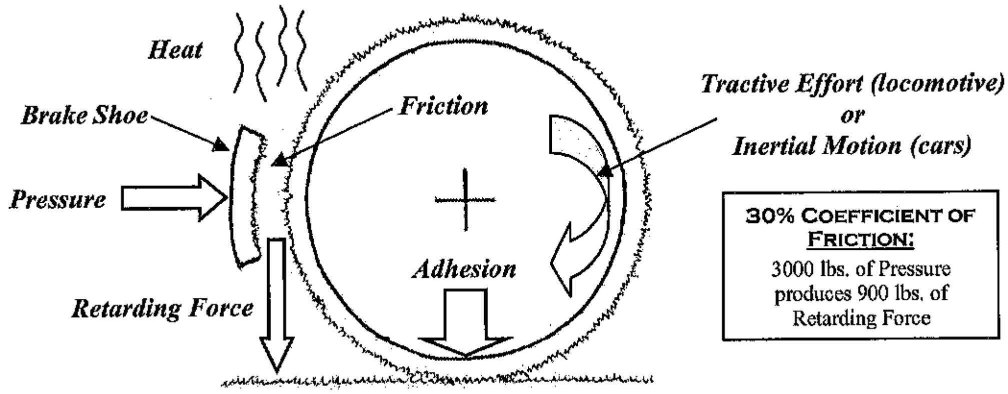
To make a normal brake application, the Engineer makes a *service* reduction of the pressure in the brake pipe using the automatic brake valve. This is also called a *service application,* as the brake pipe pressure is reduced at a controlled, or *service,* rate. On each car, the control valve senses the reduction in brake pipe pressure and directs air from the auxiliary reservoir into the brake cylinder until air pressure in brake pipe and auxiliary reservoir are again approximately equal. This results in a brake application proportionate to the amount of the reduction. Additional service reductions result in proportionate increases in brake cylinder pressure until *full equalization* occurs. This is the point at which pressures in the auxiliary reservoir and the brake cylinder are equal and air will no longer flow between them. Further service reductions beyond this point will not result in increased brake cylinder pressure or braking effort.

To release the brake, the Engineer recharges the brake pipe using the automatic brake valve. Air flows back into the brake pipe increasing brake pipe pressure. On each car, the control valve senses the increase in pressure and responds again by charging the car's air reservoirs and exhausting pressure in the brake cylinder to the atmosphere.

Should the brake pipe pressure drop suddenly at a rapid or uncontrolled rate, an *emergency application* of the brakes will result. This can be in response to the Engineer placing the automatic brake valve in the EMERGENCY position, from the opening of a conductor's valve on a locomotive or car so equipped, from the brake hoses between cars parting or bursting, from a control valve assuming the emergency position during a service application (known as an undesired emergency, or "UDE"), from the opening of an angle cock too quickly when cutting air in on a car, or from any other source which causes a sudden and rapid reduction of brake pipe pressure. When this occurs, most control valve designs respond by connecting both the auxiliary and emergency reservoirs to the brake cylinder, resulting in a higher overall cylinder pressure than can be achieved with a full service application. In addition, most control valve designs open the brake pipe to the atmosphere, reducing the brake pipe pressure even more rapidly and causing the control valves on adjacent cars to assume the emergency position in quick succession. This speeds the emergency application down the length of the train. Once an emergency application has been initiated from any source, there's no stopping it. An emergency application cannot be released until the train has stopped and all control valves reset, a process that can take several minutes.

> **KEY FACT: *Variations* in the brake pipe pressure cause the train brakes to apply or release. The *rate* at which the pressure in the brake pipe drops determines whether a service or an emergency application results.**

FRICTION & ADHESION IN BRAKING



30% COEFFICIENT OF FRICTION:
3000 lbs. of Pressure produces 900 lbs. of Retarding Force

Friction is required to both move and stop a locomotive and train. Friction between the wheel and rail is ***adhesion.*** A locomotive, through its ***tractive effort,*** converts horsepower into pulling power. This tractive effort is limited by adhesion. Likewise, adhesion between a wheel and the rail, combined with friction from a brake shoe, produces a drag force that retards the rotation of the wheels.

Inertial motion is stored energy. Any attempt to retard or dissipate this energy through friction produces heat. Therefore, not only must the railroad braking system produce the required retarding force, it must also dissipate the heat generated by the process. Locomotive and car wheels have a very high capacity to absorb and radiate the heat created by braking. However, under extreme conditions, it is possible to overheat both the wheels and the brake components. This could cause a brake failure, or a failure of the wheel & axle assembly, which could result in a derailment.

Coefficient of Friction is the percentage of the pressure of the brake shoe pressing against the wheel that is converted into *Retarding Force.* Two types of brake shoes are in use today: cast iron and composition. Composition, or "comp" shoes, are common on modern equipment, but can also be found on historical equipment. Cast iron shoes are generally being phased out of use on modern equipment, but are still common on historical equipment. Cast iron and comp shoes have very different braking characteristics. With either style of shoe, the coefficient of friction ***decreases*** as the speed of wheel rotation ***increases.*** Conversely, as the speed of wheel rotation decreases, the coefficient of friction increases. However, with cast iron shoes, the difference in braking effort between higher and lower wheel speeds is significant, whereas with comp shoes this difference is much less. Therefore, with cast iron shoes, a much higher braking force, or heavier brake application, is required at <u>higher</u> wheel speeds, which, if left unadjusted as the speed decreases, would increase in retarding force, most likely to the point of wheel slide. With composition shoes, the difference in friction between higher and lower wheel speeds is not as great, and the braking effort over any range of wheel rotation speeds remains relatively constant.

KEY FACT: Friction between brake shoe & wheel must not exceed the friction between wheel & rail or sliding wheels will result. A sliding wheel delivers less retarding force than a rotating wheel with a brake properly applied, while causing damaging flat spots on the wheel. Wet or bad rail tends to reduce adhesion & can result in sliding wheels unless braking effort is properly managed.

CHARACTERISTICS OF COMPRESSED AIR

Compressed air is measured in pounds per square inch, or "psi". This relates the amount of stored energy in compressed air to the number of pounds it exerts on one square inch of surface area.

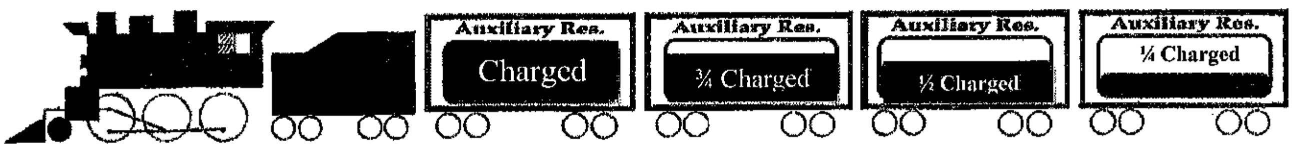
Key Things to Note Are:

- **Compressed air exerts force equally in all directions.**
- **When compressed, air is heated.**
- **As compressed air expands, it will cool.**
- **The pressure of air in a closed container, when heated, will increase.**
- **The pressure of air in a closed container, when cooled, will decrease.**
- **All air contains some amount of moisture in the form of water vapor.**
- **The warmer the air, the greater it's potential to hold water vapor. However, warm air does not automatically contain more moisture.**
- **The cooler the air, the less moisture it can hold. As warm air is cooled, its water vapor will condense into water.**
- **Air "propagates", or travels, through a brake pipe at about 600 feet-per-second.**
- **Air pressure vented from a small opening in a container or vessel is will drop first at the location closest to the vent. Pressure in the rest of the container will tend to remain higher than that in the immediate vicinity of the vent until the vent is closed. At this point the pressure throughout the container will equalize. In an elongated vessel, such as a brake pipe, this characteristic is more pronounced.**

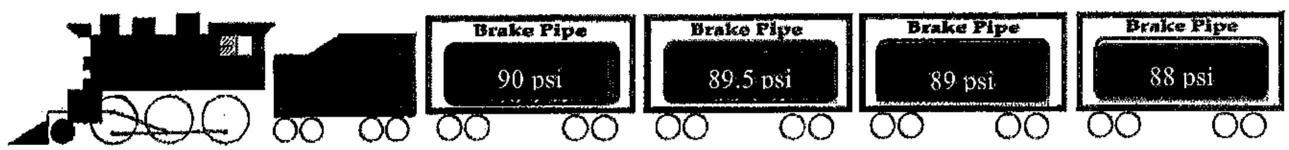
AIR FLOW PROPERTIES

When a charged brake pipe is exhausted from a single source, such as from the locomotive brake valve, air nearest the exhaust point drops in pressure first, followed by the air behind it in the system. This tends to cause the brakes nearest the exhaust to apply first. The brakes farthest from the exhaust port will apply much more slowly. If a brake pipe is vented from several places along its length, the pressure drops much more uniformly and the brakes apply more rapidly and evenly throughout the length of the train.

CHARGING THE BRAKE PIPE:

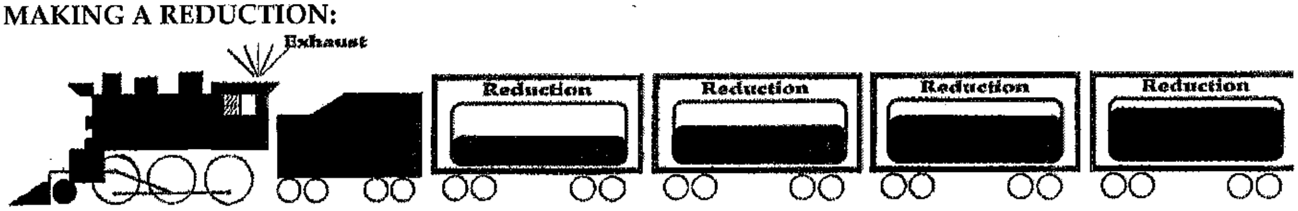


Air flowing into the brake pipe from the locomotive will build pressure on the head end first. This tends to cause the auxiliary reservoirs on the head end to charge faster than those on the rear.



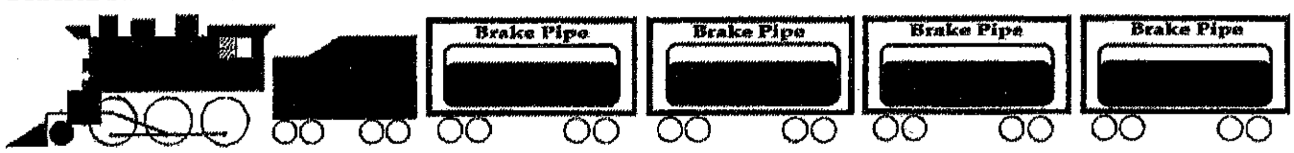
Air pressure rises throughout the length of the brake pipe. On long trains the pressure on the rear will not rise as high as pressure on the head end. The brake pipe is, however, fully charged. This is known as "brake pipe gradient".

MAKING A REDUCTION:



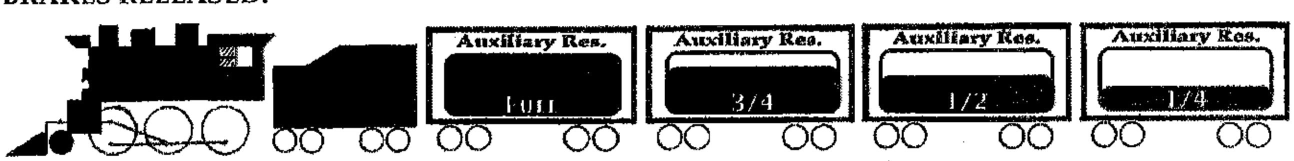
During a brake pipe reduction, air tends to reduce in pressure at the head end first.

BRAKE PIPE PRESSURE REDUCED:



Air pressure equalizes through the length of the brake pipe.

BRAKES RELEASED:

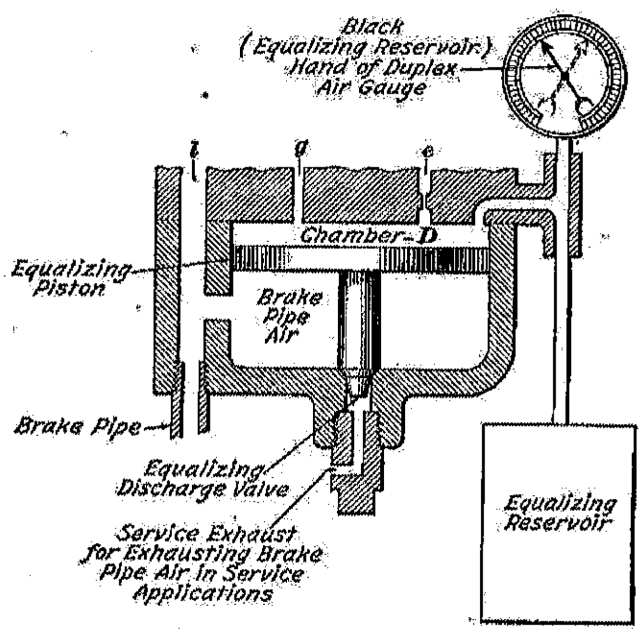


As the brakes are released, the charging process starts again.

EQUALIZING VALVE & RESERVOIR

The earliest versions of the automatic brake valve vented brake pipe air directly to the atmosphere. As train lengths and brake pipe volumes grew, a "bounce-back" effect resulted when the brake valve was closed after making a service reduction. This happened because air flowing down the brake pipe towards the exhaust vent had momentum and when suddenly cut-off, a shock wave would "bounce-back" down the length of the brake pipe. This resulted in brake pipe pressure at the head end of the train rising as it sought to equalize, resulting in the undesired release of brakes on the head end or sometimes the entire train. Westinghouse fixed this problem by adding a small reservoir called the EQUALIZING RESERVOIR (ER) to the system. The ER acts as a "master" volume for the brake pipe and whatever pressure is in the ER is duplicated in the brake pipe. During a service reduction, the automatic brake valve now directly vents air only from the ER. Attached to the ER is an EQUALIZING DISCHARGE VALVE with a tapered exhaust port controlled by an EQUALIZING PISTON. This combination of elements controls the cut-off of air discharging from the brake pipe during a service application so as to absorb the momentum of air rushing towards the exhaust vent and prevents a bounce-back wave of air pressure down the length of the brake pipe.

When making a service brake application, the Engineer now reduces air pressure in the ER, not the brake pipe. The ER volume, being much smaller than the volume of the entire brake pipe, is easier to control than venting air directly from the brake pipe. Reducing the pressure In the ER reduces the pressure in CHAMBER D, over the top of the equalizing piston. The pressure in the brake pipe forces the piston upward, opening the equalizing discharge valve, exhausting brake pipe air to the atmosphere until pressure in the ER, and thus Chamber D, is just slightly higher than that of the brake pipe. This will then force the equalizing piston back downward, closing the equalizing discharge valve. The tapered design of discharge valve slows the velocity of the exhausting air as it closes and prevents any bounce-back from occurring. The larger volume of the brake pipe takes longer to vent than the equalizing reservoir, varying from a few seconds on short trains to a minute or more on longer trains. This difference can be observed on the equalizing reservoir and brake pipe gauges in the cab, and be heard as brake pipe air exhausts from the equalizing discharge valve underneath the brake valve.

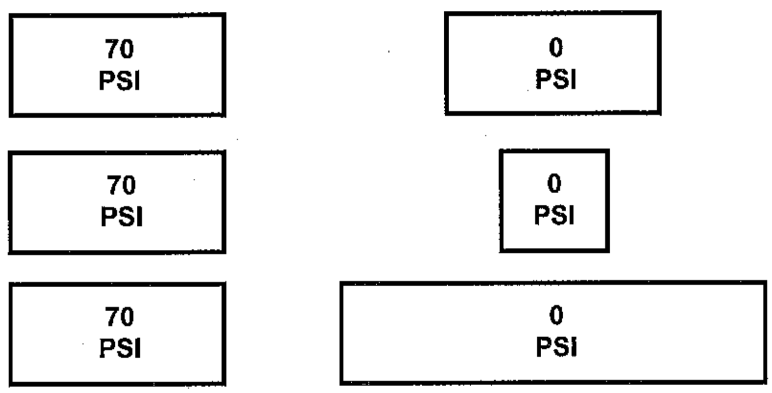


PRINCIPLES OF EQUALIZATION

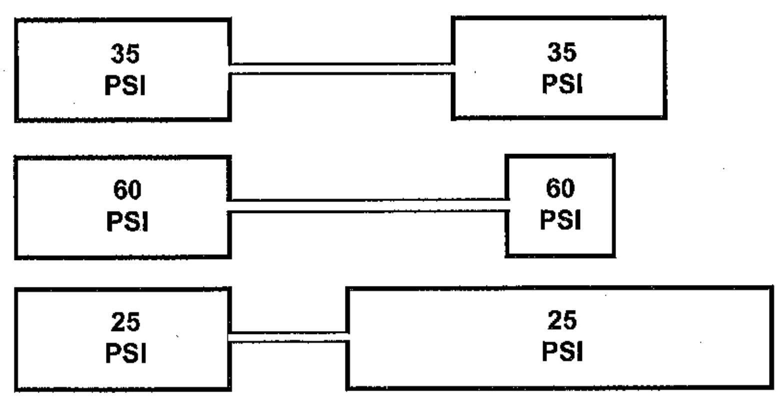
Pressurized air, like water, is a fluid and will flow, always following the path of least resistance from higher pressure to lower. In the study and use of railroad air brakes, atmospheric pressure is always considered to be zero.

Equalization is the point at which air pressures in two connected volumes are equal, and air will not flow from one volume to the other. The pressure at which equalization will occur is directly related to the comparative sizes of the volumes and the original pressures of the two volumes.

Three pairs of volumes are illustrated below. Each volume on the left is charged to 70 psi. The volumes on the right contain zero psi and are not connected to the charged volumes on the left. In the top pair, the volumes are of equal size; in the middle, the empty volume is one-half the size of the charged volume; in the bottom example, the empty volume is twice the size of the charged one:

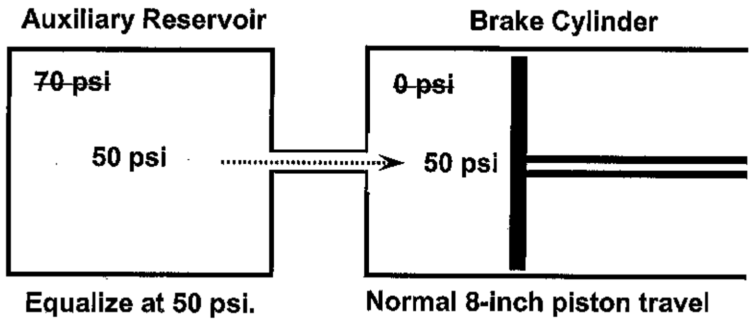


When the pairs are connected, air flows from the higher pressure in the charged volume to the lower pressure in the empty volume until *equalization* occurs. Note on the illustration at which pressures equalization occurs: only when the volumes are the same size does equalization occur at half the original pressure. When a larger volume flows to a smaller volume, equalization occurs at higher pressure; when a smaller volume flows to larger one, equalization occurs at a pressure lower than half the original pressure:

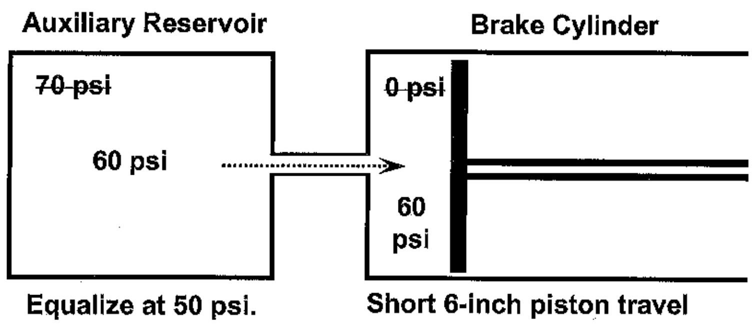


EFFECTS OF PISTON TRAVEL ON EQUALIZATION

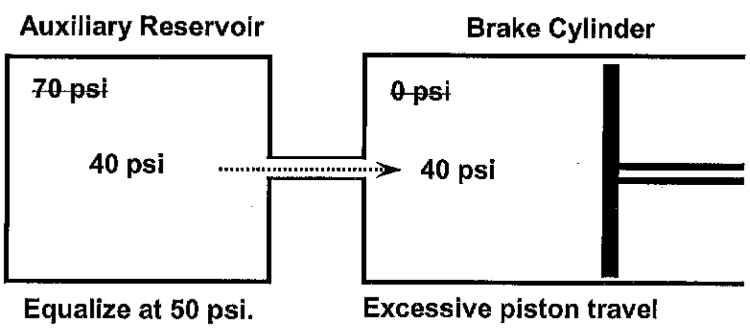
Considering the principles of equalization, and the relationship in size between the auxiliary reservoir and the brake cylinder, it is evident that the length of cylinder piston travel will affect the pressure at which the brake cylinder and auxiliary reservoir will equalize. Assume a beginning brake pipe pressure, and thus auxiliary reservoir pressure, of 70 psi.



At the standard brake cylinder piston travel of eight inches, full equalization occurs at 50 psi. This means that with a full service brake application, the maximum brake cylinder pressure from a 70-psi brake pipe will be 50-psi. This is the intended result, and the car's foundation brake rigging is engineered to maximize brake performance around this figure.



Now picture a piston travel that is adjusted too short. That same 70-psi brake pipe, and thus auxiliary reservoir pressure, will result in a brake cylinder pressure of 60-psi. This creates a greater braking effort than intended for the circumstances, and could result in sliding wheels.

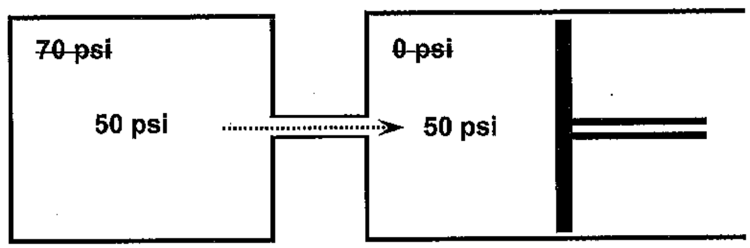


If piston travel is adjusted too long, the exact opposite will occur. For any given brake pipe reduction, the brake cylinder pressure will be lower than normal, and the resulting braking effort will be degraded.

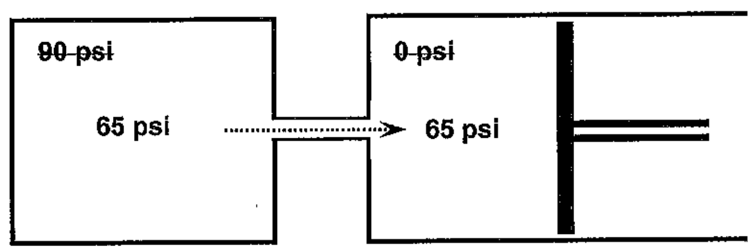
EFFECTS OF BRAKE PIPE PRESSURE ON EQUALIZATION

As we have seen, the pressure at which equalization occurs varies based on the relationship of size between the two volumes. "Full equalization" is the point at which pressures in the the two volumes, in our case the auxiliary reservoir and the brake cylinder, are equal and air will no longer flow between them. Normally, full equalization results from a *full service reduction* of the brake pipe. At this point, further service reductions in brake pipe pressure will not result in increased brake cylinder pressure or braking effort. But what happens if we increase the pressure of the brake pipe, and thus the pressure in the auxiliary reservoir? Assuming normal piston travel, the following will be true:

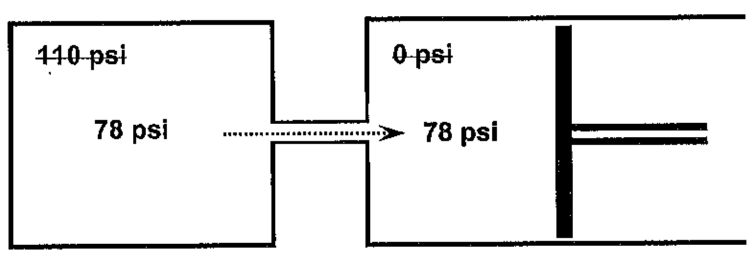
From a brake pipe pressure of 70-psi, full equalization is achieved with a 20-psi brake pipe reduction and results in a maximum service brake cylinder pressure of 50-psi.



By increasing the brake pipe pressure to 90-psi, full equalization will now occur with a 26-psi reduction, and result in a maximum service brake cylinder pressure of 65-psi. This is a braking effort increase of about 30% over a 70-psi brake pipe.



Further increasing brake pipe pressure to 110-psi now results in a full equalization pressure of 78-psi. This is achieved with a 32-psi reduction in brake pipe pressure. This is approximately a 20% increase in braking effort over a 90-psi brake pipe.

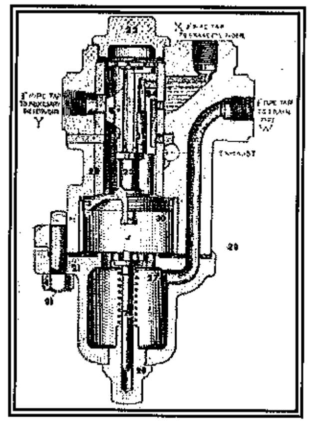


Note that for any brake pipe pressure of 70 psi or higher, the brake cylinder pressure developed with normal piston travel will be 2.5 times the amount of the reduction, up to the point of full equalization. As the setting of the brake pipe pressure in increased, the pressure at which full equalization occurs also increases, and thus the total brake cylinder pressure available for service braking. However, regardless of brake pipe pressure, the 2.5 x (amount of reduction) formula remains constant for service braking. This means that a 5, 10 or 20-psi reduction will always produce the same brake cylinder pressure, regardless of the operating brake pipe pressure.

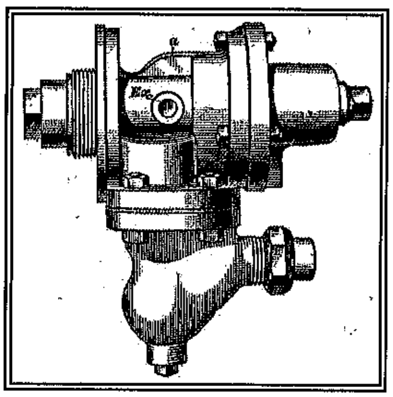
AIR BRAKE SYSTEM COMPONENTS

CONTROL VALVES

To apply and release the brakes and charge a train's air brake system, each car and locomotive is equipped with a CONTROL VALVE, sometimes known as a "Triple Valve" on older equipment. The term "Triple Valve" refers to the three functions it performs: charge, apply and release the brakes. As triple valve design and function advanced, it evolved into two or more "portions" mounted on a manifold known as a "pipe bracket", all of which became known as a "control valve". The brain of the railroad air brake, the triple or control valve automatically senses changes in brake pipe pressure and responds by charging, applying & releasing the brakes.



PLAIN TRIPLE (right): The first widely successful control valve, the "plain triple" performed only the basic functions of charging, applying and releasing the brakes. As train lengths grew, the plain triple suffered from an inability to apply and release the brakes uniformly on long trains. Brakes tended to set up quickly on the head end, but more slowly on the rear end, and release on the head end first, while brakes on the rear released slowly. This often resulted in severe undesirable slack action.



SCHEDULE K (left & below): K-type brake equipment was developed around 1900 in response to demands placed on air brake performance by growing train lengths. It was a significant improvement over the plain triple in that it "propagates", or speeds the rate at which a reduction travels the length of the brake pipe by venting a small portion of brake pipe air to the atmosphere during an initial service brake application. This is known as "quick service", and applies the brakes more quickly and evenly through the train. The K also slows the release of brakes on the head end of a train to better match the slower release rate of brakes on the rear. These features reduced undesired slack action and improved train handling. In a significant safety improvement, the K-valve also introduced higher brake cylinder pressure in an emergency application by venting brake pipe air directly into the brake cylinder to combine with the auxiliary reservoir volume. This increases brake cylinder pressure in emergency over that achievable in a full-service application, and speeds the emergency application down the train. K equipment is characterized by its single unit configuration (right), although its components can also be applied separately. While used on some passenger equipment, Schedule K was designed primarily for use on freight trains.

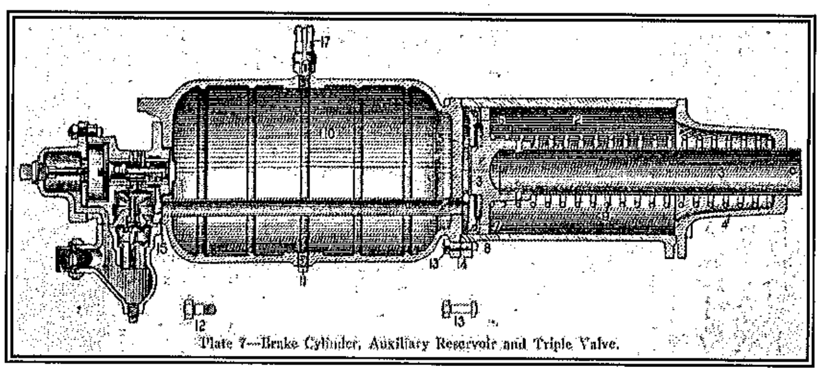


Plate 7—Brake Cylinder, Auxiliary Reservoir and Triple Valve.

SCHEDULE LN:

Last of the "Triple Valve" designs, LN was derived from the K-style valve but developed for use on passenger equipment. It introduced advanced features making it suitable for passenger train use, most notably GRADUATED RELEASE. It also has a QUICK ACTION feature and higher brake cylinder pressure in emergency. "Graduated Release" is the ability of the triple valve to modulate or "graduate" the brakes off, as well as on. However, this feature is not used on freight equipment.

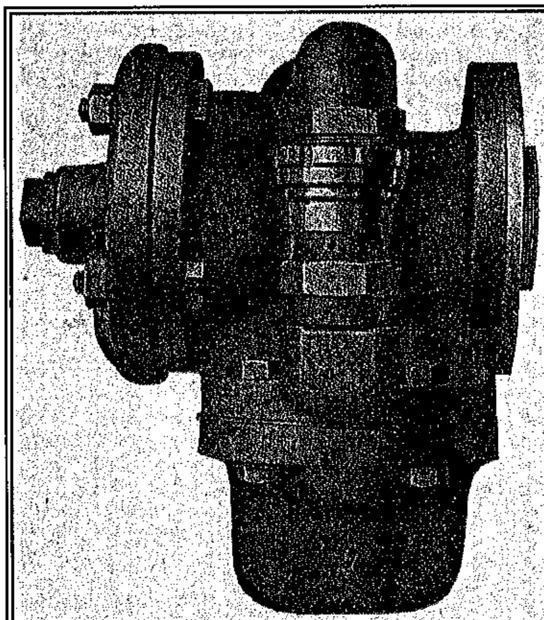


Fig. 1—The Type L Triple Valve.

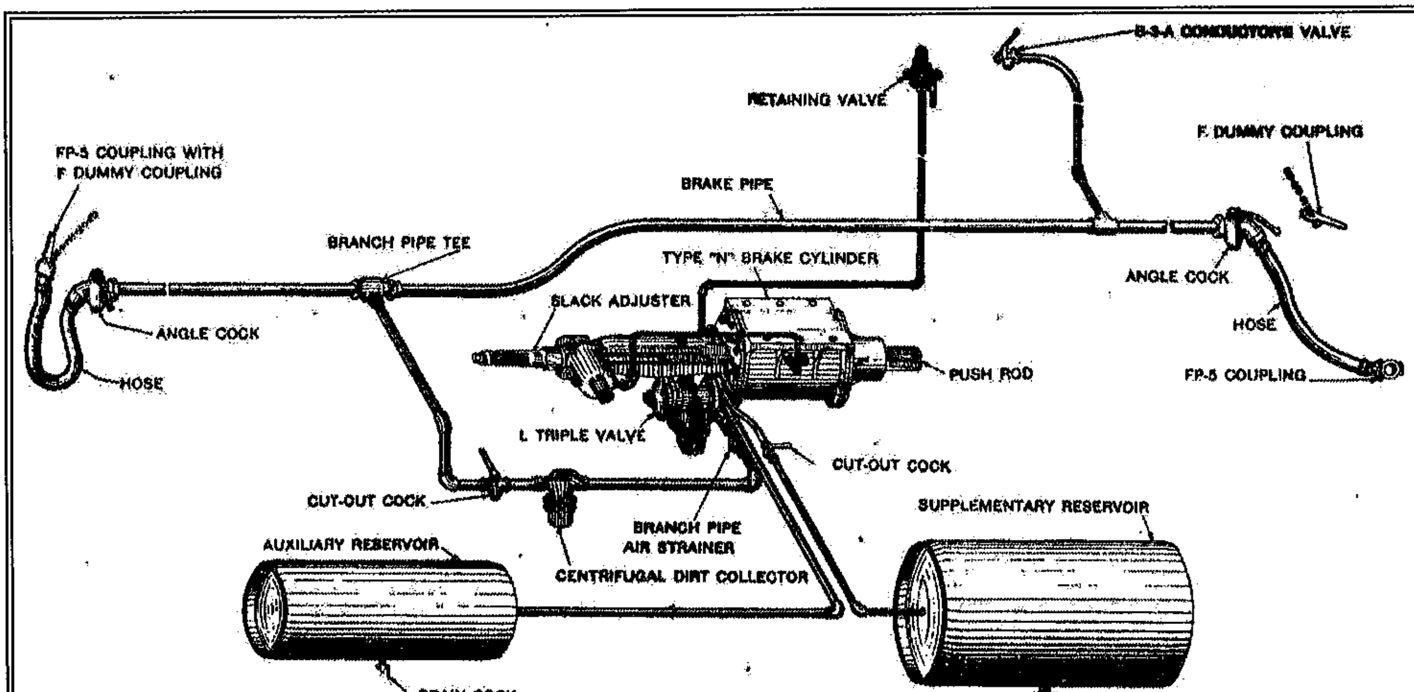


Fig. 14

LN Brake Equipment Piping Diagram.

SCHEDULE UC:

UC is one of the most common types of air brake equipment found on historic passenger cars. It is the first design to utilize the CONTROL VALVE concept, where several separate components combine to perform the functions of the "triple valve", plus a number of other more advanced features. Its innovative features include QUICK SERVICE, QUICK ACTION, selectable GRADUATED RELEASE, rapid recharge to allow for quick release and reapplications of the brake, and depletion protection, which reduces the possibility of air brake failure due to depletion of auxiliary reservoir pressure.

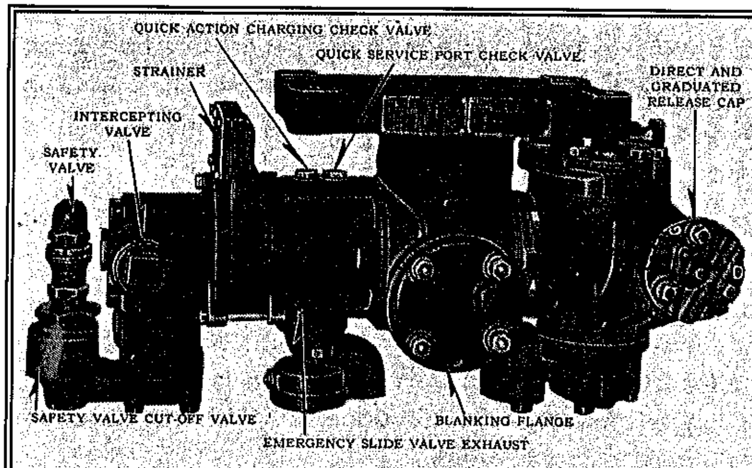


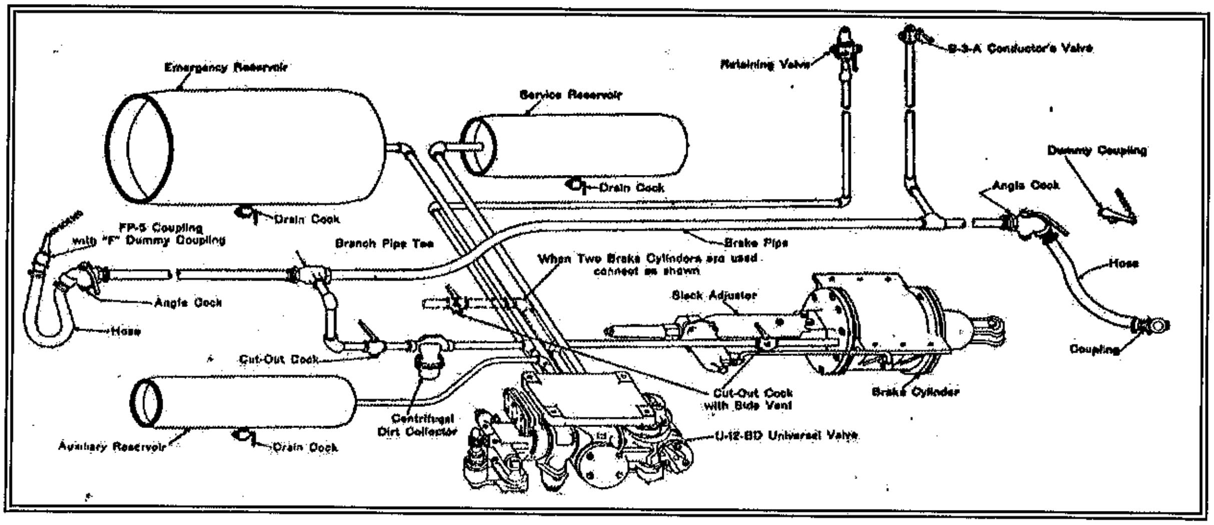
Fig. 2. View of the U-12-BD Universal Valve, Showing Various Details

Quick Service *vents a small amount of brake pipe air to the atmosphere during an initial service application, which speeds the application down the length of the train.*

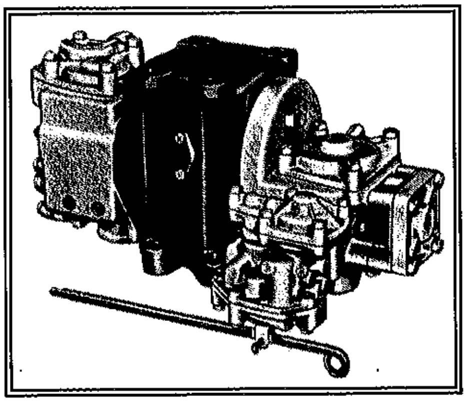
Quick Action *opens the brake pipe directly to atmosphere during an emergency application, rapidly depleting the brake pipe pressure to obtain a quick emergency application through the entire train. The emergency reservoir is also connected to the auxiliary reservoir volume, which results in a higher brake cylinder pressure from an emergency application than is possible with a full-service brake application.*

Graduated Release, *when enabled, permits the incremental brake release, as well as application.*

Depletion Protection *automatically initiates an emergency application if the brake pipe pressure drops below approximately 50 psi. This is intended to protect the train should the brake system become depleted through leakage or, a more likely scenario, over cycling the brakes. Over cycling can deplete auxiliary reservoir pressure if insufficient time is allowed to recharge the system between brake applications. UC is the <u>only</u> equipment with this feature.*



AB-TYPE BRAKE EQUIPMENT:



AB - type control valves are the genesis of modern freight car air brakes. Though applied primarily on freight equipment built after WW II, AB brake equipment is sometimes applied on passenger equipment in tourist or demonstration train operations. AB consists of three portions:

PIPE BRACKET: to which the service and emergency portions are bolted.

SERVICE PORTION: controls the desired charging of the reservoirs and the service application and release of the brakes. Attached to the service portion is the release valve, which permits manual reduction or depletion of the auxiliary and emergency reservoirs.

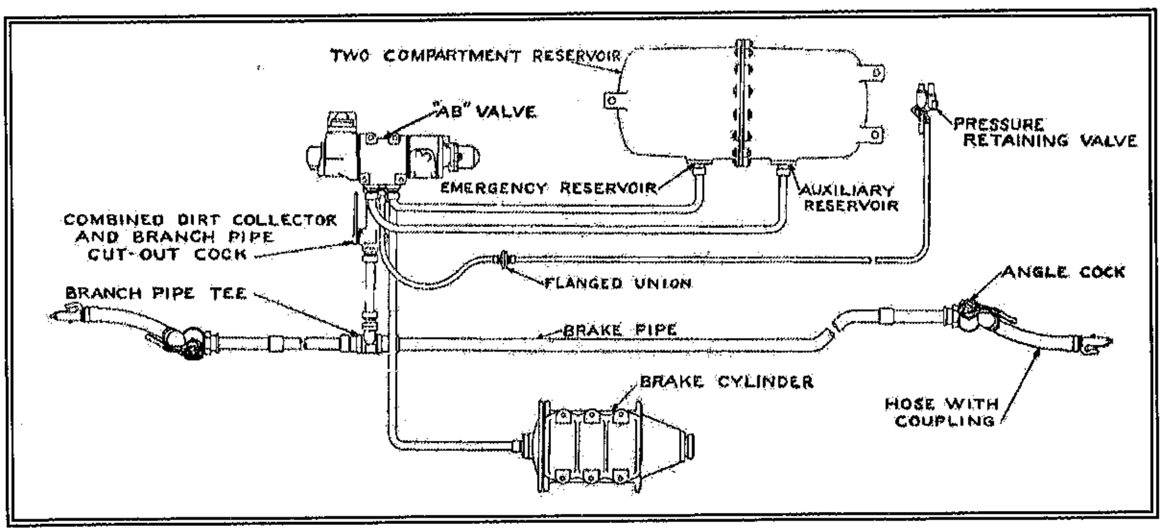
EMERGENCY PORTION: controls the emergency application of the brakes and the **Quick Action** feature, which opens the brake pipe to the atmosphere during an emergency application. It also combines both compartments of the combined auxiliary and emergency reservoirs to give a higher brake cylinder pressure in emergency.

AB equipment introduced or further developed a number of significant improvements over previous triple valve designs, including:

Improved Quick Service: ensures a prompt response to service applications. During initial service applications, the AB valve vents a small amount of brake pipe pressure to the atmosphere, resulting in an even and quick application down a long train.

Combined Auxiliary & Emergency Reservoir: Combines the service reservoir and emergency reservoir functions into a single, unitized reservoir with two separate chambers.

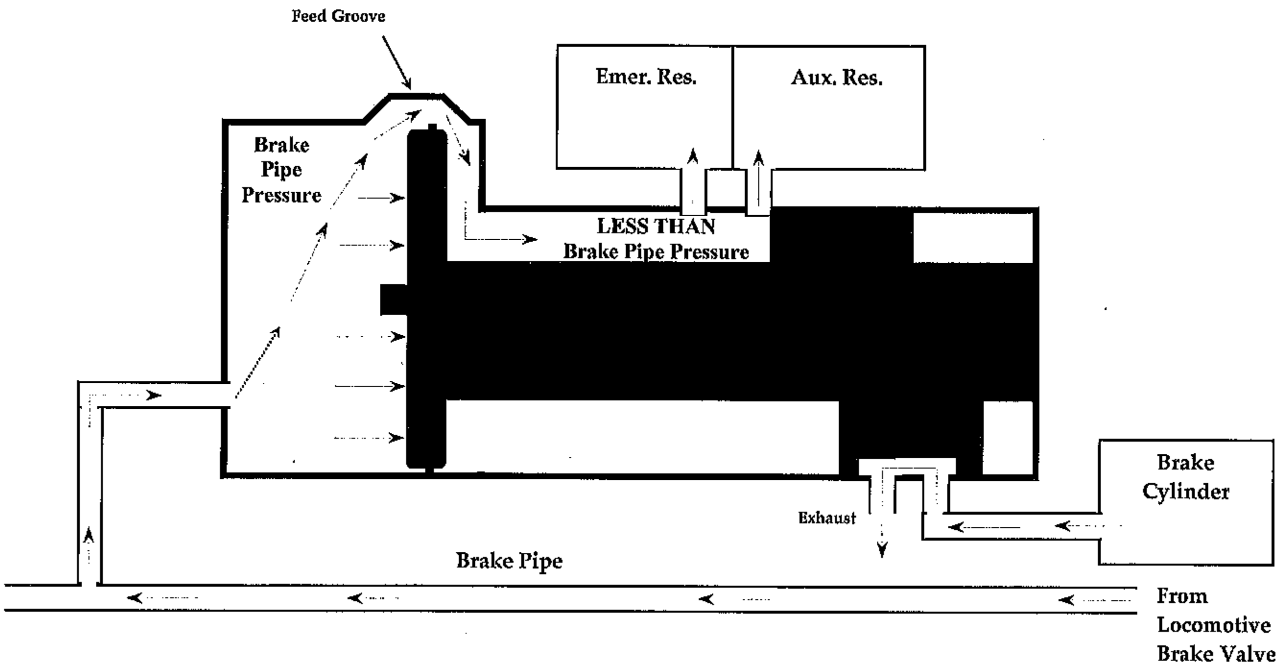
High Emergency Brake Cylinder Pressure: By combining both the volumes in the combined reservoir, a 20% higher brake cylinder pressure in emergency is achieved.



BASIC CONTROL VALVE OPERATION

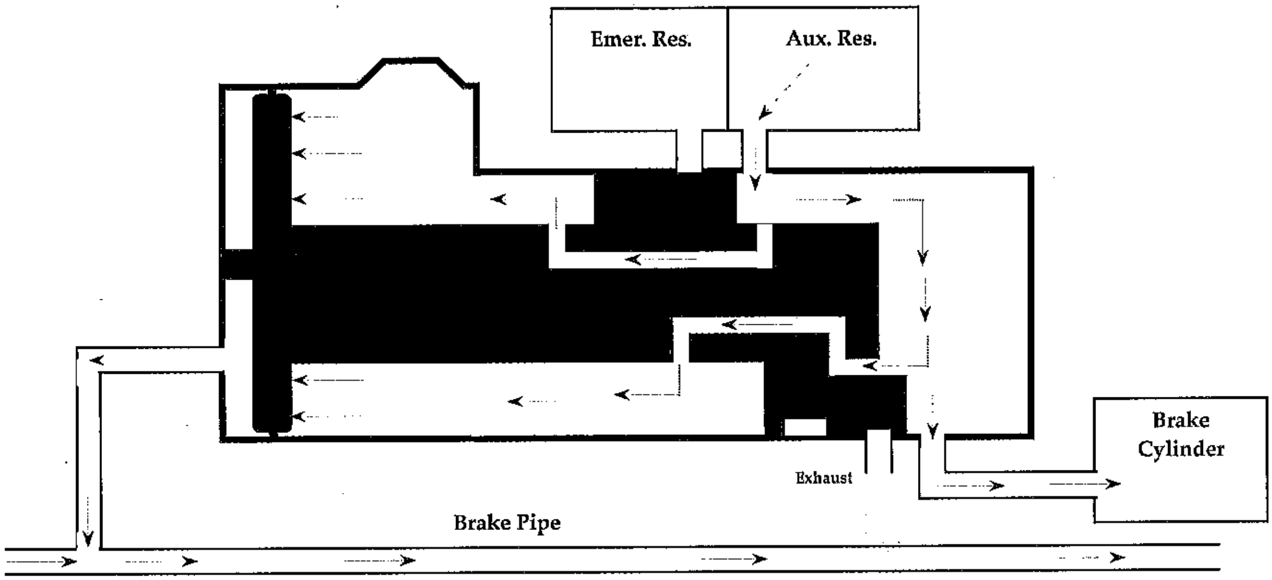
To apply and release a train's brakes and charge its air brake system, each car and locomotive is equipped with a CONTROL VALVE (sometimes called a "Triple Valve" on older equipment). The term "Triple Valve" refers to the three functions it performs: charge, apply and release the brakes. As triple valve design and function advanced, it evolved into two or more "portions" mounted on a manifold known as a "pipe bracket", all of which became known as a "control valve". The brain of the railroad air brake, the triple or control valve automatically senses changes in brake pipe pressure and responds by charging, applying or releasing the brakes, as desired.

Control valves use a system of pistons and/or diaphragms attached to internal valves and porting mechanisms. These pistons and diaphragms use differential air pressure between the brake pipe and the auxiliary reservoirs to open and close the valves and ports, admitting and exhausting air pressure to and from the appropriate chambers in order to apply and release the brakes.

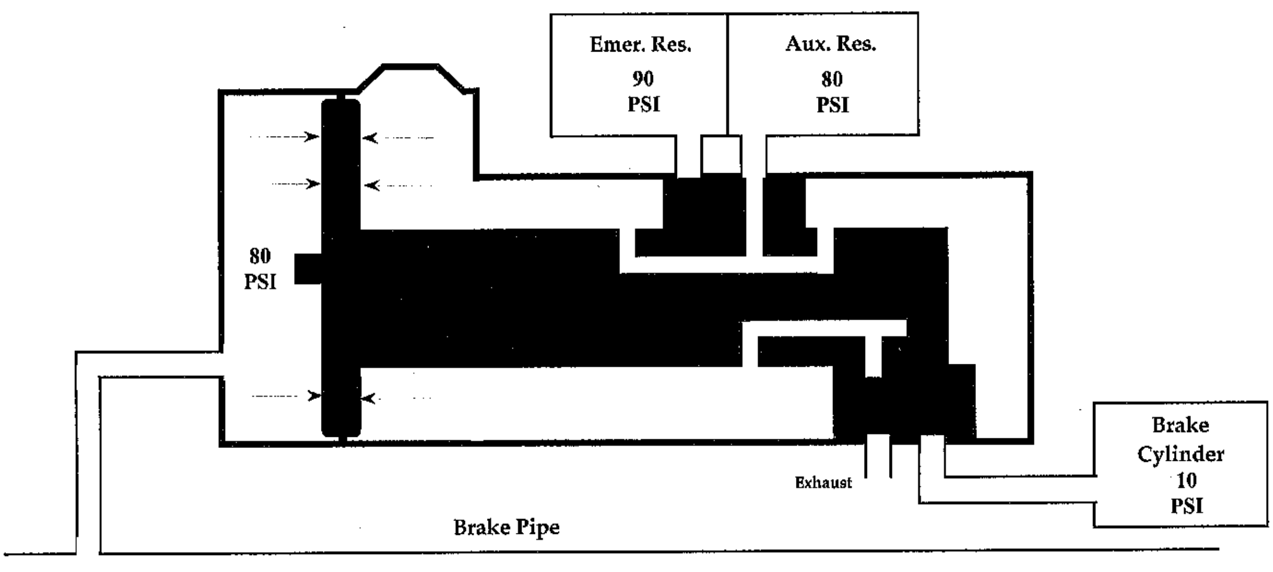


RELEASE & CHARGING (above): When the brake pipe is complete and the automatic brake valve is in the RUNNING position, air flows from the main reservoirs to the brake pipe through the FEED VALVE, which reduces main reservoir pressure to the operating pressure of the brake system. Air then flows through the branch pipe on each car and to the control valve. As the brake pipe pressure rises above that in the auxiliary reservoir, air pressure forces the piston into its charging position. In this position, air flows from the brake pipe, through the FEED GROVE and into the auxiliary and emergency reservoirs. The brake cylinder is also connected to the atmosphere, exhausting any pressure it holds. Because the feed grove opening is small, the brake pipe will charge more quickly than will the air reservoirs on each car. Therefore, the brake system may appear to be fully charged, but air may still be flowing into the reservoirs. The brake pipe is considered fully charged only when the pressures in the brake pipe and auxiliary reservoirs on each car are equal and the brake pipe pressure on the rear of the train is within 5 psi of the feed valve setting. Fully charging a dry train can require considerable time, as much as five to seven minutes per car, depending on train length.

SERVICE APPLICATION (below): The Engineer moves the automatic brake valve handle from the RELEASE position to the SERVICE position. This exhausts air from the equalizing reservoir, which opens the equalizing valve and reduces the brake pipe pressure a like amount. As the brake pipe pressure drops below the pressure in the auxiliary reservoir, the higher auxiliary reservoir pressure forces the piston forward, which closes off the brake cylinder exhaust and connects the auxiliary reservoir to the brake cylinder.



LAP (below): Air flows into the brake cylinder until pressure in the auxiliary reservoir is just slightly lower than the reduced brake pipe pressure. Brake pipe pressure now pushes the piston into its LAP position, closing off all connections between the brake pipe, the air reservoirs and the brake cylinder.

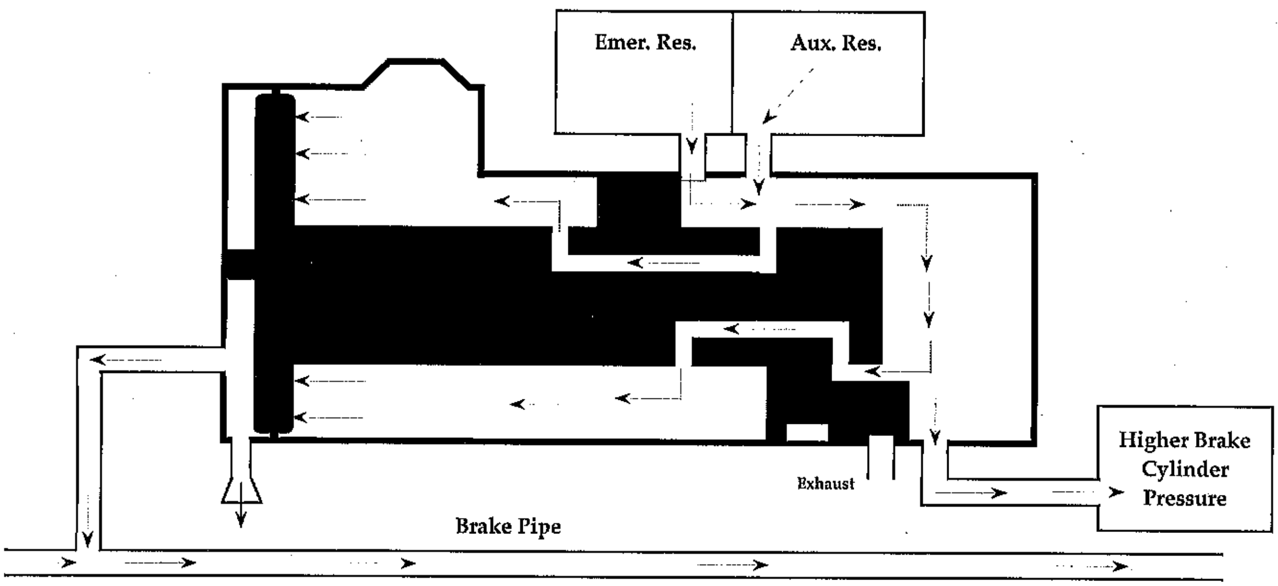


KEY FACT: Additional service reductions of brake pipe pressure will cause the control valve to again move into the service position, until full equalization occurs. Full equalization is the point where air pressures in the auxiliary reservoir & the brake cylinder are equal, & air will no longer flow from the reservoir to the cylinder. Further reductions from this point will not result in an increase of braking power!

SERVICE RELEASE (see RELEASE & CHARGING illustration): To release the brake, the Engineer recharges the brake pipe by placing the brake valve in the RELEASE or RUNNING position. Air then flows back into the brake pipe and returns to its operating pressure. This again connects the auxiliary reservoirs to the brake pipe, recharging them to brake pipe pressure, and exhausts the brake cylinder to the atmosphere.

KEY FACT: Following a SERVICE reduction, the control valve will assume the RELEASE position if the brake pipe pressure rises only about 1.5-psi above auxiliary reservoir pressure. Care must be taken not to cause an undesired release by inadvertently allowing brake pipe pressure to rise even slightly.

EMERGENCY APPLICATION (below): If an emergency-rate brake pipe reduction occurs from any source, the control valve assumes the EMERGENCY position, which connects both the auxiliary and emergency reservoirs to the brake cylinder. The larger volume of air from these combined reservoirs produces a higher brake cylinder pressure than is available with a FULL SERVICE application. Control valves also open a *vent valve,* which is a large direct passage from brake pipe to atmosphere. Connecting the brake pipe to the atmosphere at each control valve causes adjacent cars to rapidly assume the Emergency position as well, accelerating the application of the brakes.

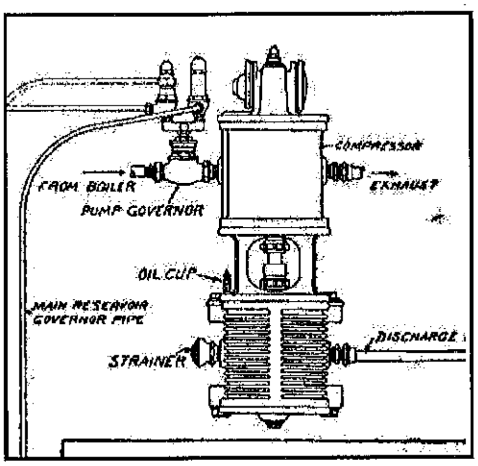


KEY FACT: Following an emergency application, the vent valve will remain open for up to several minutes, preventing the engineer from releasing the brakes before the train stops. Do not attempt to release the brakes following an emergency application for at least two minutes, or until it is known that the vent valves have all closed. If, when attempting a release, air can be heard blowing from under a car, it is likely that a vent valve is still open. Wait a little longer before attempting to recharge the brake pipe.

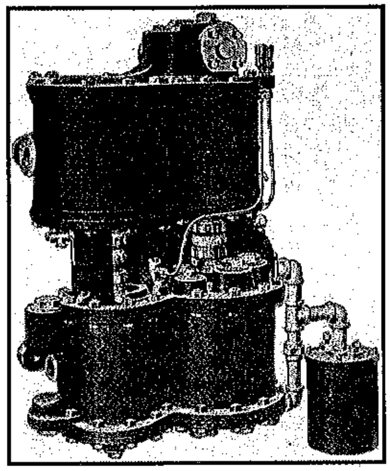
STEAM LOCOMOTIVE BRAKE SYSTEM COMPONENTS

AIR COMPRESSORS: Steam locomotives are equipped with either SINGLE PHASE or CROSS COMPOUND steam-driven air compressors

The SINGLE PHASE air compressor is the oldest design of steam-driven air compressor. It has a single steam cylinder mounted vertically above a single air cylinder. The lower air cylinder is ribbed to facilitate cooling. It is "dual acting" as each stroke, whether up or down, compresses air, i.e.: the compression stroke downward is also the intake stroke for the upward cycle, and vice versa. A reversing valve is encased on top of the steam cylinder. This design works well, but is limited in capacity and efficiency when charging large amounts of air for long trains.

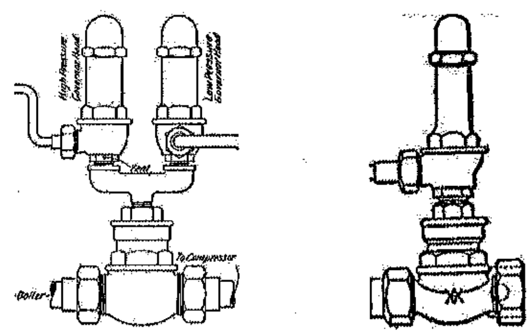


Single-Phase Air Compressor



Cross-Compound Air Compressor

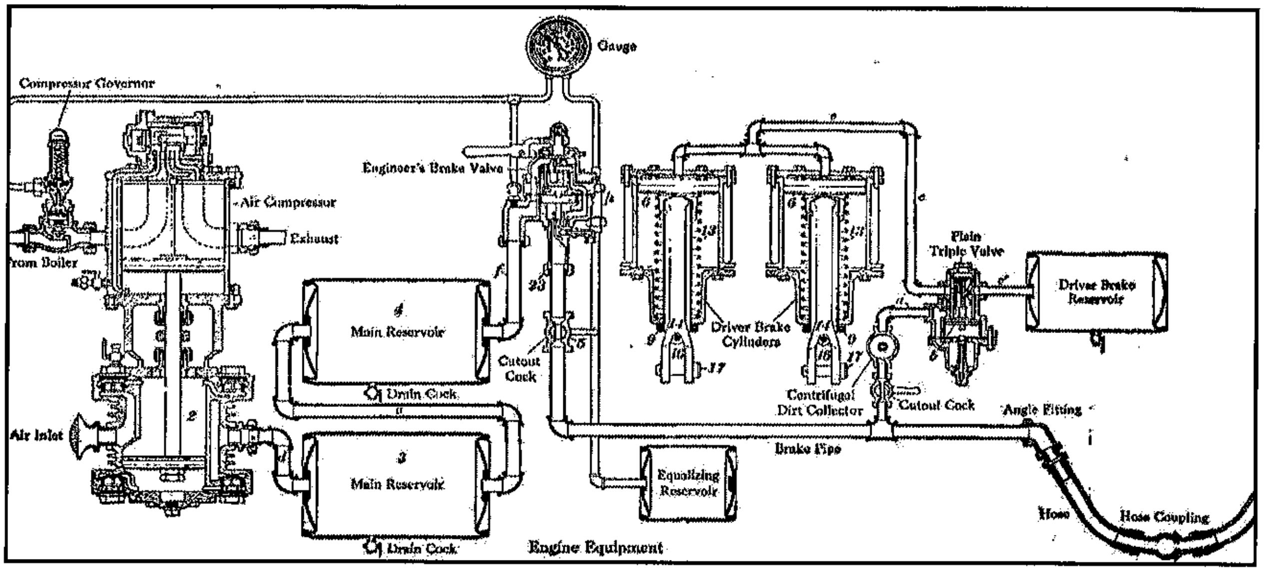
CROSS-COMPOUND air compressor improved on the single phase design by using steam twice, thus increasing its efficiency, and by significantly increasing delivery volume. This compressor uses two phases of steam expansion and of air compression and works as follows: air is first drawn into the low pressure air cylinder and compressed to an initial low pressure by the high pressure steam cylinder, which uses steam at boiler pressure. The air then flows to the high pressure air cylinder and is further compressed by the steam exhausting from the high pressure side to the low pressure steam cylinder, thus "compounding" the air compression cycles and the use of steam.



Air Compressor Governors:
LEFT: Duplex – RIGHT: Single Pressure

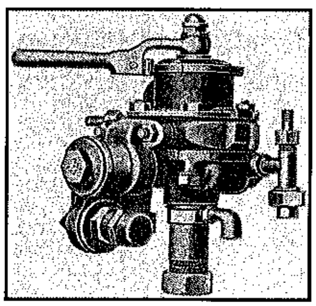
COMPRESSOR GOVERNORS: To control the air compressor and main reservoir pressure, a governor of either the single pressure or "Duplex" type is used. The single pressure type simply maintains a constant main reservoir pressure. The duplex type maintains a "high – low" range of main reservoir air pressure, thus reducing compressor cycling.

A-1 LOCOMOTIVE BRAKE EQUIPMENT



A-1 is a very early type of automatic air brake equipment and is found only on the oldest of preserved locomotives. It is the simplest form of automatic air brake and may or may not come with independent locomotive brake control.

G-6 AUTOMATIC BRAKE VALVE:

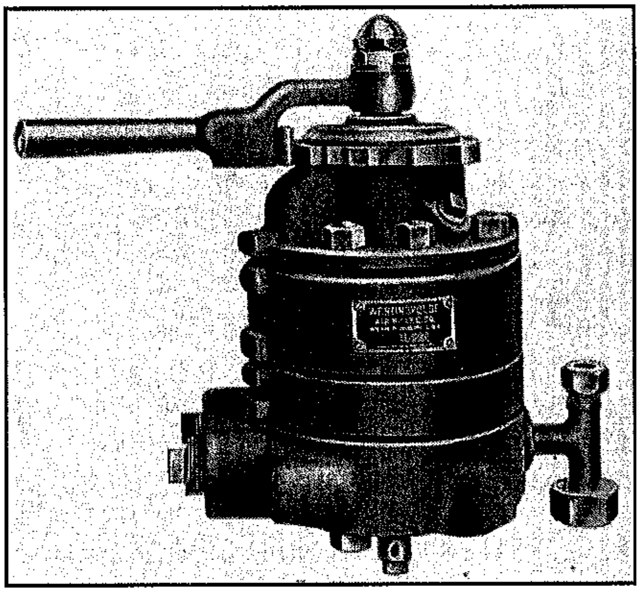


Provided to apply and release the train and locomotive brakes. Its positions are, left to right: RELEASE, RUNNING, LAP, SERVICE and EMERGENCY. It has no HOLDING feature. The function of these positions is explained under the 6-ET Equipment described in the following section.

OPERATION: Referring to the above diagram, compressed air flows from the SINGLE PHASE AIR COMPRESSOR, at left, to the MAIN RESERVOIRS, #3 and #4. Here the heated compressed air cools and moisture precipitates out, collecting in the reservoirs (which must be manually drained periodically). Air pressure in the main reservoirs is regulated by the SINGLE PRESSURE COMPRESSOR GOVERNOR, at top left. This governor measures air pressure in the main reservoirs and cycles the compressor as needed to maintain the desired pressure, which is normally between 110 - 125 psi. Air at main reservoir pressure then flows to the ENGINEER'S BRAKE VALVE. From the brake valve, the Engineer charges the brake pipe. The FEED VALVE regulates air pressure flowing to the brake pipe, and is normally set to maintain 90 psi (refer to local air brake instructions to determine the correct pressure for your particular operation). Air in the brake pipe flows to the PLAIN TRIPLE VALVE on the locomotive and charges the DRIVER BRAKE RESERVOIR, which functions as the auxiliary reservoir for the locomotive. To apply the brakes on the engine, the Engineer makes a reduction in brake pipe pressure using the Engineer's brake valve. The triple valve senses this reduction and admits air from the driver brake reservoir to the DRIVER BRAKE CYLINDERS. To release the brake, the Engineer recharges the brake pipe by placing the Engineer's Brake Valve in the RELEASE or RUNNING position.

6-ET Locomotive Brake Equipment

By far the most common equipment on steam locomotives is Schedule 6-ET. It is similar to, but more sophisticated than, the older, simpler A-1 equipment. The #6 and #14 equipments applied to diesel locomotives were derived from 6-ET. It functions similarly to the sequence described for A-1 equipment on the previous page, but includes a HOLDING brake valve position and an independent locomotive brake function with brake cylinder pressure maintaining.



H-6 Automatic Brake Valve

Engineer's automatic brake valve positions are:

RELEASE: Connects the brake pipe directly to the main reservoirs, bypassing the feed valve, while holding an automatic set of locomotive brakes applied. Used primarily for charging a long dry train. If left in this position, the brake pipe could become overcharged, that is, charged to a pressure greater than the setting of the FEED VALVE. To alert the Engineer, a distinctive "hiss" is audible when the H-6 handle is in the RELEASE position.

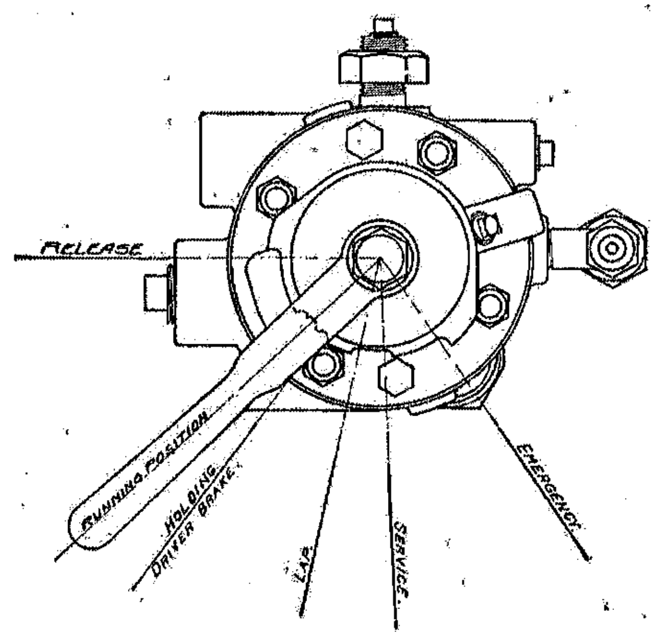
RUNNING: Connects the brake pipe to the feed valve, which reduces main reservoir pressure to the desired brake pipe pressure. This is the normal position for recharging and releasing all brakes, and when running.

HOLDING: Recharges the brake pipe to the feed valve setting and releases the train brakes, but holds locomotive brakes, if set, applied.

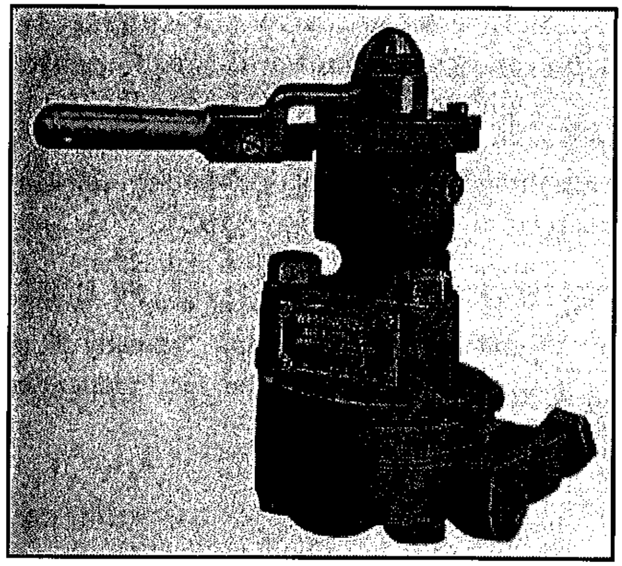
LAP: Closes all brake pipe connections. Holds the brake pipe at the desired reduction, but does not maintain it against leakage.

SERVICE: Vents EQUALIZING RESERVOIR (CHAMBER D) air pressure to the atmosphere, causing the EQUALIZING VALVE to open and reduce brake pipe pressure a like amount. This applies the brakes on the train and locomotive in proportion to the reduction.

EMERGENCY: Opens the brake pipe directly to the atmosphere causing a rapid, uncontrolled reduction of brake pipe pressure and thus an emergency application of the brakes.

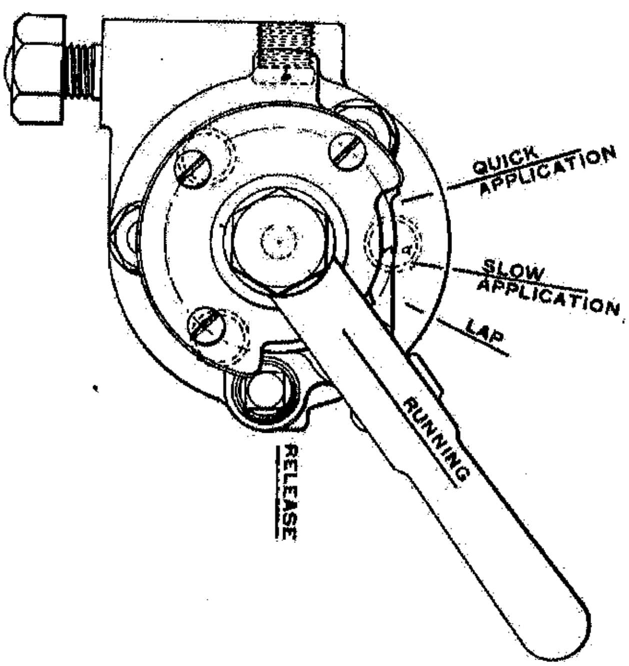


S-6 INDEPENDENT BRAKE VALVE (right):
The independent brake valve operates the locomotive brakes separately from the automatic brake valve, thus independently from brakes on the train. It is used primarily to control the engine when running light, for holding a train or locomotive stopped, for switching and for spotting the train or engine. Its secondary use can be for controlling slack, trimming a stop, for short-term speed control or for emergencies. However, the independent brake must not be used for extended downgrade speed control otherwise the driver tires could overheat and come loose from the wheel centers.



The S-6's positions and functions are:

RELEASE: Forestalls or releases (bails) an automatic application of the engine brakes, either service or emergency, following a brake pipe reduction. This is a spring-loaded position; the handle must be held in position manually or it will sprint back to the RUNNING position.



RUNNING: Normal position to carry the independent brake valve when running. Releases an independent application of the engine brakes, but not an automatic or emergency application.

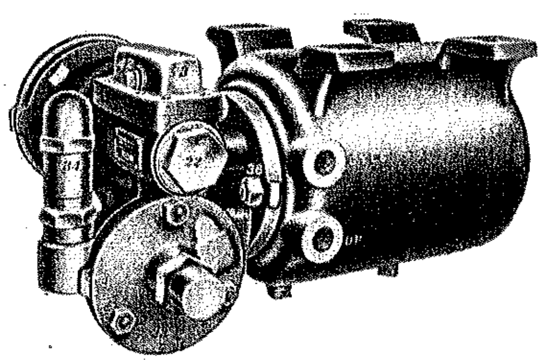
LAP: Closes all connections in the valve and holds the selected application of the engine brake applied. Unlike the automatic brake valve, this position will hold the engine brake cylinder pressure constant against minor leakage.

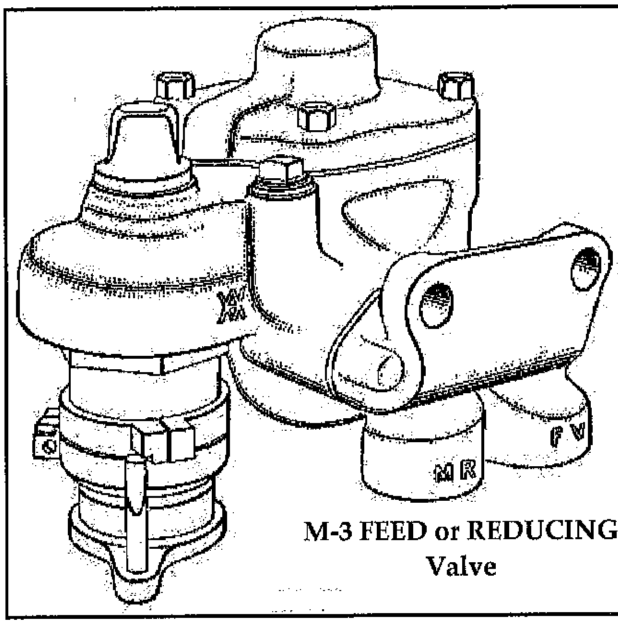
SLOW APPLICATION: Normal position for applying the independent brake, and for holding the brake applied when the train or engine is stopped. Produces a smooth but responsive build-up of locomotive brake cylinder pressure up to the independent brake REDUCING valve setting.

QUICK APPLICATION: As its name implies, produces a rapid increase of brake cylinder pressure, up to the setting of the independent brake REDUCING valve. This is also a spring-loaded position; the handle must be in position manually or it will spring back to the SLOW APPLICATION position.

M-3 FEED or REDUCING VALVE (right): Two M-3 pressure regulating valves are utilized with 6-ET applications: one to regulate brake pipe pressure, called the FEED VALVE; the other to limit independent brake cylinder pressure, called the REDUCING VALVE. In both applications, the M-3 valve takes in main reservoir pressure and maintains output pressure at its adjusted setting, typically 90 psi for brake pipe and 35-45 psi for independent brake cylinder pressure.

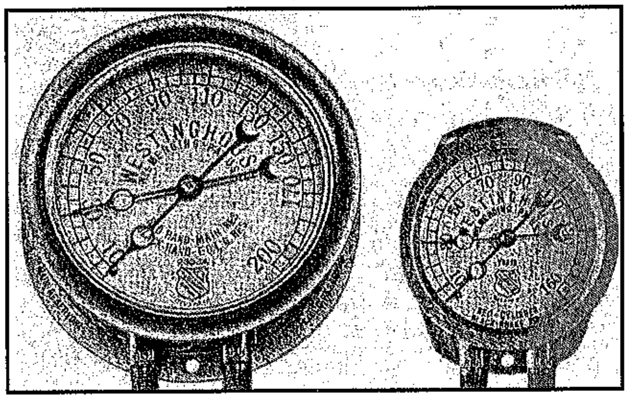
#6 DISTRIBUTING VALVE (below): The heart of the 6-ET system is the DISTRIBUTING VALVE, which is typically mounted under the Engineer's side of the locomotive cab. This multi-function device is the locomotive's CONTROL VALVE and applies, holds and releases the engine brakes in response to inputs from the automatic and independent brake valves, as well as changes in brake pipe pressure. The distributing valve "reads" control air pressure from the independent brake valve and "relays" the same pressure into the locomotive brake cylinders directly from the main reservoir. This replaces the more basic functions of the earlier A-1 equipment. Most notably, rather than relying on a limited auxiliary reservoir volume to supply air to the engine brake cylinders, the distributing valve uses the virtually limitless supply of air from the main reservoirs, which gives it the ability to maintain cylinder pressure against leakage.





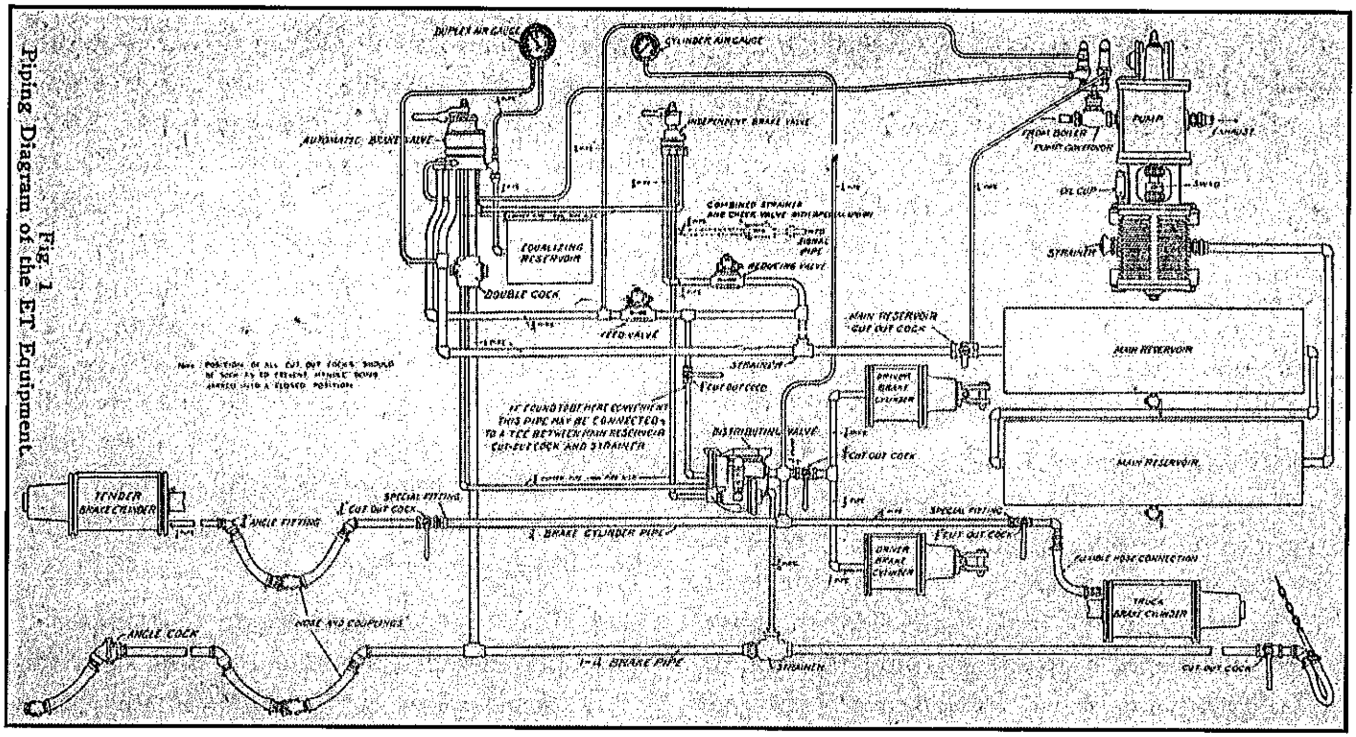
M-3 FEED or REDUCING Valve

6-ET AIR BRAKE GAUGES (below):



Two DUPLEX AIR BRAKE GUAGES, each indicating two separate functions, provide the Engineer with information needed to manage the air brake system. On the larger gauge, the red hand indicates MAIN RESERVOIR pressure and the black hand indicates EQUALIZING RESERVOIR pressure. On the smaller gauge, the red hand indicates BRAKE CY LINDER pressure on the locomotive only, while the black hand points to the actual BRAKE PIPE pressure. Gauge size and configuration may vary between locomotives, but the arrangement of pointers should always remain the same.

NO. 6 & 14 SYSTEMS OPERATION



6-ET Piping Diagram

Referring to the above diagram, compressed air flows from the AIR COMPRESSOR, upper right, to the MAIN RESERVOIRS (MR). Here the warm compressed air cools and moisture precipitates out, collecting in the reservoirs (which must be periodically drained). Air pressure in the main reservoirs is regulated by a DUPLEX AIR COMPRESSOR GOVERNOR, shown to the left of the compressor. This governor monitors MR air pressure and cycles the air compressor on and off as needed to maintain it between 110 and 125 psi. MR air then flows to the AUTOMATIC BRAKE VALVE by two routes: one feeding MR pressure directly to the brake valve, and the other through the FEED VALVE which reduces MR pressure to selected brake pipe pressure. MR air also flows directly to the DISTRIBUTING VALVE, and through the REDUCING VALVE to the INDEPENDENT BRAKE VALVE.

INDEPENDENT BRAKE OPERATION: To apply the brakes on the engine only, the Engineer moves the independent brake valve handle to the SLOW or QUICK APPLICATION position until the desired brake cylinder pressure is obtained, as indicated on the brake cylinder pressure gauge, then back to the LAP position. Sir from the independent brake valve flows to the distributing valve, which responds by admitting MR air directly into the brake cylinders to match the pressure of the input air pressure. Due to the large volume of air required to fill the locomotive brake cylinders, utilizing a distributing valve to "relay" air pressure from the MR to the locomotive brake cylinders results in a more rapid build-up of locomotive cylinder pressure than could be achieved if the independent brake valve fed the locomotive brake cylinders directly, and also maintains cylinder pressure against leakage.

To release an independent application of the brakes, the Engineer moves the independent brake valve handle from the LAP position to the RELEASE position. This vents control air pressure to the atmosphere. If the Engineer desires only reduce the independent brake application but not fully release it, the independent brake valve handle may be moved back to the LAP position to retain any desired brake cylinder pressure. The distributing valve will respond by reducing locomotive brake cylinder pressure to that selected by the Engineer.

AUTOMATIC BRAKE OPERATION: From the automatic brake valve, the Engineer charges the brake pipe by placing the handle in either the RELEASE or RUNNING position. Air flows from the automatic brake valve into the brake pipe and thence to the distributing valve on the locomotive and charges its two control volumes, which function as the auxiliary reservoir for the locomotive. Absent any control air pressure input from the independent brake valve, the distributing valve will release the locomotive brakes. If control air input is present from the independent brake valve but is less than the maximum allowable brake cylinder pressure, the distributing valve will release any pressure in the locomotive brake cylinders to match that of the control air pressure input. Air from the automatic brake valve then flows through the brake pipe to the CONTORL VALVES on each car, which sense the increase in pressure and operate to charge the cars' auxiliary reservoirs from the brake pipe and release any brake cylinder pressure.

OVERCHARGED BRAKE PIPE: When the automatic brake valve is in the RELEASE position, unregulated MR pressure flows directly to the brake pipe. While this may be useful in charging a long, dry train, the brake pipe could become overcharged if the brake valve is left in this position too long. OVERCHARGED BRAKE PIPE is a condition where the air pressure in the brake pipe and in the auxiliary reservoirs on each car is higher than the setting of the locomotive feed valve. When the automatic brake valve is placed in the RUNNING position, an overcharged brake pipe will gradually leak down to the set pressure of the feed valve, resulting in a reduction in brake pipe pressure and subsequent application of the brakes. This creates a situation where the brakes are applied but the brake pipe is at its fully charged state, leaving no pressure differential with which to release the brakes. Should this occur, the condition can be corrected by one of the following procedures:

1. Secure the train against unintended movement. Initiate an EMERGENCY application from the automatic brake valve. After the appropriate time-out interval, recover the emergency application in the normal manner by placing the brake valve handle in the RUNNING position. If the brakes do not fully release on each car, repeat this process until they do.
2. If the above procedure is not effective, then initiate another emergency application of the brakes to deplete the brake pipe pressure to zero. Ensure the train is properly secured against unintended movement, then manually drain about half the air pressure from each auxiliary and supply reservoir on every car in the train. Then recharge the system from the automatic brake valve using only the RUNNING position. After allowing sufficient time for the system to fully recharge, perform a brake test to verify proper application and release before proceeding.

SERVICE BRAKE APPLICATION: To obtain a SERVICE brake application, move the automatic air brake valve handle from RUNNING to SERVICE and observe the EQUALIZING RESERVOIR gauge in the cab. When the desired reduction in pressure is achieved, move the handle to LAP to close off all ports in the valve. Additional reductions may be made by moving the handle from LAP back to SERVICE, then back again to LAP, as desired. In the SERVICE position, EQUALIZING RESERVOIR pressure is vented to the atmosphere. This causes the EQUALIZING DISCHARGE VALVE to vent brake pipe pressure to the atmosphere at a controlled or "service" rate of reduction. (See page 9). As brake pipe pressure reduces, the locomotive distributing valve will apply the engine brakes in proportion to the reduction.

RELEASE of an AUTOMATIC APPLICATION:

Independent Brake Release: Following a service brake application, a locomotive brake application may be forestalled or released by momentarily holding the INDEPENDENT BRAKE VALVE handle in the RELEASE position. This position is spring-loaded on the brake valve quadrant so the handle must be held here manually or it will return to the RUNNING position. In RELEASE, the independent brake valve signals the distributing valve to release any air pressure in the engine brake cylinders.

Running Position: Moving the automatic brake valve from LAP to RUNNING feeds MR air to the brake pipe through the FEED VALVE. As brake pipe pressure increases air flows to the distributing valve and to the control valves on each car. The control valves then release each car's brake cylinder pressure and recharge their auxiliary reservoirs. Unless an application signal is present from the independent brake valve, the distributing valve will also release any air pressure in the engine brake cylinders.

Holding Position: Functions the same as RUNNING except that HOLDING signals the distributing valve to retain engine brake cylinder pressure while the brake pipe is recharged.

EMERGENCY BRAKE APPLICATION: To reduce the brake pipe pressure as quickly as possible and obtain an EMRGENCY application, swiftly move the automatic brake valve handle to EMERGENCY. In this position, CHAMBER D and the EQUALIZING DISCHARGE VALVE are bypassed and the brake pipe is connected directly to the atmosphere through a large opening. This produces a rapid, uncontrolled reduction in brake pipe pressure which causes each car's control valve to assume its EMERGENCY or QUICK ACTION position and immediately apply maximum braking effort.

RELEASE of an EMERGENCY APPLICATION:

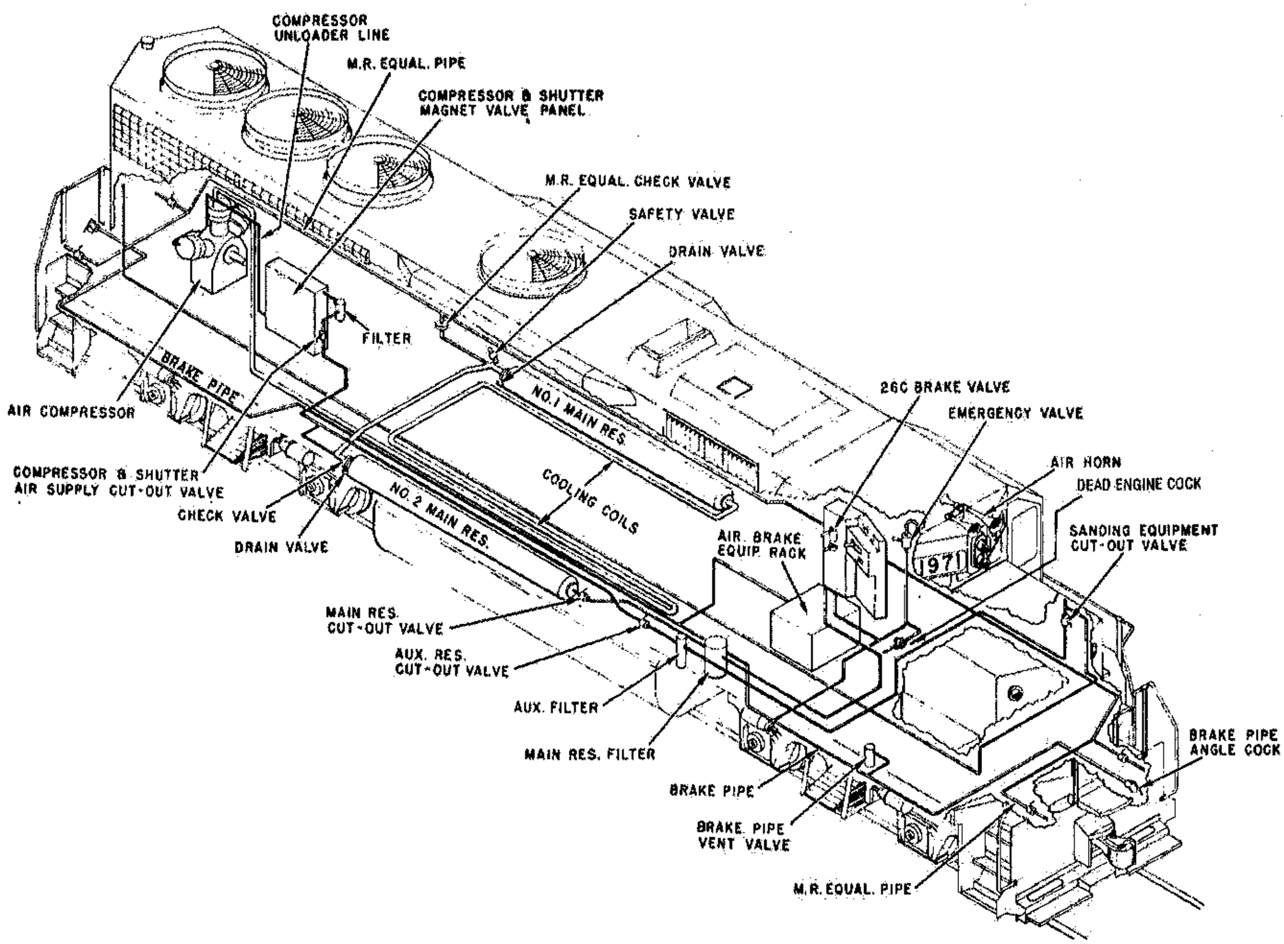
Once initiated, an emergency brake application cannot be released until the train has stopped and VENT VALVES on each car have closed. Control valves so equipped assume QUICK ACTION during an emergency application which open vent valves that connect the brake pipe directly to the atmosphere. This helps speed an emergency application down the length of a train. Following an emergency application, vent valves remain open for at least 60 to 90 seconds, during which time the brake pipe cannot be recharged. Once vent valves have closed, the automatic brake valve should be placed in RUNNING on most train consists to recharge the brake pipe. On longer trains or on trains requiring a high volume of air to recharge, the automatic brake valve may be placed briefly in RELEASE; however, the Engineer must remain attentive to actual brake pipe pressure as indicated on the gauge and move the handle to RUNNING before creating an OVERCHARGED BRAKE PIPE condition.

DIESEL LOCOMOTIVE BRAKE SYSTEMS

Diesel locomotive air brake systems typically consist of:

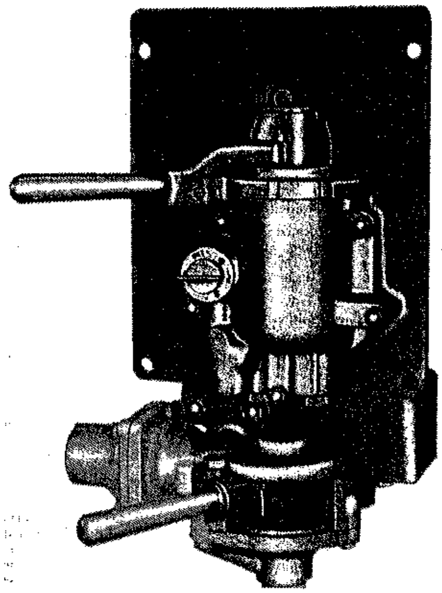
- **AIR COMPRESSOR** that provides pressurized air in sufficient volumes to operate the train's air brake system;
- **MAIN RESERVOIRS** to store compressed air to operate the air brake system.
- **ENGINEER'S BRAKE VALVES** to operate the train and locomotive brake systems either independently or in conjunction with each other.
- **LOCOMOTIVE CONTROL VALVE** to apply and release the locomotive air brakes in response to inputs from the Engineer.

Diesel locomotive air brake systems are typically configured as follows:

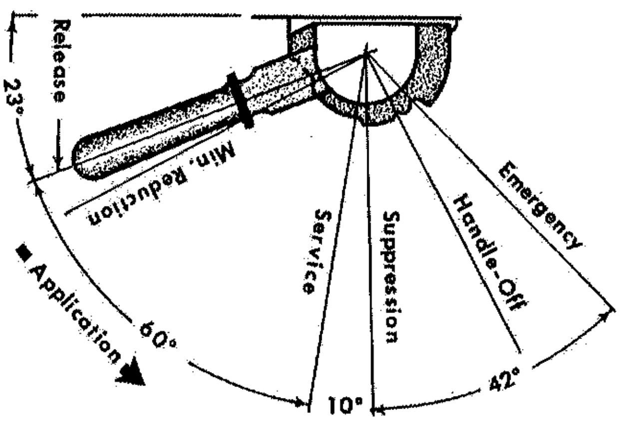


26-C BRAKE EQUIPMENT

The 26-C locomotive brake valve is a contemporary "self-lapping" type that provides a brake pipe reduction proportionate to the movement of the brake valve handle into an application zone, rather than back-and-forth between SERVICE and LAP positions. The equipment also has a PRESSURE MAINTAINING feature that maintains brake pipe pressure at any given level of reduction against minor leakage that may occur in the brake pipe. This feature works by feeding air to the brake pipe at whatever pressure is in the equalizing reservoir, regardless of the amount of reduction or minor leakage in the brake system. Without pressure maintaining, even minor leakage in the brake pipe would continue to reduce its pressure, causing a heavier application of the brakes than desired.



The 26-L type automatic brake valve positions and their functions, from left to right are:



RELEASE: Charges the brake pipe and the equalizing reservoir to the pressure set by the TRAINLINE AIR REGULATING VALVE, which releases the brakes

MINIMUM REDUCTION: Reduces equalizing reservoir pressure 5-7 psi, which reduces brake pipe pressure a like amount. Initiates QUICK SERVICE feature of control valves on the train and results in about 10 psi. of brake cylinder pressure on each car.

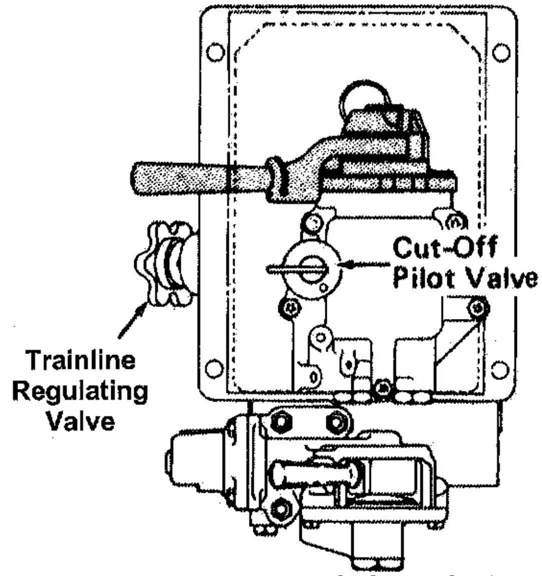
SERVICE or APPLICATION ZONE: Movement into this zone from left to right further reduces equalizing reservoir and brake pipe pressure.

FULL SERVICE: The position at which brake pipe equalization will occur and maximum service braking effort is obtained.

SUPPRESSION: A full service application is obtained in this position and any over speed or safety control brake application, if equipped, will be suppressed.

HANDLE OFF: All connections in the brake valve are closed in this position, and the handle may be removed; brake-pipe pressure is gradually reduced to zero.

EMERGENCY: Known as the "Big Hole", this position opens a large and direct opening between the brake pipe and the atmosphere, causing a sudden and uncontrolled reduction in brake pipe pressure; also resets the brake valve following an emergency application from another source.



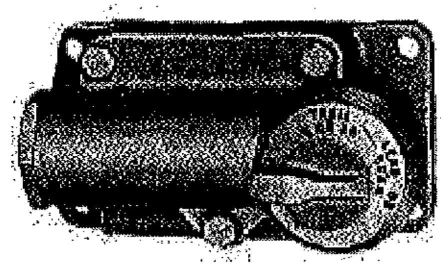
SA-26 Independent Brake Valve

SA-26 INDEPENDENT BRAKE VALVE: A self-lapping, pressure-maintaining independent brake is mounted below the automatic brake valve handle and provides independent control of the locomotive brakes separate from an application of the train brakes. The brake valve has two positions: RELEASE, at the far left of the quadrant, and FULL APPLICATION, at the far right of the quadrant. In between these positions is the APPLICATION ZONE. Movement of the handle to the right into this zone provides increasingly higher locomotve brake cylinder pressure until full application is obtained. The pressure maintaining feature will maintain brake cylinder pressure at the desired pressure against allowable leakage. A QUICK RELEASE or "bail-off" feature is incorporated into the valve whereby an automatic brake application may be released on the locomotive only by depressing the independent brake valve handle downward. "Bailing-off" reduces locomotive brake cylinder pressure to the value called for by the position of the handle in the APPLICATION ZONE. If the handle is in the RELEASE position, locomotive brake cylinder pressure will be reduced to zero.

TRAINLINE REGULATING VALVE: Left of the Engineer's automatic brake valve is the *Train Line Regulating Valve,* or air pressure adjustment valve. This adjusts the level of air pressure fed to the equalizing reservoir and thus the brake pipe. The local Air Brake Rules typically specify the required brake pressure setting for this valve.

CUT-OFF PILOT VALVE: Two or three-position valve with IN and OUT, or FRT, PASS and OUT positions, located on the front of the Engineer's automatic brake valve. Cuts the automatic brake valve IN or OUT. The PASS position cuts in a GRADUATED RELEASE feature sometimes used with passenger equipment. When cut-out, it disables pressure maintaining and all handle positions except EMERGENCY, which is always functional. The automatic brake valve is cut out when unit trails in a multiple-unit consist, and when performing air brake tests.

MU-2A M/U SELECTOR VALVE: Sets up the #26 equipment independent brake to operate as the lead unit in a locomotive consist, or to function properly as a trailing unit when connected to a lead locomotive equipped with a brake schedule other than 26-L. This valve is usually located on the backside of the locomotive control stand and it is crucial that this valve be set properly for the intended service.



OPERATION OF THE EQUIPMENT

Compressed air for the operation of both locomotive and train air brakes is provided by the air compressor on the locomotive. On a diesel locomotive, the compressor is driven off of the main engine. A governor loads and unloads the compressor, as needed, to maintain pressure in the main reservoirs between 110 to 140-psi.

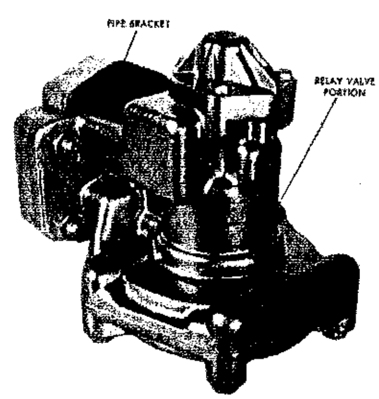
Air, along with any water vapor it contains, is drawn into the compressor and compressed, significantly raising its temperature. From here, the hot, moist air is discharged into a system of piping known as COOLING COILS, which are designed to radiate the heat away. As the air travels through this piping, any water vapor will begin to condense into water. On diesel locomotives, one or more filters or water separators are usually located at or near the end of this piping to trap and remove this water. Typically these filters and separators will be equipped with an AUTOMATIC BLOW DOWN to periodically drain any accumulated water away. The air, now cooler and drier, then enters the MAIN RESERVOIRS for storage. The stored air will continue to cool in the main reservoirs, causing more water vapor to condense. Therefore the reservoirs are often equipped with additional moisture drains, either manual or automatic, to drain off accumulated water.

From the main reservoirs, air flows to the Engineer's 26-C automatic brake valve and the SA-26 independent brake valves. The automatic brake valve controls brakes on both the locomotive and train; the independent brake valve controls the brake only on the locomotive or the multiple unit locomotive consist.

CHARGING THE SYSTEM: When the brake pipe is complete on a train and the 26-C brake valve is placed in the RELEASE position, air flows from the main reservoirs to the brake pipe through the TRAINLINE REGULATING VALVE that regulates main reservoir pressure to the operating pressure of the brake system, which is 90-psi for most railroad operations. However, consult local operating rules or instructions for the proper brake pipe pressure setting for your territory.

Air then flows through the brake pipe, to the CONTROL VALVE on the locomotive and each car in the train, which senses the increase in pressure and moves into its charging position. In this position, air from the brake pipe flows through the control valve into the AUXILIARY and EMERGENCY RESERVOIRS. Each car's brake cylinder is also vented to the atmosphere, releasing any pressure it may have held.

INDEPENDENT BRAKE OPERATION: When an independent brake application is made from the SA-26 independent brake valve, control air pressure is sent directly to the J-RELAY VALVE independent of any brake pipe activity.



J-Relay Valve

The J-Relay valve supplied with 26-C air brake equipment applies and releases the locomotive brakes in response to control air pressure input from the independent brake valve <u>or</u> the locomotive control valve. The J-Relay maintains brake cylinder pressure against any leakage using main reservoir air as its supply volume.

If the SA-26 handle is in the APPLICATION ZONE during an automatic brake application and the brake cylinder pressure corresponding with the position of the independent handle is greater than that of the automatic application, brake cylinder pressure will be increased to the greater value. Moving the SA-26 handle back to the release position will reduce locomotive brake cylinder pressure to that corresponding with the automatic brake application.

Depressing the independent brake valve handle activates the QUICK RELEASE or BAIL feature which, in turn, activates the quick release portion of the locomotive control valve. When the bail is actuated, the position of the independent brake valve handle in the quadrant will **override** an automatic or EMERGENCY APPLCIATION of the locomotive. If the independent brake valve handle is in the RELEASE position when the bail is actuated, locomotive brake cylinder pressure will be reduced to zero. If the independent handle is in the APPLICATION ZONE and the bail is actuated, brake cylinder pressure will adjust to correspond with the position of the handle.

SERVICE APPLICATION: To initiate a service application, the Engineer moves the automatic brake valve handle from the release position to the MINIMUM REDUCTION position on the 26-C quadrant. This will reduce pressure in the EQUALIZING RESERVOIR between 5 and 7 psi, causing the EQUALIZING DISCHARGE VALVE to reduce the brake pipe pressure by the same amount. This will initiate the QUICK SERVICE function on control valves so equipped which will vent a small volume of brake pipe air directly to the atmosphere at each control valve location, and speed the initial build-up of brake cylinder pressure on each car.

KEY FACT: After the initial service reduction, additional brake pipe service reductions can be obtained by moving the brake valve handle further into APPLICATION ZONE of the 26-C quadrant. This will cause the control valves on each car to increase brake cylinder pressure a corresponding amount until FULL EQUALIZATION occurs. Full equalization is the point at which air pressures in the auxiliary reservoir & the brake cylinder are equal & air no longer flows from the reservoir into the cylinder. Further brake pipe pressure reductions from this point will not result in increased braking power!

RELEASE of SERVICE APPLICATION: To release a service application of the brakes, move the 26-C handle all the way to the RELEASE position at the far left of the quadrant. Air then flows into the brake pipe as described under CHARGING THE SYSTEM, affecting a release of the brakes.

KEY FACT: With the CUTOFF PILOT VALVE properly set to the IN or FRT position, partial movement of the brake valve handle from the APPLICATION ZONE towards the RELEASE position will <u>not</u> increase brake pipe pressure nor affect a release of the brakes. However, if the cutoff pilot valve is set to the PASS position, partial movement of the brake valve handle from the application zone towards the release position WILL INCREMENTALLY INCREASE BRAKE PIPE PRESSURE & RELEASE THE BRAKES, BUT WILL NOT FULLY RECHARGE THE SYSTEM. THIS COULD BE VERY DANGEROUS!

KEY FACT: Following a service reduction, a control valve will assume its release position if the brake pipe pressure rises only about 1.5-psi above auxiliary reservoir pressure. Care must be taken not to cause an undesired release by inadvertently allowing brake pipe pressure to rise even slightly.

EMERGENCY APPLICATION: If an emergency-rate brake pipe pressure reduction occurs from any source, the EMERGENCY PORTION of the locomotive control valve initiates QUICK ACTION. This opens a VENT VALVE in the emergency portion, connecting the brake pipe directly to the atmosphere through a large direct opening. Rapid venting of brake pipe air causes adjacent cars' emergency portions and vent valves to rapidly propagate the emergency rate brake pipe pressure reduction through the train. The emergency portion then connects the emergency reservoir to the brake cylinder, which, along with the volume of air in the auxiliary reservoir, combines to create a higher overall brake cylinder pressure. If the reservoirs were charged to 90 psi, cylinder and reservoir equalization will occur at about 77 psi. in an emergency application, 13 psi. more than a full service application. The quick action valve slowly vents a volume of air pressure through a choke while holding the vent valve open. After about 70 seconds the vent valve will close. Brake pipe pressure cannot begin to be restored until all of the vent valves on the train have closed. Therefore, a running release of an emergency application is not permitted.

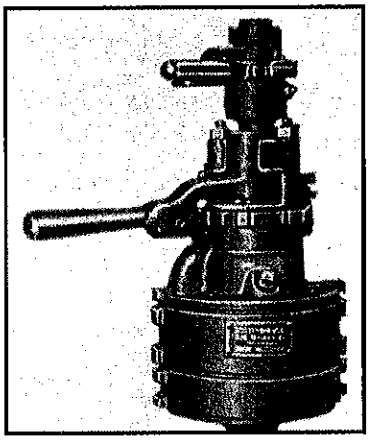
KEY FACT: From a brake system fully charged to 90 psi., a full-service brake application is achieved with a 26 psi. brake pipe reduction. This is the point at which the auxiliary reservoir & brake cylinder pressures equalize & will yield a brake cylinder pressure on each car of about 64 psi. In an emergency application, the control valve combines the volumes of both the emergency & auxiliary reservoirs, resulting in about 77-psi of brake cylinder pressure on each car.

CRITICAL KEY FACT About 26-C Pressure Maintaining

The MINIMUM REDUCTION position of the 26-C brake valve automatically makes a 5 - 7 psi reduction in EQUALIZING RESERVOIR pressure which results in a corresponding drop in brake pipe pressure. This activates the QUICK SERVICE feature on each car & obtains about 10-psi of brake cylinder pressure. However, we know that a reduction as light as 1.5-psi will activate the control valves on each car, so why don't we just make a 2 or 3 psi reduction to initiate quick service?

Here's why: remember that in quick service the control valve on each car vents a tiny amount of brake pipe air to the atmosphere. This reduces brake pipe pressure throughout the train about 4 to-6 psi. Recall that PRESSURE MAINTAINING reads equalizing reservoir pressure & feeds air to the brake pipe to match it. If the Engineer were to reduce equalizing reservoir pressure only 3-psi & the corresponding drop in brake pipe pressure activated quick service on each car, the ensuing 4 to 6-psi drop in brake pipe pressure would leave the brake pipe pressure <u>lower</u> than that of the equalizing reservoir. Pressure maintaining would then immediately raise the brake pipe pressure back "up" to match the original 3-psi reduction. This condition would release the brakes, but leave the Engineer believing a minimum application was indeed set on the train.

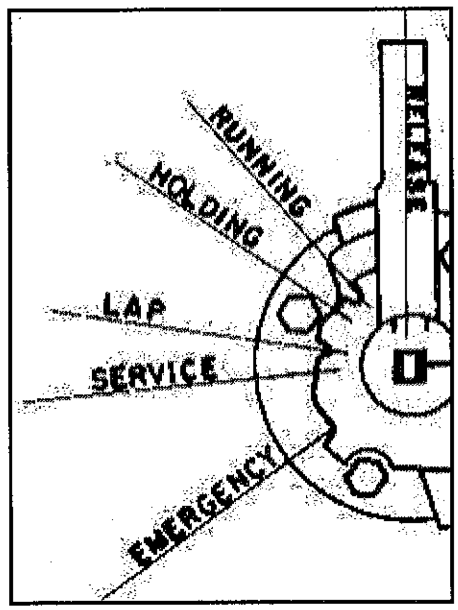
SCHEDULE 6 & 14 DIESEL LOCOMOTIVE BRAKE EQUIPMENTS



Schedule 6 and its variant #14 pre-date the development of the 26-C system and are common on older, preserved locomotives in operation. Schedule 6 equipment came in several versions including 6-BL, 6-DS, 6-SL and 14-EL, all of which are operated essentially the same. All use a variant of the #6 automatic brake valve which, unlike the self-lapping 26-C, is a manually lapping valve requiring movement of the handle between the SERVICE and LAP positions to affect and hold a service brake application.

A more detailed description of system functions is found in the **Schedule 6 & 14-Type Systems Operation** section of this manual.

#6 & #14 type automatic brake valve positions and their functions, from left to right are:



RELEASE: A large and direct connection between the MAIN RESERVOIR and the equalizing reservoir and brake pipe. Bypasses the FEED VALVE and provides maximum volume air flow into the brake pipe. If left in this position, the brake pipe may become charged to a pressure greater than that of the feed valve setting, resulting in an OVERCHARGED BRAKE PIPE condition.

RUNNING: Normal position for charging the brake pipe and releasing all brakes. In this position air from the main reservoir flows to the equalizing reservoir and brake pipe through the FEED VALVE, thereby charging the system to the pressure set by this valve. The feed valve maintains a predetermined pressure in the brake pipe and equalizing reservoir against allowable leakage.

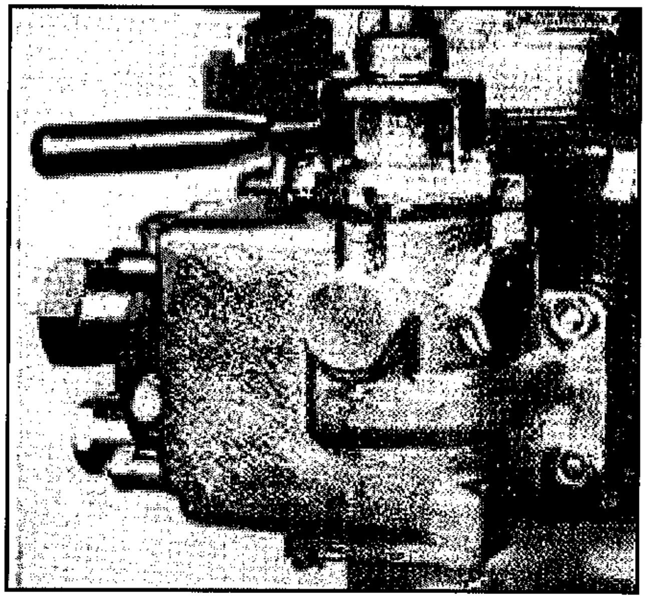
HOLDING: Functions the same as RUNNING position except that it holds locomotive brakes applied while charging and releasing the train brakes.

LAP: Closes all ports in the brake valve and holds brakes applied after a SERVICE application. Does not maintain against brake pipe leakage, which can cause further reduction in brake pipe pressure.

SERVICE: Vents pressure in CHAMBER D above the equalizing piston to the atmosphere in a controlled manner. Brake pipe pressure then raises the equalizing piston and brake pipe air is exhausted through a control orifice to the atmosphere until pressure in brake pipe and the equalizing reservoir are the same.

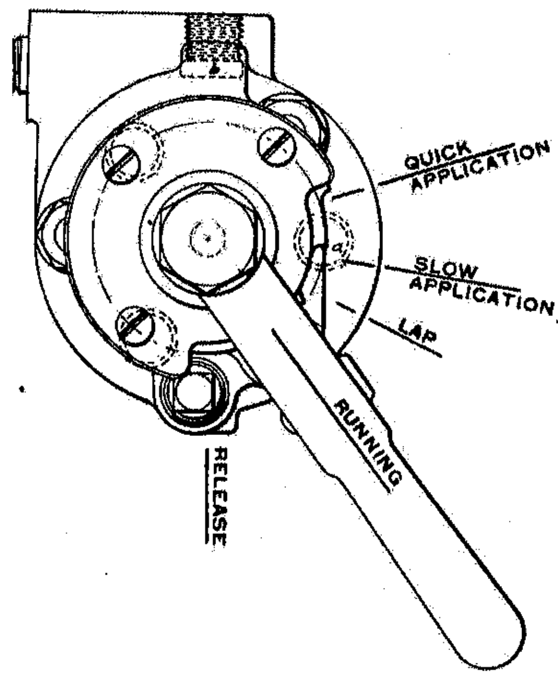
EMERGENCY: Used to obtain the most rapid and heavy brake application possible. Connects the brake pipe directly to the atmosphere causing a rapid, uncontrolled drop in brake pipe pressure. This initiates an emergency application of the train brakes.

Schedule 6 independent brake valves may be of the self-lapping or manual lapping type:



<u>SELF-LAPPING (left):</u> The self-lapping independent brake valve has two positions: RELEASE, at the far left of the quadrant, and FULL APPLICATION, at the far right of the quadrant. In between these positions is the APPLICATION ZONE. Movement of the handle to the right into this zone provides increasingly higher locomotve brake cylinder pressure until full application is obtained. A PRESSURE MAINTAINING feature will maintain brake cylinder pressure at the desired pressure against allowable leakage. A QUICK RELEASE or "bail-off" feature is incorporated into the valve whereby an automatic brake application on the locomotive only may be released by depressing the independent brake valve handle downward. "Bailing-off" releases the automatic application on the locomotive consist and reduces locomotive brake cylinder pressure to the value called for by the position of the handle in the APPLICATION ZONE. If the handle is in the RELEASE position, locomotive cylinder pressure will be reduced to zero.

<u>MANUAL LAPPING:</u> The lap-type independent brake valve has four positions:



RELEASE: Releases an automatic brake application on the locomotive only.

RUNNING: Releases an independent brake application and is the normal position in which the brake valve is carried.

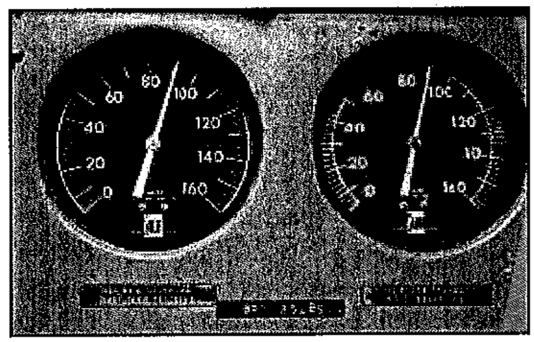
LAP: Closes all ports on the brake valve and holds a independent application of the brakes against allowable brake cylinder leakage.

SLOW APPLICATION: Applies the independent brake at a normal or service rate.

QUICK APPLICATION: Utilizes a slightly larger port opening in the brake valve to obtain a somewhat more rapid application of the independent brake.

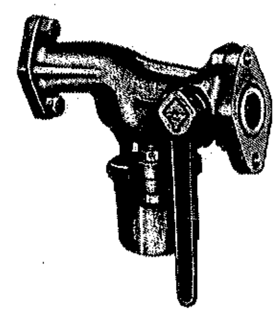
OTHER AIR BRAKE COMPONENTS & THEIR FUNCTIONS

Train brakes consist of individual car brake apparatus, connected by a single air line known as the brake pipe, which, combined with the locomotive's independent air brake, form the complete train brake system. Each car is typically equipped with the following, or some other similar, air brake system components:

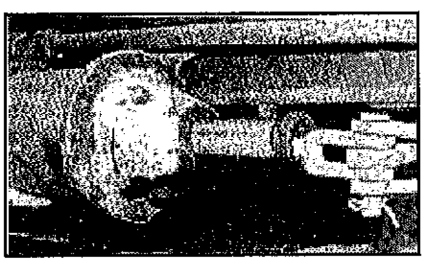


AIR BRAKE GAUGES (right): The most important information sources the Engineer will refer to are the locomotive air gauges. These provide information on the status of the most important system the Engineer uses: the brakes. These gauges are called "duplex gauges", each with a red and a white needle, and each display two functions. The gauge on the left will always display MAIN RESERVOIR pressure (RED needle) and EQUALIZING RESERVOIR pressure (WHITE needle). The gauge on the right will always display the BRAKE CYLINDER pressure of the locomotive (RED needle) and the BRAKE PIPE pressure (WHITE needle). Note that the equalizing reservoir and brake pipe indications are always on separate gauges and the needles are both white.

ANGLE COCK (left): valve at each end of the car to close off the brake pipe. Angle cocks are the only air valve on railroad equipment that are open when the handle is in-line with the flow of air; other air cocks, such as branch pipe cut-out cocks, are open when their handles are perpendicular, or 90-degrees, from the flow of air;

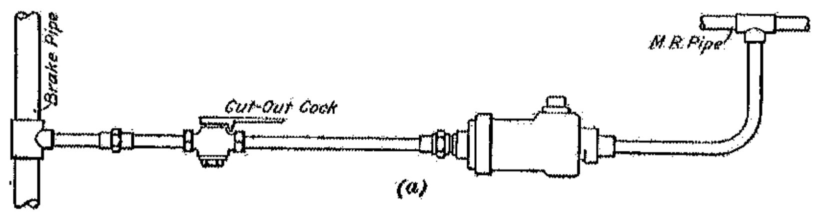


DIRT COLLECTOR/CUT-OUT COCK (right): a combination air filtering and cut-out valve located on the branch pipe between the brake pipe and a car's control valve. Used to cut-out a car's air brakes from the system.

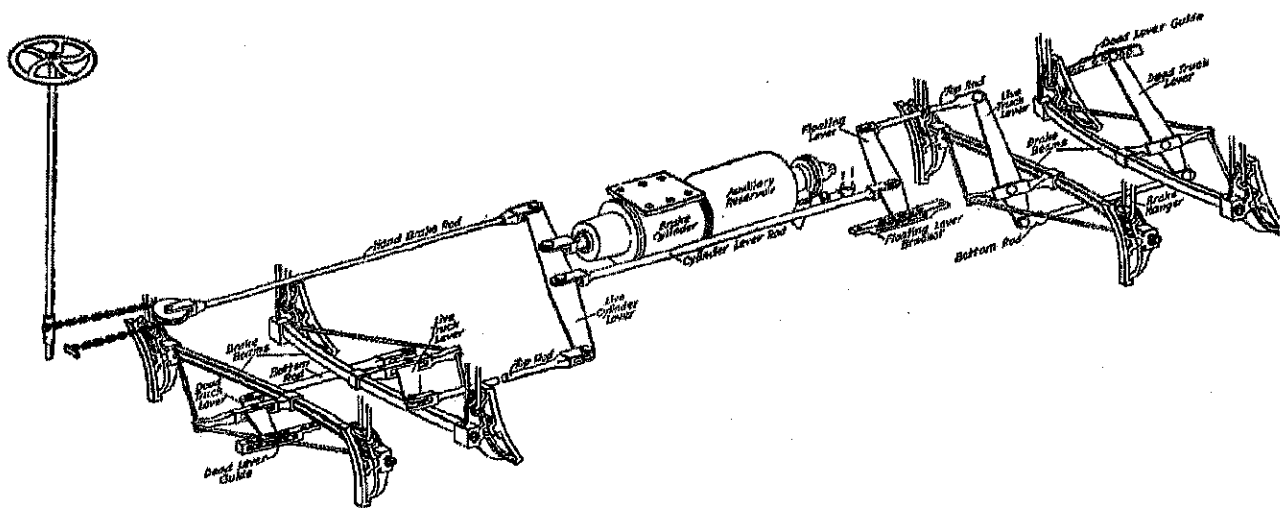


BRAKE CYLINDER (left): a cylinder and piston which, when filled with compressed air, imparts its force on the foundation brake rigging to apply the brake shoes against the wheel. The cylinder shown in the photo is applied, with the piston rod extended out from the cylinder body.

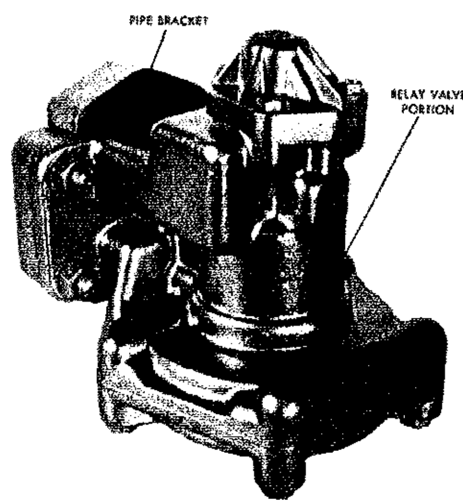
DEAD ENGINE DEVICE: Facilitates the movement of a dead locomotive in a train. This feature will charge the main reservoirs from the brake pipe, which permits the engine brakes to work as if it were a car in the train. The device consists of a strainer/check valve and cut-out cock in a connection between the brake pipe and the main reservoir. This feature is normally cut-out. However, when cut-in, the main reservoirs will charge from the brake pipe, thus providing air to operate the brakes.

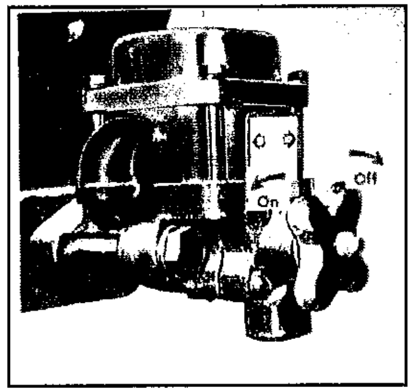


FOUNDATION BRAKE RIGGING (below): a system of rods and levers that connect the brake cylinder to the brake shoes and press them against the wheels

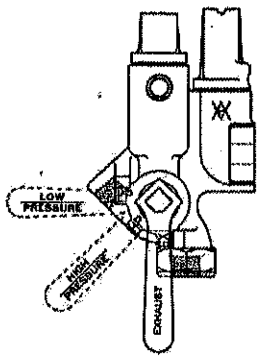


J-RELAY VALVE (right): Air pressure relay valve supplied with 26-C locomotive air brake equipment. Applies and releases the locomotive brakes in response to control air pressure input from the independent brake valve or the locomotive control valve using main reservoir air as its supply volume.





MAIN RESERVOIR AUTOMATIC BLOWDOWN (right): a device on most diesel locomotives attached to the main reservoirs to automatically drain off accumulated moisture in the tanks.



RETAINING VALVE (left): a valve on the end of the brake cylinder exhaust pipe which permits the retention of air pressure in the brake cylinder when the brakes are released. Used for braking on long or heavy grades.

TRUCK CUTOUT COCKS (not shown): Located under the running board above each truck is a bleed-type cut-out cock which will cut the air communication to that truck's brake cylinders out. This is to be cut-in at all times during normal operation. The brakes on a locomotive truck should never be cut-out unless of a severe failure of the air brake system that makes it unsafe to move the unit unless one truck, and nor more than one truck, is cut-out of the system and its brakes do not apply.

GENERAL PRINCIPLES
OF
AIR BRAKE & TRAIN HANDLING

CHARGING THE BRAKE PIPE

Auxiliary, emergency and control air reservoir volumes on cars and locomotives are charged through small openings in the control or distributing valve called *charging chokes* or *charging ports.* Because these openings are small by design, air pressure in the brake pipe will usually rise to its operating pressure more quickly than the air reservoirs on each car. Therefore, the brake pipe gauge in the locomotive may indicate the desired pressure, but air may still be flowing into the reservoirs on each car. This can give the Engineer a false impression that the brake system is fully charged when, in fact, it is not.

KEY FACT: The brake system is fully charged ONLY when air pressure in both the brake pipe & the air reservoirs is equal to the operating pressure set by the regulating valve on the locomotive & air is no longer flowing from the automatic brake valve into the brake pipe.

TIME TO PROPAGATE APPLICATION

From the time the Engineer makes an initial service reduction, brake cylinder pressure on the first car is initiated in about five seconds, and initial brake cylinder pressure is achieved on the first few cars in the train in about 15 seconds. However, on the last car of a 50-car train, it will be seven seconds before the brake even begins to apply and closer to 20 seconds before 10-psi of brake cylinder pressure is achieved.

KEY FACT: Keep in mind that the longer the train, the longer it will take the cars on the rear end to react to an automatic brake application.

DOWNGRADE TRAIN CONTROL

A characteristic of regular Railtown train operations is typically the short two or three car train operated over relatively heavy, undulating grades. On longer trains, the force between the flanges and the rail creates very noticeable curve drag, reducing the rate at which the train accelerates. Heavy trains tend to accelerate more slowly than light trains due to their greater mass and thus their resistance to changes in their state. A short train can accelerate quickly while drifting downhill because of the lack of curve drag and reduced mass.

Controlling train speed on undulating downhill grades is challenging. Gravity is pulling the train downgrade while braking friction and curve drag are resisting that pulling force. When the resisting forces are equal to the gravitational forces, the train is said to be "balanced" and its speed is maintained constant. But balancing a downhill train on the Sierra is more of a theoretical state than one that can actually be achieved due to the undulating nature of the railroad grade. Balance can only be achieved if the gravitational force remains constant. This requires a compensated railroad grade, a precision-engineered incline designed and built to maintain a steady gravitational pull on a train and to "compensate" for curve drag and other variables. Compensated grades are costly to build and do not exist on the Sierra Railroad. This requires the engineer to compensate for the constantly-changing forces over this railroad through the proper use of the train's air brake system.

In a hypothetical scenario, a train starts out on the downgrade from Jamestown with the brakes released and the brake system fully charged and tested. The engineer allows the train to accelerate to a safe speed and then makes a brake application to check that acceleration. If the brakes are applied to the theoretical optimum, the speed of the train will be held perfectly in check, balanced against the pull of gravity. However, in actual practice, especially with short trains, this is rarely possible.

What usually occurs is this: as the train accelerates downgrade, the engineer makes one or more brake pipe reductions to check the acceleration. The brakes apply and the speed of the train begins to decrease. Instead of balancing, however, the train gradually slows to a speed below the optimum desired. The engineer then initiates a brake release and the train begins to accelerate again, necessitating another brake application. On a long downgrade, it is necessary to "cycle" the air brakes on and off: release the brakes, the speed builds, apply the brakes, the speed decreases. The frequency of brake cycling must be minimized, and the time between applications maximized, to give the reservoirs on the cars time to recharge between each application. If needed, there is a reserve margin of air in the brake system if not fully recharged. Be aware, however, that each successive brake application without full recharge will be potentially less effective than the previous. If over-cycling continues, eventually brake effectiveness could diminish beyond the minimum required to control speed or stop the train on the downgrade.

To limit the amount of braking cycles needed to control the train, retainers are used. The function of retainers is to slow the release of air pressure from the brake cylinders and to retain a few pounds of air and thus some braking effort or drag. The use of retainers on downhill grades allows the engineer to reduce the number of braking cycles needed to control the train speed. Retainers are usually set before heavy downgrades and released when the grade allows.

An engineer must constantly be aware of the grades and curves in order to control the speed of the train. If a grade levels off or a curve is encountered, less braking effort is required. Conversely, an increasing grade or tangent track requires more braking effort. Familiarity over the territory helps the engineer to anticipate the braking needs, but even over familiar territory, conditions can change that affect train braking.

To handle a train well, an engineer must use all senses. While drifting downgrade, it is helpful to listen to the noise of the running gear or rail joints to determine if the train is accelerating or decelerating. Running a train is more intuitive than intellectual. Since the brakes do not apply or release immediately, anticipating the braking needs is a skill that must be learned. Proficiency in train handling only comes through experience.

MANAGING SLACK

Smooth train handling depends on the ability to control slack and an understanding of how to prevent it from running in or out harshly. Slack action is controllable by exercising forethought in the use of power, train and engine brakes, and sand. The heavier the engine and the longer the train, the greater the care required for the effective management of slack.

EMERGENCY BRAKE APPLICATIONS

Should circumstances require, do not hesitate to use an emergency brake application to obtain the quickest possible stop. If such a situation arises, quickly move automatic brake valve handle to emergency position. Automatic brake valve handle must be left in emergency position until the train stops. After making an emergency brake application, close the throttle and open sanding valve in case engine is not equipped with automatic emergency sanding. Continue use of sand by manual sander, if necessary, until the movement stops. This is important to prevent wheel slide as a sliding wheel will not produce as quick a stop as a rolling wheel with the heaviest possible brake applied that rail adhesion will permit.

In case an emergency brake application originates from any source other than the brake valve, the automatic brake valve handle must be placed in emergency position. Whenever the automatic brake valve handle is placed in emergency position it must be left there until train stops. Do not attempt to release brakes until at least 70 seconds have elapsed.

If the dynamic brake is in use when the emergency application occurs, care must be used to control the locomotive brake cylinder pressure by means of the independent brake valve in order to prevent wheel sliding.

NEVER, UNDER ANY CIRCUMSTANCES, ATTEMPT TO RELEASE AN EMERGENCY BRAKE APPLICATION BEFORE THE TRAIN COMES TO A STOP!

AIR BRAKE & TRAIN HANDLING RULES

General Rules:

A. Never move cars or engines without air brakes cut-in, charged and tested, except within yards or mechanical facilities and then only when other safeguards are provided to ensure the safe handling of equipment or rolling stock.

B. Brake pipe pressure regulating (feed) valves shall be maintained at 90-psi at all times. Locomotive Main Reservoir pressure must be maintained at least 15 psi above feed valve setting at all times.

C. Condensation must be blown from the pipe from which air is taken before connecting house air or locomotive air to train.

D. Air brakes must not be depended upon to secure equipment from undesired movement.

E. Set a sufficient number of handbrakes, and/or use chocks or skates, as necessary to secure equipment from unintended movement.

F. "Bottling the Air", or closing angle cocks on both ends of a standing cut of cars, is prohibited.

AB-1.0 Operative Brakes

Air brakes on all cars in a train must be operative unless they fail enroute. Cars with failed air brakes may continue in service to the nearest location where repairs can be made, provided air brakes on no fewer than 85% of cars in the train are operative. Otherwise, car with failed air brakes must be set out at the nearest possible location.

Under no circumstances shall a car known to have inoperative air brakes be handled at the rear end of a train unless a crewmember is in position to operate the hand brake.

AB-2.0 Air Brake Tests

AB-2.1 Locomotive Air Brake Test

Perform a Locomotive Air Brake Test before moving when:

a. First taking charge of a locomotive or locomotive consist.
b. Locomotive consist is changed.
c. Operating end is changed.

Locomotive Air Brake test procedure:

1. Secure locomotive to prevent unintended movement.
2. Ensure main reservoirs are fully charged.
3. From ground, observe application and release of independent brake.
4. Make a 10-psi reduction in brake pipe pressure and observe the application and release of automatic brake from ground. Test independent brake Quick Release or Bail-Off feature.

AB-2.2 Initial Terminal Air Brake Test

Only persons properly qualified may perform initial terminal air brake tests.

Perform an Initial Terminal Air Brake Test when:

a. Train is originally made up or dispatched at the beginning of the operating day (initial terminal), or a train is received in interchange.
b. Previously-tested cars have been disconnected from an air source for more than four hours.
c. The train consist is changed. However, an Initial Terminal Air Brake Test is not required if the train consist is changed only by:
   - Changing or repositioning motive power (including changing ends);
   - Removing a car or solid block of cars from the train;
   - Removing or changing the caboose;

In any of these cases, perform an **Application and Release Test** as described in Rule AB-3.2.

Initial Terminal inspection and test procedure:

1. Fully charge brake system until brake pipe pressure on last car is within 5 psi of the locomotive feed valve setting, as indicated by an accurate gauge or EOT, and air from automatic brake valve has stopped flowing into the brake pipe.
2. Inspect train air brake system:
   - Verify angle cocks are properly positioned.
   - Verify air hoses are in good condition, properly coupled and not leaking.
   - Verify that all retaining valves are in the EXHAUST position.
3. Upon receiving proper signal, make a 20-psi reduction from the automatic brake valve.
4. Once brake pipe exhaust stops, wait 60 seconds for brake pipe pressure to equalize, then cut out or lap automatic brake valve.
5. Wait an additional 60 seconds, then time brake pipe leakage for one minute. Leakage must not exceed 5 psi/min.
6. Verify by walking inspection that:
   - Brakes apply on each car.
   - Piston travel is within the range allowed for that car.
   - Brake rigging does not bind or foul.
   - Brake shoes align properly with wheels.

Upon receiving proper signal, recharge brake pipe and verify that brakes release on each car. Release verification may be completed by roll-by inspection of train by a qualified person. Verify that all handbrakes are released before moving train.

Handheld air gauges used for air brake tests do not require periodic inspections but must function properly. Defective gauges must be removed from service and not used until repaired. Do not leave gauges coupled to air hose following the completion of test.

AB-2.3 Application and Release Test

An Application and Release test may <u>only</u> be performed on trains that have previously received an Initial Terminal Brake test and have not been disconnected from an air source for more than four hours.

Conduct an Application and Release Test when:

a. Changing or repositioning motive power (including changing ends);
b. A caboose is changed.
c. A car or solid block of cars is removed from the train.
d. Helper locomotives are removed from the train.

Note: See Rule AB-2.5 for procedures when <u>adding</u> helper locomotives.

Application and Release test procedure:

1. Fully charge brake system.
2. Set retaining valve on rear car to EXHAUST.
3. Make a 20-psi brake pipe reduction with the automatic brake valve.
4. Verify that brakes on the rear car apply.
5. Move automatic brake valve to RELEASE position.
6. Verify that brakes on the rear car release.

AB-2.4 Running Air Brake Test

Conduct a Running Air Brake Test on passenger-carrying trains, regardless of type of equipment, when:

a. Train departs any location following an Initial Terminal or an Application and Release test.
b. Locomotive, engine crew or operating ends have been changed.
c. Any angle cocks or cutout cocks in the train have been closed.
d. A moving train strikes any debris on the track.

Running Air Brake test procedure:

1. Begin running brake test as soon as train speed will prevent stalling.
2. Make a 10-psi brake pipe reduction and bail-off (release) independent brake.
3. Verify brake application creates noticeable retarding force before releasing brakes.
4. Stop train immediately if braking force feels inadequate. Determine and correct cause before proceeding.

NOTE-1: Before proceeding, perform an Initial Terminal Air Brake Test on any train that fails a Running Air Brake Test. Once moving, immediately perform a Running Air Brake test again.

NOTE-2: If train is being shoved or cars are being handled ahead of engine and a crewmember on the point of movement has control of the air brakes, the Running Air Brake Test must be performed by the crewmember on the point of movement utilizing the air brake controls provided for the movement. Engineer must verify brake pipe continuity by observing the drop and restoration of brake pipe pressure on the proper air brake gauge in the cab.

AB-2.5 Adding Helper Locomotives

Except in case of emergency, air brakes must be controlled from leading locomotive at all times and automatic brake valves cut-out on all trailing locomotives.

2.5.1 Adding Helper Locomotive to Head-End:

1. Prior to adding helper locomotive, make a 20-psi brake pipe reduction from the road locomotive.
2. Couple helper locomotive and stretch coupling.
3. Make a 20-psi brake pipe reduction on the helper locomotive.
4. Cut-out automatic brake valve on <u>trailing</u> locomotive(s).
5. Connect brake pipe hoses and open angle cocks.
6. Fully recharge brake pipe from helper locomotive.
7. Perform Application and Release Test as outlined in AB-2.3; verify brakes on trailing locomotive(s) apply and release automatically.

2.5.2 Adding Helper Locomotive to Rear-End:

Helper locomotives must <u>not</u> be cut-in behind occupied caboose.

1. Prior to adding helper locomotive, make a 20-psi brake pipe reduction from the road locomotive.
2. Couple helper locomotive(s) and stretch coupling.
3. Make a 20-psi brake pipe reduction on helper locomotive(s) and cut-out automatic brake valve.
4. Connect brake pipe hoses and open angle cocks.
5. Fully recharge brake pipe from lead locomotive.
6. Perform Application and Release Test as outlined in AB-2.3; verify brakes on helper locomotive(s) apply and release automatically.

2.5.3 Adding Helper Locomotive Mid-Train or Behind Road Locomotive:

1. Prior to adding helper locomotive, make a 20-psi brake pipe reduction from the road locomotive.
2. Set handbrakes on train as necessary.
3. Cut train and couple to helper locomotive(s); stretch coupling.
4. Make 20-psi brake pipe reduction on helper locomotive(s) and cut-out automatic brake valve.
5. Connect brake pipe hoses and open angle cocks.
6. Recharge brake pipe from lead locomotive and test automatic brake before moving; verify brakes on helper locomotive(s) apply and release.
7. Re-couple to train and perform Application and Release Test as outlined in AB-2.3; verify brakes on helper locomotive(s) apply and release automatically.

AB-3.0 Use of Retaining Valves (Retainers):

Where use of retaining valves is required by the SNRY Special Instructions, westward trains must set not less than one retaining valve for every three cars in the train. Trains of fewer than three cars in length cars must set at least one retaining valve. Retaining valves are to be placed in the settings requested by the Engineer.

At all times use of additional retaining valves shall be at the discretion of the Engineer and must be set promptly when requested.

AB-4.0 Piston Travel:

Brake cylinder piston travel must be adjusted within a certain range for brakes to be effective.

Piston travel shall be adjusted as follows:

Freight Cars:	Minimum: 7-inches	Maximum: 9-inches
Passenger Cars:	Minimum: 6 -inches	Maximum: 9-inches
Diesel Locomotives:	Minimum: 3-inches	Maximum: 6-inches
Steam Locomotives:	Minimum: 4-inches	Maximum: 6-inches