DATA SHEET

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Sheet #:	**D9o**
Title:	**AIR BRAKES - Operation and Application**
Updated by:	**Gord Proudfoot**
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Originally Compiled by:	**Robert E. Warren, Jr.**
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1.0 THE BRAKING OF TRAINS

1.1 BASIC PRINCIPLES

Each train, consisting of locomotives and cars, must have a continuous pipe running from the front of the first locomotive to the end of the last car. This Brake Pipe supplies air from the compressor on the locomotive, through the brake valve (the engineman's valve) on the locomotive, to the control valve and reservoirs on the cars. The lead locomotive in a locomotive consist controls the operation of the brakes on the train; in case of an emergency, the train conductor can make an emergency brake application from the caboose although more commonly today, the "End of Train Monitor" (an electronic/pneumatic unit) is able to initiate an emergency brake application at the rear of the train when a radio signal is transmitted from the cab.

Train brakes are an automatic power brake. A control valve on every locomotive and car will apply and release the brakes on each individual unit of the train. Air is used as the power for the brakes and this air is stored in reservoirs on each rail car. The compressed air is also used as the medium to carry the signal to the control valve which will react to apply and to release the brakes. When the control valve is in the release position, the brake cylinder is drained of air and the air reservoirs of each car will be charged to the same pressure as the brake pipe. Except when an emergency brake application is initiated, the brake pipe will always be pressurized.

To apply the brakes, the engineman reduces the pressure in the brake pipe by moving the brake valve to the application position. This reduction in brake pipe pressure causes the control valve on each car to go to the applied position. In the applied position air is transferred from the auxiliary reservoir to the brake cylinder. As pressure is built up in the cylinder, the force developed by the piston is multiplied by the brake rigging and the brake shoes are pressed against the tread of the wheels. The amount of braking force in the train is proportional to the distance the engineman moves the brake handle into the application position. When the desired level of braking is achieved, the brake handle is moved to the lap position thus stopping the reduction in brake pipe pressure. In this position the required degree of braking is held until additional braking power is needed or the brakes are released.("26" type brake equipment, introduced in the earl 1960's, are self-lapping and will maintain brake pipe pressure at the set level without any further brake handle movement). To release the brakes, the brake valve is moved to the release position, compressed air flows into the brake pipe, raising its pressure. This rise in brake pipe pressure is detected by the car control valves, which then assume the release position and allow the air in the brake cylinder to exhaust to atmosphere. At the same time, brake pipe air is directed to the auxiliary reservoir to recharge it to brake pipe pressure.

1.2 BRAKE PIPE PRESSURE

The control valves mounted on each car as well as on the locomotive respond to pressure changes in the brake pipe, as well as the rate at which these changes occur. A decrease in brake pipe pressure, made by the engineman in the cab, applies the brakes. Any increase in brake pipe pressure releases the brakes and recharges the car reservoirs. For a normal (or *service*) brake application the brake pipe pressure is reduced at a relatively slow rate. A very rapid decrease in brake pipe pressure will cause an emergency application of the brakes.

The brake pipe pressure in a train is governed by the operating railroad and can vary between 75 psi and 90 psi. The higher brake pipe pressure allows a higher brake cylinder pressure for a full service brake application, so generally you will find higher brake pipe pressures where trains are heavier and longer, or in the more mountainous areas of the continent.

1.3 THE STRAIGHT AIR BRAKE

In 1869, George Westinghouse designed and manufactured the original air brake now known as the "Straight Air Brake".

The locomotive equipment consisted of a compressor, reservoir, three way cock, brake cylinder, piping, brake rigging, and brake shoes. The cars were equipped with a brake cylinder, piping, hose, brake rigging, and brake shoes.

The brake was applied by positioning the three way cock to allow the compressed air, stored in the main reservoir on the locomotive, to flow to the brake cylinders. Air pressure in the brake cylinders acting through the brake rigging caused the brake shoes to be applied against the wheel. The brakes were released by positioning the three way cock to exhaust the air from the brake cylinders. The *independent* brake on locomotives is a straight air brake. It provides the quick braking response necessary during hostler operations, however, as presented here, the straight air brake is not practical for trains over 8 or 10 cars.

1.4 THE AUTOMATIC AIR BRAKE

The next development from the original straight air brake was the "Automatic Air Brake" in 1873. This redesign was essential for two important reasons. Firstly, in the event of a train break-in-two with a straight air brake, the portion of the train broken away from the locomotive had no supply of air for the application of the brakes. The brakes were therefore non-operational. The second reason was that when trains reached a length of 20 cars or so, the build-up of air pressure in the brake cylinders closest to the locomotive was much faster than the pressure build-up in the brake cylinders toward the rear of the train. This unequal build-up of brake cylinder pressure throughout the train resulted in severe slack action and run-in of the cars.

The automatic air brake provides a local, auxiliary supply of air on each car for use by the brake cylinder. This auxiliary air supply is centered around a control valve known as the "Triple Valve" which operates to charge the auxiliary reservoirs, apply the brakes, and release the brakes. This arrangement, which makes a brake application by reducing brake pipe pressure, automatically applies the brakes if the train "breaks-in-two". Since each car has its own supply of air, it also results in a more equal brake cylinder pressure build-up throughout the train.

1.5 DIRECT AND GRADUATED RELEASE.

When making a brake application, in either freight or passenger service, the brakes may be set up in stages, that is a small brake application may be followed with a second one, increasing the braking force in stages.. This may be done until a full service brake application is in effect, that is when the pressure in the reservoir and the brake cylinder are equal. There is however a big difference between the releasing of the brakes on a passenger train and on a freight train. In passenger service, once a brake application is made, it may also be graduated off, that is, the brakes may be released in steps. This is not possible on a freight train. The freight brake is a direct release brake. Once the brakes have been set, they can only be released completely, they cannot be released in steps. The reason for this is the extreme lengths of brake pipe usually found on freight trains. It was found impossible to be able to transmit a "partial release" signal down a long train. With the relatively shorter trains found in passenger service and the more sophisticated equipment used, graduated release is possible, and desirable, in passenger service. A skillful engineman can, however make a "running release" of the brakes on a still moving freight.

1.6 CHRONOLOGY

	FREIGHT EQUIPMENT
YEAR	**EQUIPMENT**
1869	Straight Air Brake
1870	Plain Triple Valve
1871	"K" Triple Valve
1871	"AB" Brake Equipment
1950	Cobra® High friction brake shoes
1955	Wabcopac® and NYCOPAC truck mounted brakes
1956	"ABD" Brake equipment
1997	"ABDW" Brake Equipment
1989	"ABDX" Brake Equipment (WABCO) and "DB-60" (NYAB)
1990	TMX™ Truck Mounted Brakes
20xx	"ECP" Brake Equipment (Electronically Controlled Pneumatic)

HSC is essentially D-22 type equipment with added features to make it suitable for High Speed Control of Streamliners (Burlington Zephyr and subsequent trains).

	PASSENGER EQUIPMENT
YEAR	**EQUIPMENT**
1869	Straight air Brake
1887	Quick Action Triple Valve
1913	UC Equipment (Universal Control)
1914	HSC Equipment (High Speed Control) Early streamliners
1915	D-22-A Equipment Conventional passenger service
1916	HSC Equipment with Decelostat® (Wheel slip control)
1917	26C Equipment
1918	CS-1, CS-2 Equipment

2.0 FREIGHT CAR BRAKE EQUIPMENT

2.1 THE FREIGHT CAR CONTROL VALVE

The chart on page 3 outlines the history of the more significant Westinghouse Air Brake control valves that have been approved and fitted to freight cars over the past 100 years. The "K" Triple valve was removed from the Interchange Approval list in the mid 1940's and may not be used on revenue freight cars. There is now some pressure to remove the "AB" valve (1930 technology) from interchange service, to allow the maximum advantages offered by the newer (ABDW, ABDX, and DB60) valves.

2.2 THE "K" TRIPLE VALVE EQUIPMENT

The "KC" equipment was a unitized arrangement with the triple valve, auxiliary reservoir and brake cylinder integrated as a unit. On cars that still had wooden underframes this was a big advantage due to the large reduction in piping joints. For hopper type cars this arrangement was not always convenient, so the components were available as separate units. Note that the "K" triple valve did not have provision for increased braking effort under emergency conditions. It did have however a feature known as 'Quick Action', which increased the *rate* at which brake cylinder pressure built up when an emergency application was necessary.

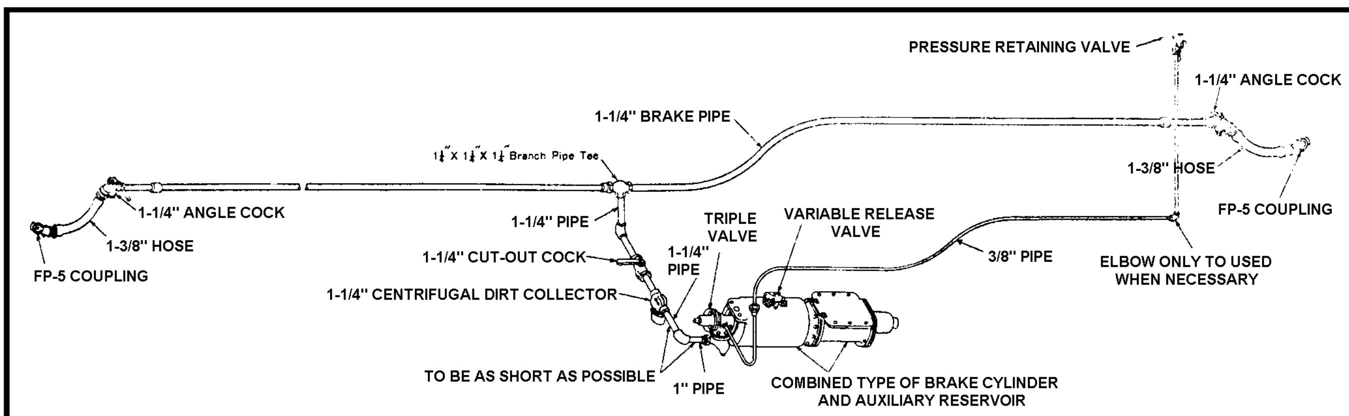

Figure 1: PIPING DIAGRAM OF THE TYPE KC FREIGHT CAR BRAKE EQUIPMENT "W"

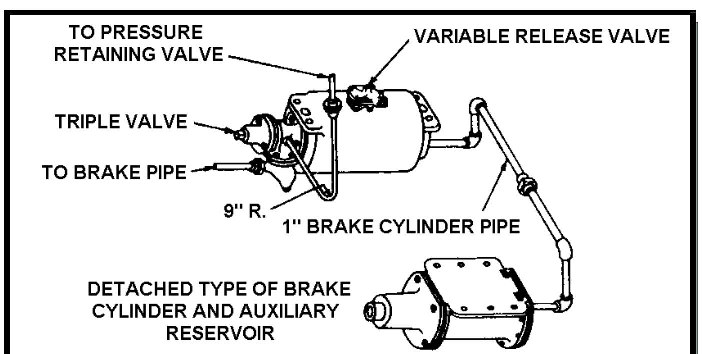

Figure 2: TYPE KD EQUIPMENT "W"

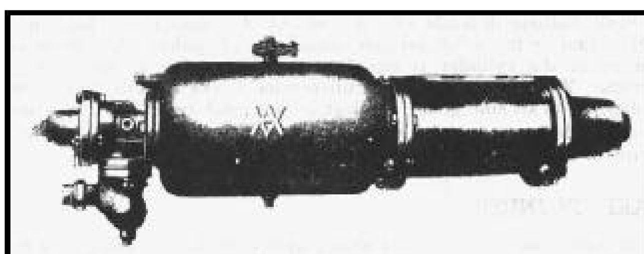

Figure 3: COMBINED TYPE BRAKE CYLINDER AND AUXILIARY RESERVOIR WITH TRIPLE VALVE AND VARIABLE RELEASE VALVE "W"

2.3 MAJOR COMPONENTS "AB" FREIGHT CAR BRAKE EQUIPMENT

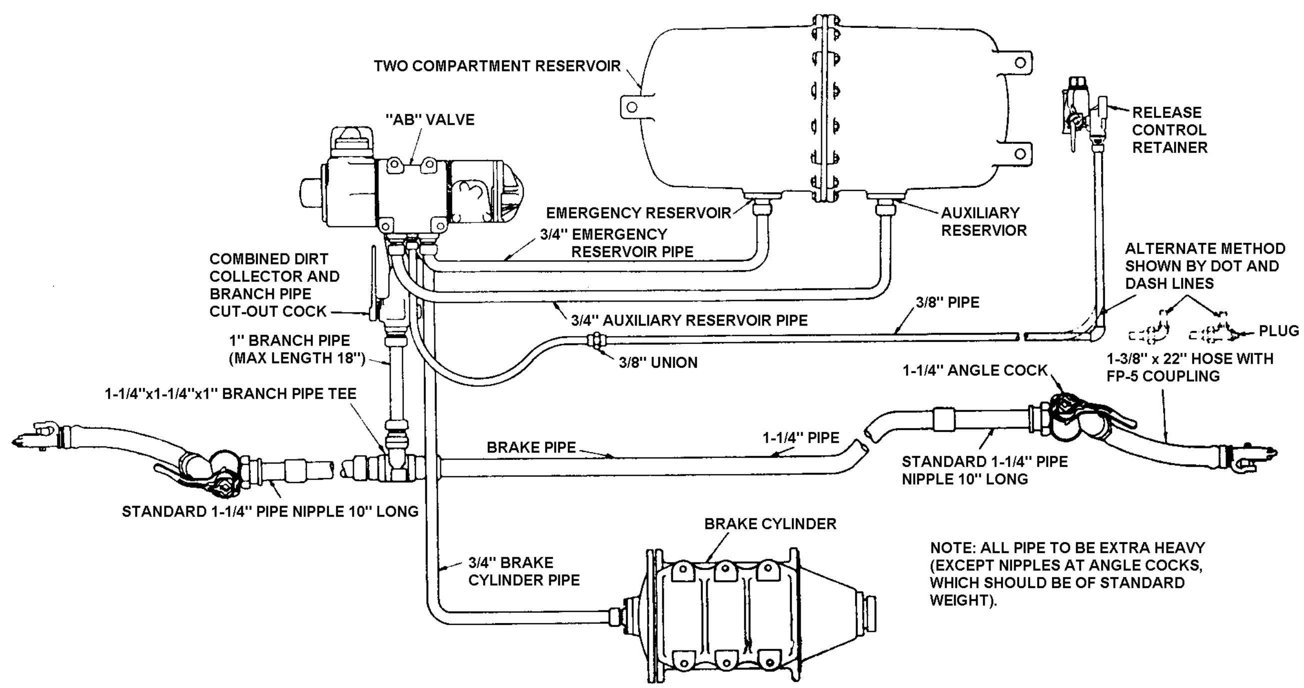

Figure 4: PIPING DIAGRAM OF THE COMPLETE "AB" FREIGHT CAR BRAKE EQUIPMENT

a) The "AB" Type Control Valve.
The "AB" type includes all variations of the AB valve, the major versions being the AB (1930), the ABD (1962), the ABDW (1974) and the ABDX (1989). New York Air Brake have a compatible control valve, the DB-60, introduced in the early nineteen nineties. The control valve operates to apply the brakes, release the brakes and charge the reservoirs.

b) The Two Compartment Reservoir
A cast iron or, more commonly today, a fabricated steel reservoir, combining the auxiliary and emergency reservoir volumes. The auxiliary volume supplies air for service brake applications, the auxiliary and emergency volumes together supply air jointly for emergency brake applications. The emergency volume also supplies a small volume of air to assist in the release of the control valve after a service application.

c) The Combined Dirt Collector and Cut-Out Cock.
Normally mounted on the control valve pipe bracket, its purpose is to reduce the possibility of entrance of foreign particles into the AB control valve. The cut-out cock provides a means of isolating the control valve from the train brake pipe.

MAJOR COMPONENTS "AB" FREIGHT CAR BRAKE EQUIPMENT - continued

d) The Branch Pipe Tee
This is the tee connector between the brake pipe and the AB Valve pipe bracket. It is arranged to minimize the possibility of water passing into the control valve.

e) The Angle Cocks
These are located on the brake pipe at each end of the car and may be closed to retain brake pipe pressure in a car or a cut of cars that are NOT part of a train.

f) The Brake Pipe Hoses
These are threaded into the angle cock at each end of the car and provide a flexible connection for the brake pipe from one car to the next.

g) The Pressure Retaining Valve
The retaining valve is connected, through the control valve, to the brake cylinder exhaust. When set manually the retainer valve will extend the time it takes for the brake cylinder to completely release the brakes or will hold the brakes set until manually released by resetting the retainer.

h) The Brake Cylinder
The brake cylinder piston is connected to the brake shoes by means of a series of levers and rods. The piston is moved by means of compressed air supplied from the reservoir by the control valve to apply the brakes. When the brake cylinder air pressure is released, the piston is returned to its retracted position by means of a spring.

I) The Automatic Slack Adjuster
The slack adjuster will automatically maintain a consistent brake cylinder piston travel over the complete range of wear of the brake shoes and wheels of the car.

j) The Handbrake
The handbrake is a manually operated mechanical device used to apply the brakes on a stationary car - a parking brake. Once the handbrake is set it must be released manually.

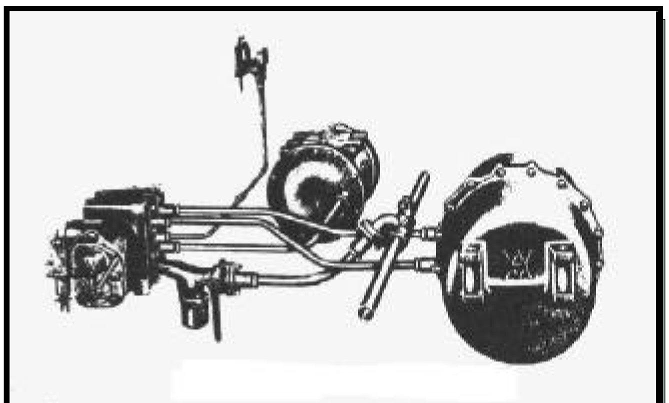

Figure 5: ASSEMBLY VIEW OF THE "AB" EQUIPMENT "W"

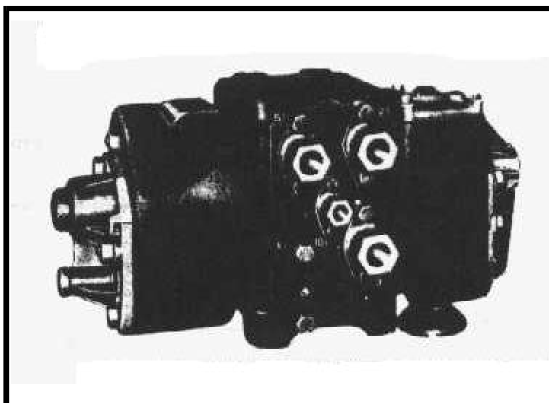

Figure 5: VIEW OF THE "AB" VALVE SHOWING PIPE CONNECTIONS

2.4 EQUIPMENT ARRANGEMENT

2.4.1 Major Equipment

Drawings on the subsequent pages show in picture form the arrangement of equipment on a freight car.

Conventionally, one brake cylinder is mounted on the freight car body and the braking force produced by the cylinder is transmitted to the shoes by means of levers and rods or "brake rigging". The Wabcopac® NYCOPAC and TMX brake assemblies put the brake cylinders right on the brake beams of the freight car and act directly to push the brake shoes against the wheels. All freight cars must be fitted, as a minimum, with the equipment shown. As rule of thumb, this equipment is required for every two trucks, which includes conventional as well as articulated multi-unit (5-pak and similar) cars.

The brake pipe must be continuous along the whole length of the train, the connections between cars being made with the brake pipe hose. The brake pipe may be closed off by means of the angle cocks ONLY when the car or cars are not part of a train (cars and locomotive). The control valve may be isolated from the brake pipe for maintenance reasons in the yard; it is also possible to "cut-out" a control valve should it be non-operative when the car is part of a train.

2.4.2 Auxiliary Equipment

Additional equipment may be fitted to a car to compensate for a long car brake pipe length or a high Light Weight to Gross Rail Load Ratio.

2.4.3 Long Cars

The A-1 Reduction Relay Valve helps transmit a brake application signal (service or emergency) along the brake pipe when there may be a long distance between control valves, that is on very long cars. On some TTX articulated cars, an ABDW Emergency Portion and Pipe Bracket has been used in place of the A-1 Valve. The improved efficiency of the ABDW and ABDX valves eliminates the need for the A-1, although a Vent Valve is still required if the brake pipe length of the car is more than 75'-0. A vent valve only functions under emergency brake applications and helps ensure that the emergency signal is transmitted rapidly and strongly along the train.

2.4.4 Light Weight Cars

Empty and Load equipment is used to detect whether a car is empty or loaded. This equipment helps ensure that the wheels do not slide when an empty car is braked heavily. The equipment determines whether the car is empty or loaded by determining the deflection of the truck springs. The S-1 Sensor Valve, P-1 Proportional Valve and Equalizing Reservoir form the Empty and Load Equipment. Many of the more modern cars use a unitized sensor and proportional valve. (ELX empty and load equipment). Another recent development used to detect a loaded bulk commodity car is a pressure sensitive diaphragm mounted in the slope sheet. All empty and load equipment considers whether the car is either "Empty" or "Loaded", no effort is made to determine partial loading. If a car is less than 20% loaded, it is considered to be empty by the Empty and Load equipment.

2.5 TRUCK MOUNTED BRAKES

The conventional two compartment reservoir has sufficient volume to handle four 8-1/2" Wabcopac cylinders at the lower limit of the AAR Braking Ratio Standard. Some 100 ton cars and early articulated cars (Wheat Board hoppers and CN Laser Intermodal cars, for example) were fitted with four 9" diameter cylinders, two cylinders for each truck. The standard two compartment reservoir no longer has sufficient capacity to provide the required full service and emergency brake cylinder pressures. For these cars, the two compartments of the standard reservoir were piped together externally to form the emergency reservoir; a separate reservoir was added as the auxiliary reservoir. This allowed the use of standard reservoir equipment, a big factor in interchange service.

2.6 COMPONENT ARRANGEMENT

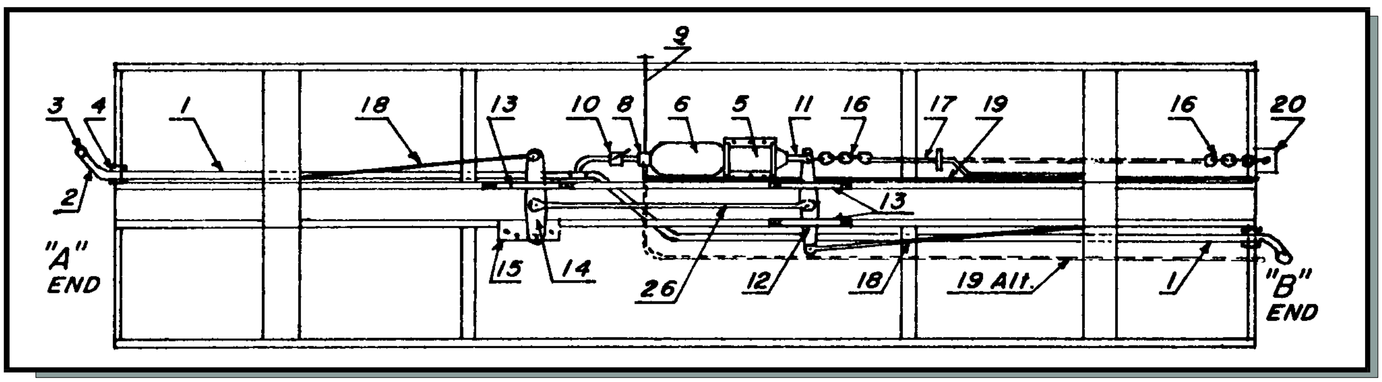

Figure 5a: COMPONENT ARRANGEMENT OF K-2 SYSTEM "SSR"

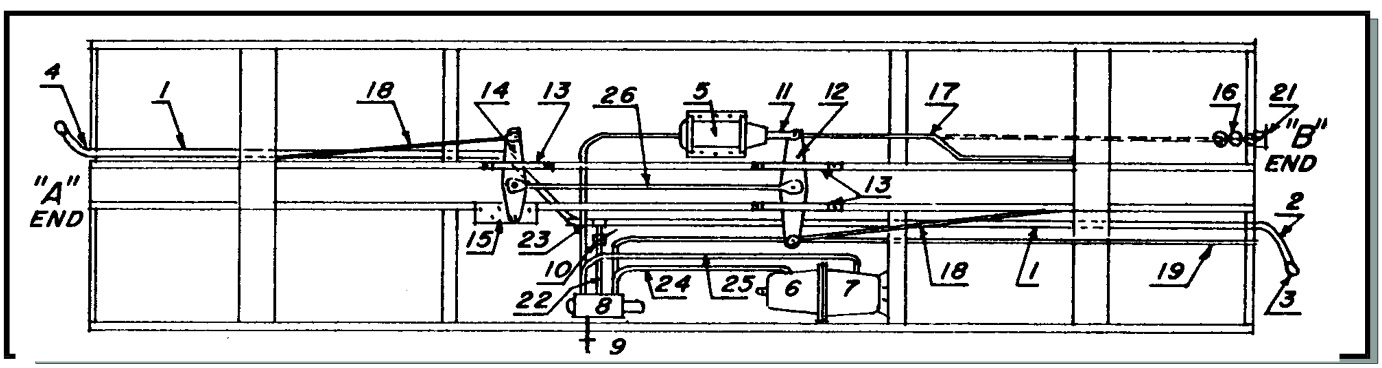

Figure 5b: COMPONENT ARRANGEMENT OF AB SYSTEM "SSR"

1. Train Line
2. Hose
3. Hose Coupling (Glad Hand)
4. Angle Cock
5. Cylinder
6. Auxiliary Tank
7. Emergency Tank
8. Triple Valve
9. Bleeder Rod
10. Dirt Collector & Cut Out Cock
11. Piston Rod
12. Live Cylinder Lever
13. Lever Hangers
14. Floating Lever
15. Floating Lever Bracket
16. Chain
17. Hand Brake Rod
18. Rod to Truck Levers
19. Retainer Line
20. Brake Staff Stirrup (For Horizontal Brake Wheel)
21. Bell Crank for Chain to Hand Brake Gear Box (Ajax etc.)
22. To Train Line
23. To Cylinder
24. To Aux. Tank
25. To Emerg. tank
26. Cylinder Lever Rod

3.0 PASSENGER CAR BRAKE EQUIPMENT

Piping diagrams of the major types of passenger car brake equipment are shown on subsequent pages. Since passenger cars were not in interchange in quite the same way as freight cars, there is not so much standardization on equipment arrangement. When modeling passenger cars, builder information is essential to determine the type of equipment, brake rigging arrangements and reservoir sizing.

The heavier the car, the more effort it takes to stop it. Therefore passenger cars may have brake cylinders of 12, 14 or 16 inches diameter and may have 1, 2 or 4 cylinders. To ensure proper brake cylinder pressure development, the reservoirs will be sized to suit.

UC PASSENGER CAR BRAKE EQUIPMENT						
RESERVOIR SIZING						
BRAKE CYLINDER INSIDE DIAMETER		14	16	18	14	16
NUMBER OF CYLINDERS		1	1	1	2	2
SIZE OF RESERVOIR	VOLUME (CU IN)					
AUXILIARY RESERVOIR						
10 x 33	2125	1	1	1		
12 x 27	2450				1	
12 x 33	3088					1
SERVICE RESERVOIR						
12 x 33	3088	1				
14 x 33	4476		1			
16 x 33	5724			1		
16 X 42	7436				1	
16 X 48	8577					1
EMERCENCY RESERVOIR						
18½ x 42	10014	1				
20½ x 42	12082		1			
20½ x 48	14003					2
22½ x 48	16661				1	
22½ x 60	21223					

MODEL APPLICATION

The following drawings show how air brake components may be applied to model rolling stock. They are not all-inclusive for the particular cars shown but are typical examples from which to work with so that a representative underbody may be reasonably modeled.

Such items as center-sills and cross-bearers have been omitted, but the modeler must take them into consideration when building up the air brake details. Such items as brake rodding and levers may go "through" a particular member if an appropriate-sized hole or slot is cut, or may "straddle" one or more underframe members. It is important that levers and connecting rods be kept at a near-level plane, usually in line with the brake cylinder. Most train line pipes are clamped directly to the underside of the floor of the car.

PIPING

Train line 1¼" OD
Brake Cylinder ¾ " OD
Branch Pipe ¾" OD
Emergency Reservoir ¾" OD
Auxiliary Reservoir ¾" OD
Retainer line 3/8" OD

RODDING

Varies from 7/8" OD to 1¼" OD, the rods connecting the two levers and cylinder being ¼" larger than the other rods.

LEVERS

Vary in both length and width, with the lever at the brake cylinder averaging 36" - 48" and the floating lever 30" - 36". Both levers are from 6" - 8" at the widest point and 2" - 3" at the ends.

MODEL APPLICATION - continued

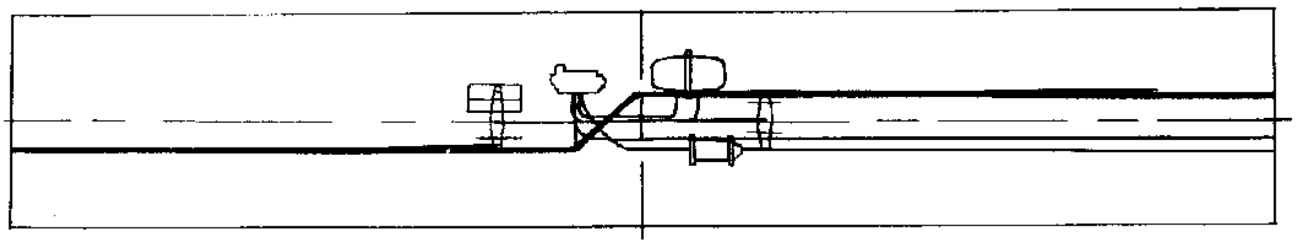

Figure 6: BRAKE ARRANGEMENT DROP BOTTOM GONDOLA "GATC"

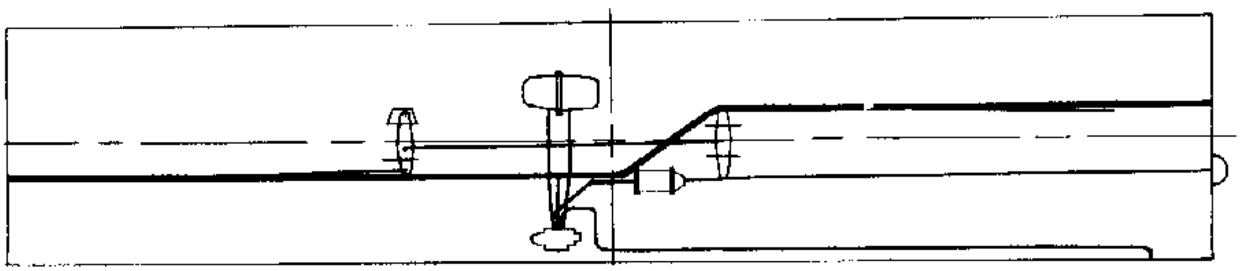

Figure 7: BRAKE ARRANGEMENT FLAT CAR "GATC"

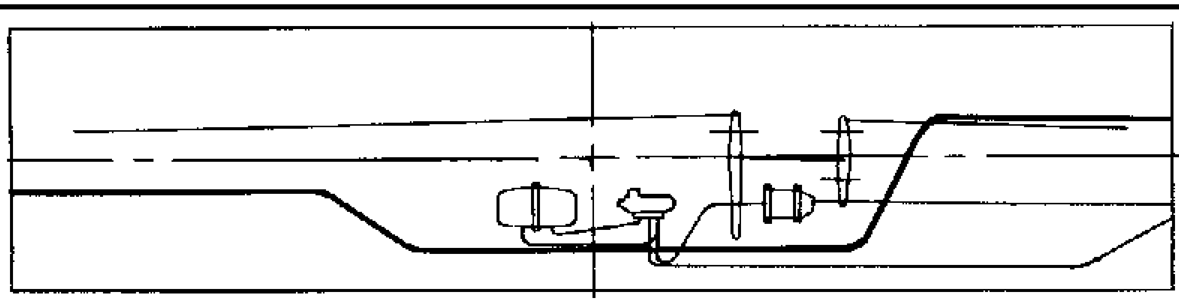

Figure 8: BRAKE ARRANGEMENT 40' BOX CAR "GATC"

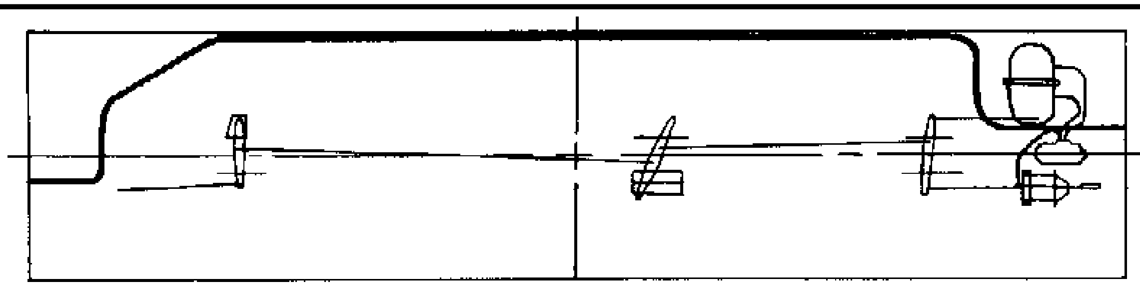

Figure 9: BRAKE ARRANGEMENT 70 TON HOPPER "GATC"

MODEL APPLICATION - continued

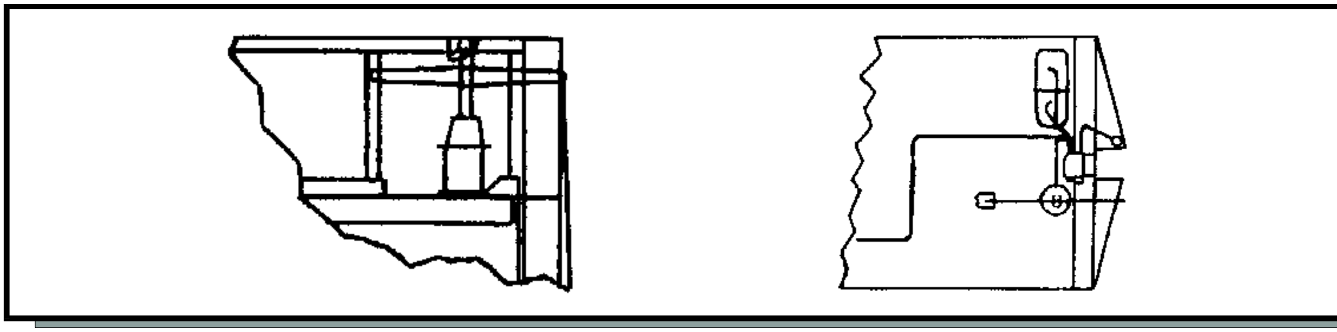

Figure 10: END VIEW AND PARTIAL SIDE VIEW OF 70 TON HOPPER "GATC"

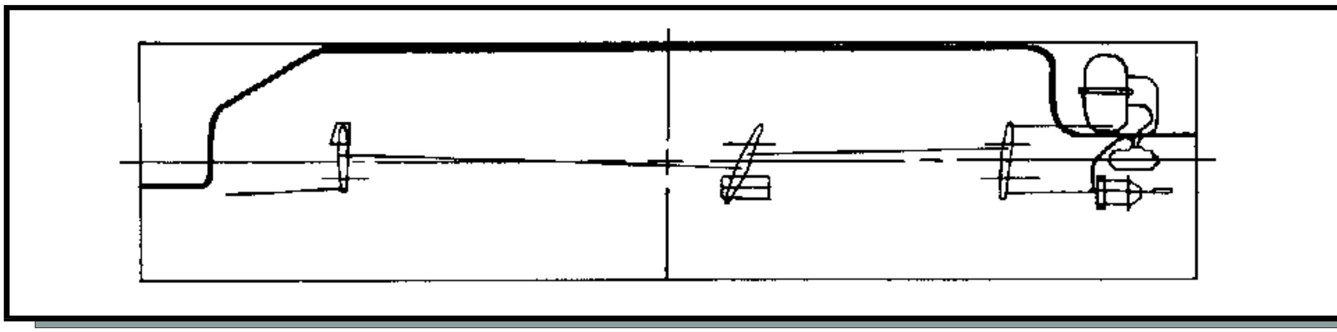

Figure 11: BRAKE ARRANGEMENT CABOOSE "GATC"

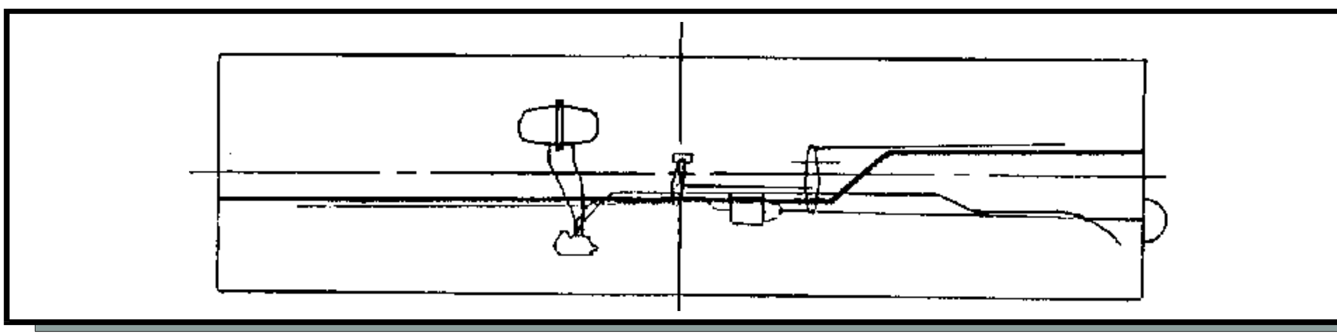

Figure 12: BRAKE ARRANGEMENT TANK CAR "GATC"

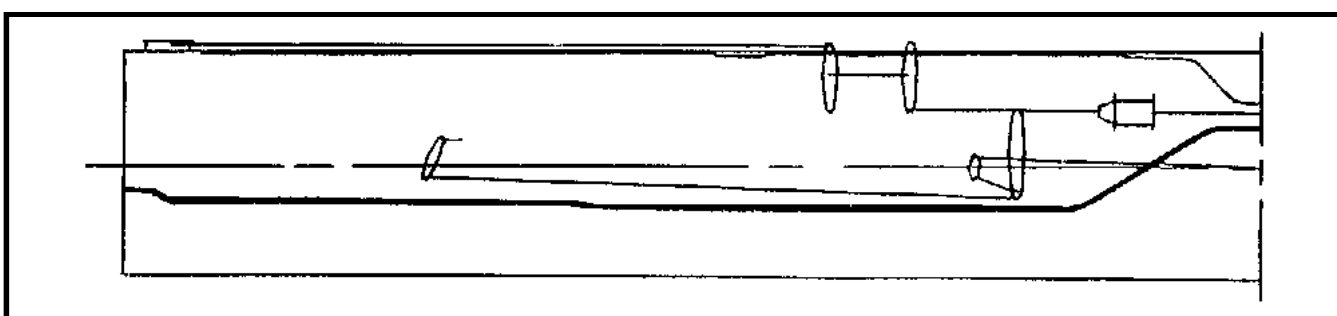

Figure 13: BRAKE ARRANGEMENT 85' TOFC FLAT CAR "B" - END "GATC"

MODEL APPLICATION - continued

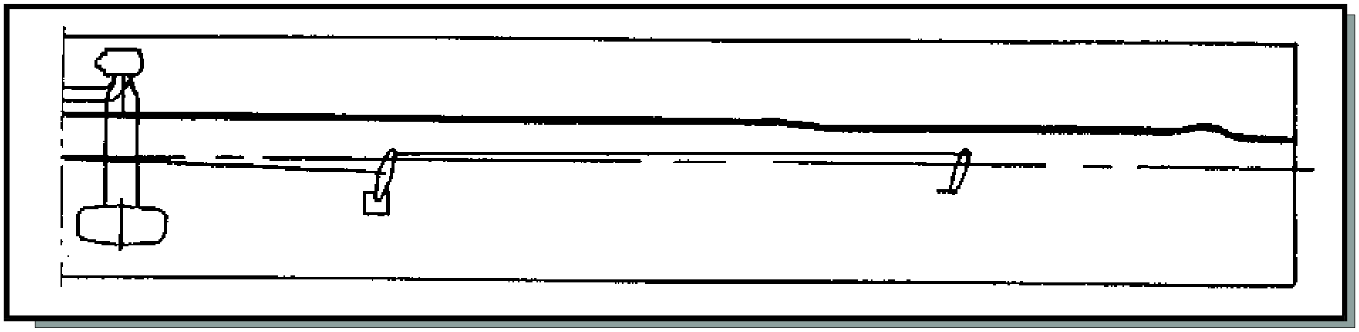

Figure 14: BRAKE ARRANGEMENT 85' TOFC FLAT CAR "A" - END "GATC"

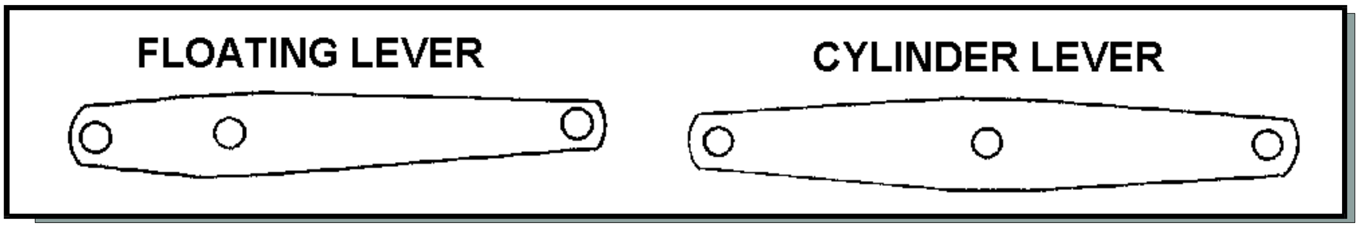

Figure 15: BRAKE LEVERS "GATC"

PASSENGER EQUIPMENT UNDERFRAMES

There is no prescribed or required location for air brake equipment. The location will depend upon the type of car which, in turn, dictates the items and placement of underfloor equipment. Air brake equipment is then installed in such as manner as to allow the shortest distances feasible between components. Piping is installed to clear the underfloor equipment and to allow accessibility to it and the other components.

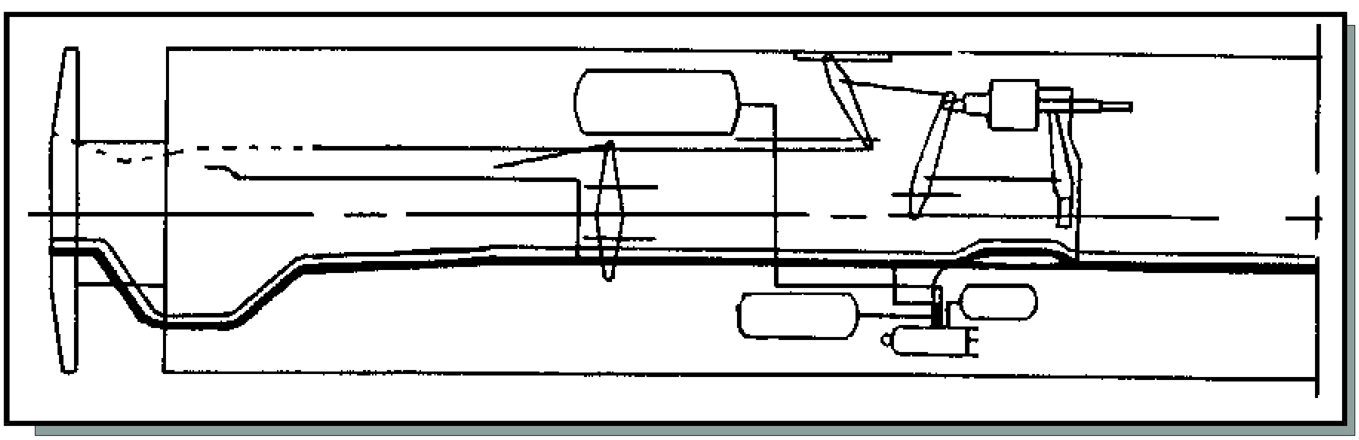

Figure 16: BRAKE ARRANGEMENT PASSENGER CAR "B" - END "ACL RR"

MODEL APPLICATION - continued

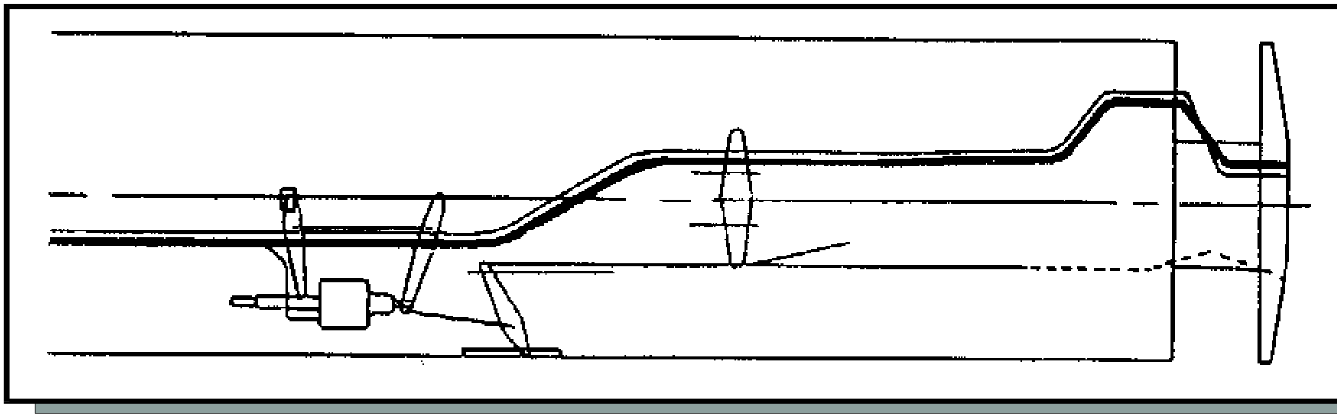

Figure 17: BRAKE ARRANGEMENT PASSENGER CAR "A" - END "ACL RR"

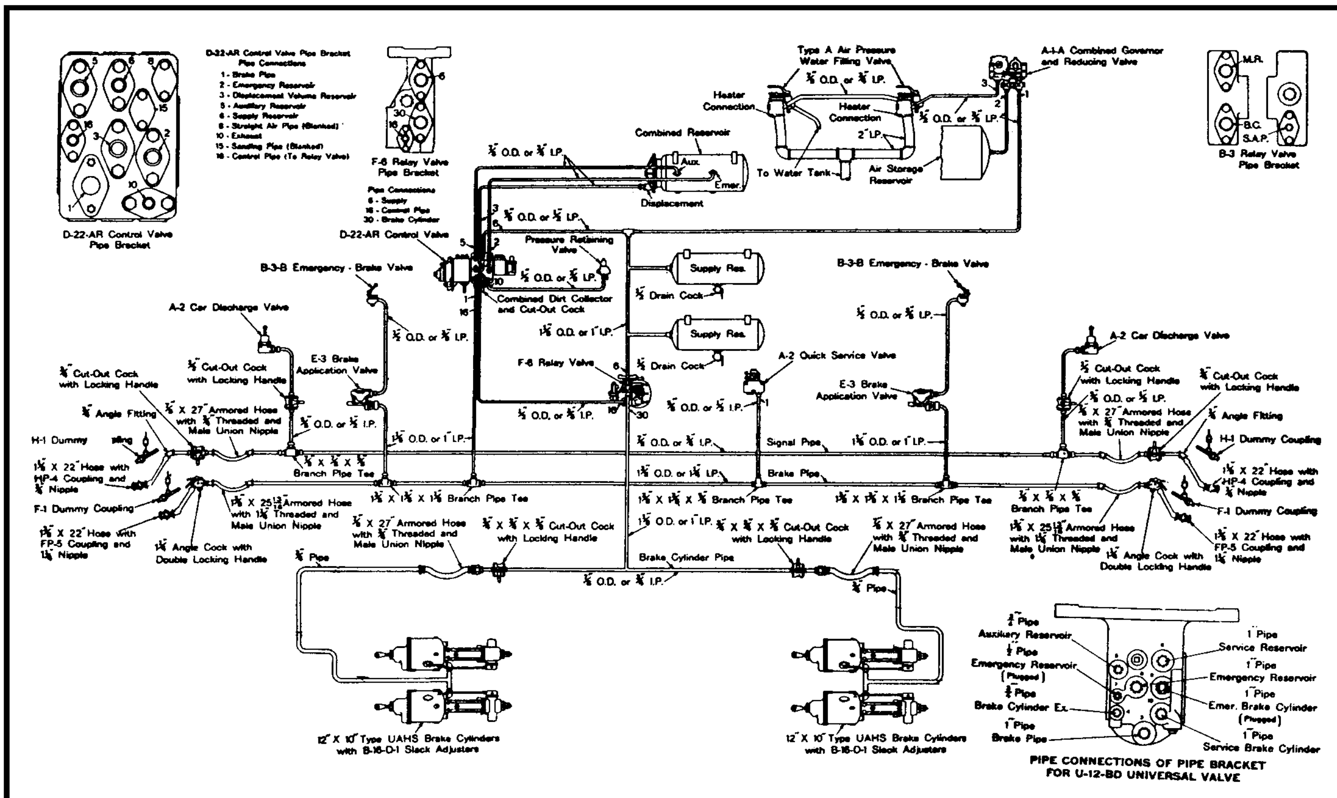

Figure 18: PIPING DIAGRAM OF THE D-22-P PASSENGER CAR BRAKE EQUIPMENT "W"

MODEL APPLICATION - continued

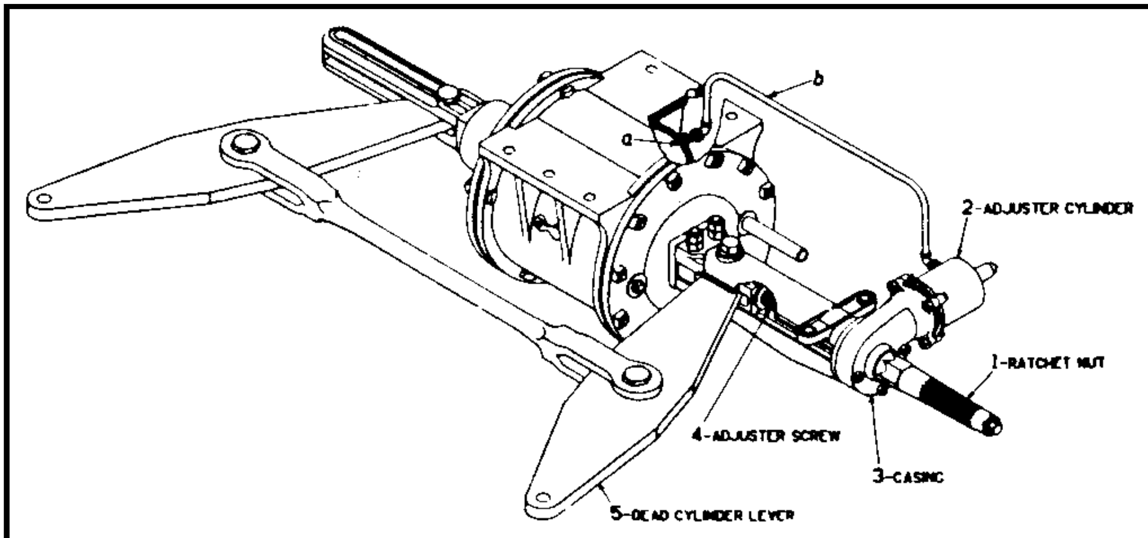

Figure 19: APPLICATION OF SLACK ADJUSTER TO BRAKE CYLINDER "W"

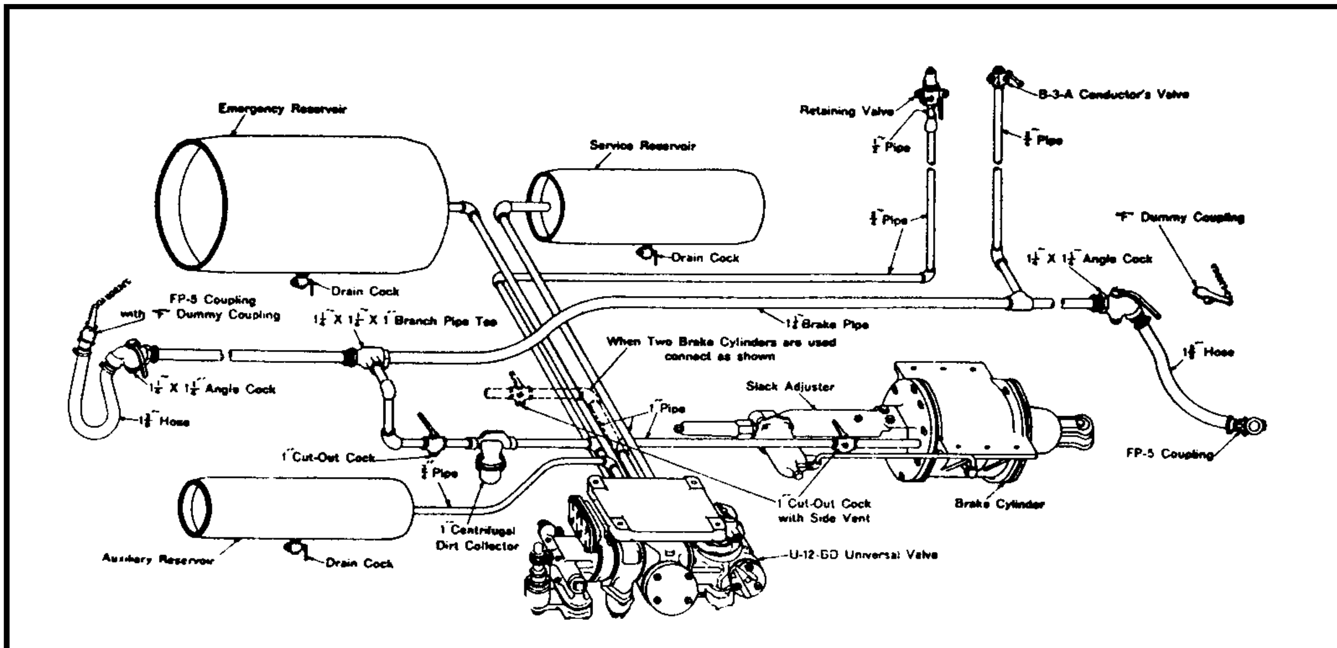

Figure 20: UC PASSENGER CAR BRAKE EQUIPMENT PIPING DIAGRAM "W"