Air Brakes For The Private Car Owner

By Artisan

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As everyone knows, the primary purpose of air brakes on a passenger car is to enable the car to stop when desired. The purpose of this article is to explore the braking system with a view toward discovering why a particular car continuously used up more brake shoes than it should and would also incur slid flat wheels. During the course of the investigation, a great deal was learned about the passenger car air brakes, and the function of the various parts.

Fundamentally, there are few differences between passenger car brakes and freight car brakes. Both require a control valve a supply reservoir, an auxiliary reservoir, and one or more brake cylinders. In fact, a freight car valve such as the ABDW can be substituted for the D22 valve found on most modern passenger cars with only a minor loss of function. That minor function is the capability of the passenger car brake to provide a graduated release. When freight car brakes are released, they release throughout the train immediately. Passenger car brakes, on the other hand, can be released in stages.

To begin the study of air brakes, it is recommended that various sources of information be read and analyzed. A good beginning point for an overview is an article entitled "The Westinghouse Air Brake Story", which was published in TRAINS magazine starting in October, 1975, and has been reprinted in pamphlet form by them. Another very valuable source on the history of air brakes is found in your public library. There, you will find the International Correspondence School textbooks on air brakes, and also various booklets written by air-brake instructors and engineers on the history and workings of various kinds of air brakes. Additionally, pamphlets have been produced by Westinghouse Air Brake Co. which contain instructions on the operation of the various types of brake equipment. In addition, Westinghouse has also prepared booklets on the testing devices for the various kinds of air brakes, as well as shop maintenance instructions. They have also prepared catalog sheets which are invaluable when it is necessary to order new parts. The catalog sheets do not explain the workings of the brake and thus do not show where the various passages go. For this, you will require an instruction manual.

In addition, the Air Brake Association located in the Railway Exchange Building in Chicago also publishes a number of books on air brakes. Most of their publications are designed for instruction in locomotive brakes. Locomotive brakes generally have little to do with passenger cars, however, on some of the latest adaptations for business cars, a number of the locomotive devices are being used. Finally, the Railway Educational Bureau, 1809 Capitol Ave., Omaha, Nebraska 68102 offers correspondence lessons on air brakes.

At one time a very valuable source of information on passenger car brakes was the local air brake man, and to some extent, the Westinghouse Air Brake and New York Air Brake representatives. Since so few passenger cars are now being built, the manufacturers' reps are largely skilled only in freight car brakes. The local air brake repairman who dealt with passenger trains is a dying breed. Today, there are few small brake repair shops scattered around the railroads. Most of the railroads have consolidated their air brake shops in one location and all parts are sent there for cleaning and/or exchange. The few qualified independent shops are generally inconveniently located and their repair prices are relatively steep.

Consequently, when air brake troubles arise, there will be few places to turn for help. Therefore, you will be required to study all of the available texts and then make your own diagnosis of the problem. You should start with the

proposition that if your passenger car is a standard car, it was built in accordance with certain physical requirements, and that if there is nothing broken or malfunctioning in the brake system, the car will brake and handle as it was intended to handle. The car designer knew what the weight of the car would, be, and undoubtedly arranged the brake cylinder sizes and the mechanical advantage of the brake rigging to suit the car and the type of brake shoes for which it was designed.

The braking characteristics of cast iron brake shoes are completely different from the braking characteristics of the high friction composition brake shoes (Cobra) which in turn are different from the low friction composition brake shoes. Each requires a different arrangement in the mechanical rigging of the brakes. Often, when brake problems arise on private cars the suggestion is made that you should change from cast iron brake shoes to Cobra shoes. The reason is that a cast iron brake shoe works most effectively at slow speeds, and thus if there is a tendency to lock up and make the wheels slide, this will be done at a slow speed. On the other hand, the Cobra brake shoe frictional characteristics are generally linear throughout the speed range. Consequently, the Cobra brake shoe is no more likely to lock up at slow speeds than it is at high speeds. However, the Cobra brake shoe requires substantially less pressure to actuate and to obtain the same result as a cast iron brake shoe. Therefore, it is not possible to substitute Cobra shoes for cast iron shoes without making further changes in the brake arrangements. Fortunately, on some D-22 equipped cars this can be done by simply changing the relay valve so that a lower pressure is impressed on the brake cylinders, However, while this is theoretically possible, it may not be possible as a practical matter since the relay valve which you now have may be of the smallest reduction available. But, more on this concept later.

The most widely used brake equipment on passenger cars today is the D-22. The D-22 equipment has three major components namely the control valve, the relay valve and the brake cylinder. D-22 equipment is more complex than the UC (U-12-BD) which it replaced, and this in turn is more complex than the LN equipment which it replaced. The most modern passenger car equipment is the 26-C which is rarely found on any private cars. The outstanding advantage of the 26-C is its service life, which should be comparable to the ABDW valve found on modern freight cars. The ABDW valve has now been rated for 12 years of use before it must be removed and cleaned. This has happened as a result of replacing all of the pistons and brass rings with modern silicone rubber diaphragms and "O" rings. Because of its passenger application, however, 26-C has a conservatively rated service life of 36 months.

The D-22 equipment must be removed from the car and thoroughly inspected, repaired and renewed every 24 months. The earlier type valves require even more frequent reconditioning. As the number of passenger cars in service is reduced, the availability of spare parts becomes more of a problem. It is not unusual to find that air brake suppliers no longer have the parts that you need in stock and they must be back-ordered. The long term solution for a private car owner is to change from the D-22 to ABDW or 26-C as has been done on AutoTrain, Mopac Southern, and Conrail business cars.

Referring to the D-22 Diagram (Figure 1), you will see that attached to the brake pipe are only four connections. One of these is at each end of the car and goes through the E-3 brake application valve to the conductor’s valve. The conductor’s valve generally has only two positions: closed and open. When it is open, it actuates the E-3 brake application valve to dump all of the air in the brake pipe to the atmosphere. As an aside, it should be pointed out that if the conductor’s valve is ever opened by mistake when the train is in motion, it should not be closed until the train is brought to a complete stop. The reason is that all of the brakes in the train will be thrown in emergency. But if the conductor’s valve is then closed, it is possible for some of the brakes to move from their emergency position to release position, while others remain in the emergency position, resulting in a fair possibility of derailing the train and/or causing problems when it comes time to recharge the system to proceed. It should also be pointed out that a passenger car is designed to come to a stop in emergencies without sliding the wheels. Occasionally, the wheels do slide but this is usually the result of greasy or wet rails, and not as a matter of mechanical malfunction. The key word is "usually", and we will soon get into our story.

Another connection to the brake pipe is the quick service valve. Its function is to propagate local quick service activity from car to car in a long train, thereby quickening the application of the brakes.

The primary connection to the brake pipe is the D-22 control valve. The control valve is the modern triple valve and has two portions. One is the service portion, which controls all of the ordinary service applications of the brakes. The other is the emergency portion which controls the emergency application of the brakes. You will note there is a small pop valve, or safety valve, on the emergency portion. This safety valve is set at 60 PSI and forms no part of the emergency portion. Instead, its function is to prevent a service application of the brakes from exceeding 60 PSI in the control line. Connected to the control valve is a combined auxiliary, emergency and displacement reservoir. The air pressure contained in this reservoir is utilized by the D-22 control valve to control the relay valve through the control line 16.

In the diagram, the relay valve is shown to be an F-6 valve and the control line from the D-22 control valve is line 16. The relay valve takes air from the two supply reservoirs and feeds it through the brake cylinder pipe to the brake cylinders in proportion to the pressure in line 16. If the relay valve were an F-1 (standing for 100%) valve, then the relay valve would supply and maintain pressure in the brake cylinders identical to that contained in control line 16. Most heavyweight cars and nearly all lightweight cars having disc brakes use an F-1 relay valve. Most lightweight cars using cast iron brake shoes use an F-6 (i.e. 60%) relay valve. The F-6 relay valve delivers only 60% of the control line 16 pressure to the brake cylinders. You will note in the diagram a reference to a B-3 relay valve. It was a predecessor to the F-1 and operates in the same manner as the F-1 relay. In some more modern cars, the F relay has been replaced with a J relay. The J relay is commonly used in locomotives and can be used in a wide variety of proportions. The advantage of the J relay is the same as that of the new ABDW valve, it has no pistons and rings but instead uses silicone rubber diaphragms and "O" rings.

The other major piece of plumbing seen on the diagram is that belonging to the signal system. There is a signal pipe running the length of the car and generally there is a signal valve at each end of the car. It is used to actuate a small whistle in the locomotive, so that the conductor may communicate with the engineer.

Often you will discover a number of other components under the car which are attached to the brake pipe. One of these may be the air connections to the water raising system. Typically, the water tanks are below the car and air pressure is used to move the water up to the faucets. This requires the use of a combined governor and reducing valve whose function is to reduce the air pressure to 25 p.s.i. or less and hold it at a constant value to provide a head for the water tank.

Additionally, if yours is a rear end car, you will also have a back up whistle connected through a whistle valve to the brake pipe.

Another connection in the brake pipe is to a duplex air gauge. The duplex air gauge has two pointers. The black pointer indicates the pressure in the brake pipe, which on a passenger train is typically 110 pounds. In freight service it may be 70 or 90 pounds, depending on the railroad. The red pointer indicates the pressure in the brake cylinders. Ordinarily, when the engineer applies the brakes, you will notice a brake pipe reduction of, say, 10 pound. With an F-1 relay, the brake cylinder pressure will then go up to 20 - 25 pounds; that is to say, that generally the brake pressure is a little more than twice the brake pipe reduction. This does not hold true when the brakes are put in emergency or after the maximum braking pressure is reached. Because of the safety valve, mentioned earlier, on the emergency portion of the D-22 valve, the control line pressure should never exceed 60 pounds during a service application, and will ordinarily be considerably lower.

Back in the '30s, a new brake system was developed which was a combination of both pneumatic and electrical components. The story of this system is found in Part 3 of *The Westinghouse Air Brake Story*, and a more technical explanation is found in the Westinghouse instruction pamphlet for the D-22BR control valve. Although a great number of cars were built with this system, and nearly all of them have been changed over to the more familiar D-22AR control valve, a few cars may be left with the old electropneumatic system, but

they have been deactivated. However, a number of strange braking problems can occur because of the residual effects of this attempt at high-speed braking. You can identify if your car was ever equipped with the electropneumatic braking system by a careful inspection of the braking components found under your car. Generally, the most obvious telltale sign was the third brake pipe which ran the length of the car. Typically, the glad hands have been removed, but the pipe left under the car. It is a small diameter pipe, 5/8 inch in diameter, and thus is readily distinguished. The signal pipe is a 3/4 inch diameter line and still necessary. The brake pipe is 1 1/4 inch diameter. An additional clue would be the presence of magnet valves and electrical wiring near the relay valve, which do not fit the piping diagrams for the ordinary D-22 system. The electrically driven components may not have been removed since they do not affect the current operation of the air brake system. In addition, the F-6 relay valve blanking plate may have magnet valves attached to it. Again, these may have been left in place, and do not affect the proper working of today's systems. These magnet valves were used in conjunction with an electrical generator system to change the brake cylinder pressure in proportion to the speed of the car as the brakes were being applied. Thus, your car may have a blanking plate with magnet valves on it which indicate that it is an F-1864 relay valve. If the electrical connections have been broken, this relay will act as though it were an F-6 relay.

Your car may also be equipped with the Decelostat system. This device is utilized to determine when the wheels are not rolling and reduce the brake cylinder pressure at that instant. Thus, the system works to prevent the brake from locking up and to prevent the formation of flat spots on the wheels. The Decelostat is entirely pneumatic in operation. There is also an electrical equivalent of this system, known as the Rolokron, which performs the same function through electrical transition. Either system works fine, and if your car is so equipped, you are exceedingly lucky, and should keep it in proper repair.

With all the background out of the way, we will now begin our story. A passenger car was acquired which had a brake system that acted properly, For example, during an emergency brake application on the SUNSET, the car came to a rolling stop. The wheels did not slide.

A year or so later, it came time for the two year brake cleaning and the car was turned over to a railroad for this work. Rather extensive renewal was required, including replacement of three brake cylinders, the making of new bolts in the brake rigging to replace worn bolts, and the like. All of the various needed components were traded for rebuilt items from the railroad's stock. The reason that the repairs were so extensive is that the previous owner railroad had failed to perform the type of maintenance which would have been required if they were going to keep the car in service. This car was acquired just before the railroads went out of the passenger business.

After these repairs, it was noted that the car seemed to burn up an inordinate number of brake shoes. For example, after a 700 mile trip, it might be necessary to replace three or four cast iron shoes. Additionally, flat spots were being to develop, for no known reason. A thorough investigation of the brake system was instigated. On several occasions, the compressors were borrowed, the single car tester obtained, and numerous checks made to see if the brakes were functioning properly. In every instance, it was found that the brakes applied and released as they were supposed to. Each of the brake cylinders has a pair of pipe plugs in it and these plugs could be removed and pressure gages inserted. The pressure gage should have a 1/8 inch NPT fitting on it, or an adapter may be used. In this manner, it can be observed what actual pressure is applied to each cylinder. In my case, four gages were used. All pressures were identical, as they should be, since they are all connected in parallel to the relay valve (refer to the D-22 Diagram). The pressures actually observed at the brake cylinders were roughly equivalent to the pressure shown by the red pointer on the duplex gage within the car. Unfortunately, there were no data sheets available to indicate what the brake cylinder pressure should be. We noted that in an ordinary brake application, the brake cylinder pressure might get up to 60 pounds, and in an emergency application, the instantaneous pressure would go up as high as 95 pounds. These observed pressures were not out of line for some passenger cars, but appeared to be too great for this car, because the brake shoes were being used up. It should be added that after the investigation of the functioning of the D-22 control valve, there was no discernible problem with the relay valve.

Consequently, the decision was made to solve the problem a different way. The lines between the relay valve and the truck mounted brake cylinders were cut, and pop valves or safety valves were inserted in the lines. The safety valves were set at 40 p.s.i., and would bleed off the excess pressure, hence the brake cylinder pressure to the brakes would be thereby limited. Additionally, you will recall that there is a safety valve in the emergency portion of the D-22 control valve. As was mentioned, this safety valve does not affect the emergency operation, but instead is a limitation on the pressure during service brake applications. This valve was also reduced from 60 lbs. to 40 lbs.

As a result of these modifications, some relief was noted. In theory, total relief should have been obtained, but in practice it did not happen. Nonetheless, at that time we did not fully understand what we had done but felt that the following was the result. First, in ordinary brake applications, the control line pressure would be limited to 40 p.s.i., and the relay valve would act accordingly. Further, even in an emergency application the brake cylinder pressure should have never gotten over 40 p.s.i., because of the two safety valves which were put in the line on the way to the brake cylinders. However, this did not solve the problem. Instead, it was found that when the car went into emergency, the brake cylinder pressure would still instantaneously jump up to 90 or 95 p.s.i. It took some time for the safety valve to bleed off the pressure and reduce it back to 40 p.s.i. During this definite time, which might extend to 15 or 20 seconds, the brakes would apply entirely too much pressure, hence the tendency toward flat spots was reduced but not eliminated.

In retrospect, it should be observed that the reason that the pop valves in the brake cylinder line did not function as we had hoped that would is that the relay valve was being told what pressure to put on the brakes by the control line 16. The relay valve is supplied with the air to do this job from the two large supply or main air reservoirs under the car. The volume of compressed air in these reservoirs is so great, that they would continue to supply high pressure air to the relay valve until they were depleted. As a result, we still continued to burn up cast iron brake shoes during each trip.

In any event, we began to suspect, after the above described modifications, that our flat spot problem was only occurring during emergency brake applications. Although you would think this is a rare phenomenon, it occurs more often than it should. We have been on several trips, where the locomotive has broken an air hose, causing the entire train to go into emergency at 90 m.p.h. Also, it is not uncommon for switch engine operators to throw the cars into emergency when they are transferring a private car from one siding to another. Additionally, we have backed into passenger stations, and have had the conductor throw the train into emergency in order to stop it so that it would not hit the bumping post. These kinds of bad handling practices go on because of lack of training of the personnel in handling passenger equipment. But they are all particularly bad when they occur at slow speeds, for that is when the cast iron brake shoe is most efficient.

A discussion of this phenomenon with experts in the air brake field led to no solution. Several stated that similar problems were being encountered by other passenger car operators. Many old wives' tales were discussed. For example, it is commonly felt that the car at the rear of the train always takes more of the braking load than any other car in the train. Perhaps there is some truth to this rumor. It is certainly clear that the rear car's brakes do not release as quickly as do the brakes in the cars closer to the engine because of the delay in the receipt of an increase in the brake pipe pressure which would cause the rear car's brakes to release. Certainly, this phenomenon would occur if your car were set so that the brake were in the graduated release position, while the remainder of the train was in direct release. It should again be pointed out that freight car brakes do not have any graduated release either. Consequently, if your car is handled in mixed service, then the blanking plate on the D-22 valve should be turned to the position which will result in direct release of the brakes.

We also discovered that when our passenger cars were being move in a freight drag, that the freight conductor would often hook up the air to the passenger cars, but not hook up the air to the remainder of the train. Consequently, the passenger cars were being used to stop the entire train. We felt this would also cause flat spots on the wheels. We don't know the truth of this story.

We investigated other methods of reducing cylinder pressure, tried by the Southern Railway and Missouri Pacific. Our erroneous belief was that these were attempts to solve problems similar to ours. In reality, they were designed to bring the passenger car's braking ratio closer to that of freight cars, so the railroad's business cars could operate in a freight train without assuming more than their share of the train braking.

The concept of the electropneumatic system was discussed, as best we could. Probably the most important bit of information to come to light in the conversations was the concept of placing a pressure gage in the control line 16, so that the actual pressure applied to the relay valve was a known quantity. This was done by simply cutting the line and soldering in an appropriate copper tube fitting and a 160 p.s.i. gage. Thereafter, the brakes were tested by obtaining an air compressor, and charging up the brake system to the limit of the compressor, which happened to be 105 p.s.i. After the system was fully charged, the brake pipe cock was closed, and a 5 lb. brake reduction was effected. This was relatively simple with our car, because it has back-up controls on it. If your car does not, this same result can be achieved by simply bleeding 5 lbs. of pressure out of the main brake pipe. After this brake pipe reduction, it was noted that the control line 16 pressure was a little more than twice as much as the reduction, or approximately 12 p.s.i. This seemed to fit in with our understanding of the D-22 system, which, up to certain limits, provides a 2 1/2 times magnification of the brake pipe reduction. Observation of the brake cylinder pressure revealed that it closely followed the pressure in the control line 16. All the pressures observed were recorded and all pressures seemed to fit within the expected range.

For example, when the brakes were placed in emergency, the brake pipe reduction was complete from 105 p.s.i. down to 0. The control line 16 pressure jumped up to 96 p.s.i., and the brake cylinder pressure jumped up to approximately 96 p.s.i. and then after half a minute because of the action of the safety valves, the brake cylinders bled down towards 40 p.s.i. The results of this test were pretty much as expected, and there was no indication that anything was amiss. The results obtained were thoroughly cussed and discussed. The reason that we did not understand what the results meant was because we did not have sufficient knowledge of the history of the car and of the results which should have been obtained. Nonetheless, the clue to the problem with these brakes has been given to you — do you know what the problem was?

The solution to the problem came only after study, more study, and the rethinking of the history of the car in its earlier life. Almost no attention had been given to the D-22BR instruction pamphlet, since the car did not contain that valve, but instead had the D-22AR control valve. With the demise of the electropneumatic brake system, it was assumed that the components in the car would operate as an ordinary D-22 system would operate.

Nonetheless, a rereading of the pamphlet disclosed that cars with electropneumatic brakes had a braking system with a braking ratio (force of shoes against wheels divided by car weight) of 250% in emergency. That is, when the car was going at high speeds, the brakes could be applied at a high pressure, and as these speeds were reduced the relay valve would reduce the pressure applied to the cylinders accordingly, so that 40% of the control line pressure was applied to the brakes when the car was going 20 m.p.h. or less.

The standard railroad car is given a braking ratio of only 150% in emergency. But our car had a potential braking ratio of 250%. To compensate for this, the F relay was rigged so that it was an F-6 relay. This means that only 60% of the control line 16 pressure was to be applied to the brake cylinder. At the 60% level, our car had an effective braking ratio of 150% (250 x 0.6), and was thus equivalent to the standard railroad passenger car. The F-6 relay valve reduces cylinder pressure to 60% of control line pressure. Thus, if there is 100 p.s.i. imposed on the control line, then the F-6 relay should impose only 60 p.s.i. on the brake cylinders. You will recall from the tests mentioned previously, that it was not happening. Instead, the F relay was imposing 100% on the brake cylinder.

After these facts had been ferreted out, it was decided to closely inspect the F relay valve and the instructions for it. First, it was noted that the blanking plate had the symbols F-6 stamped on it. Then, the catalogue sheet for the F relays was obtained and thoroughly studied. From this, it appeared to us that all F relays, in the relay portion, are identical. That is to say, any F relay

is capable of being an F-1, F-4, F-6 or an F-8. The sole difference in the various relays appeared to be only in the blanking plate. The catalogue sheet revealed that the F-relay was composed of three parts. First there is a relay portion; second, a blanking portion; and third, an inshot valve portion. Our car had all three parts. The removal of four coats of paint from the blanking plate revealed the only marking on all three items, namely the letters "F-6" stamped in the blanking plate.

Indeed, a study of the catalogue sheet showed the relay portion of the F-1864 valve was identical to the relay portion of the F-6 valve and also the various other relay portions of the F series relays. Then, the catalogue numbers for the various parts were studied and it was found that, in truth and in fact, the relay portions of all F relay valves are identical. The only differences in the various F relays were found in the blanking plate and in the number and kind of magnet valves which were applied, if any.

Now the study went back to the instruction pamphlet for the D-22BR valve. At the very end was found a piping diagram and air flow chart for the F-6 relay, Plate 9. This chart is invaluable, since it shows what happens and where rather than showing the various catalogue parts. From this flow diagram, it was discovered that the control line 16 air pressure will always apply to the 40% diaphragm. Because of the F-6 blanking plate involved, it was found that the same pressure was also applied to the 60% diaphragm. However, this pressure could not seemingly be applied to the 80% or 100% diaphragm without some breakdown of the inshot valve, or some internal breakdown in the relay portion itself. Further study revealed that the inshot valve was designed to bleed off excess pressures, hence the only way we could have obtained 100% pressures out of the F-6 relay was if the 60% diaphragm had ruptured, or had been improperly installed.

With great trepidation, both the blanking plate, with the inshot valve applied, and the relay portion were removed from the car's pipe bracket. To make a long story short, after several tests, the relay portion was dismantled and it was discovered that the 60% diaphragm had been improperly installed, in that a portion was folded over. Thus the air which was supplied to the 60% diaphragm would leak past it to the 80% and to the 100% diaphragms. Thus the relay did not provide 60% of the control line pressure to the brake cylinders, but instead applied 100%. While this 100% pressure would have been all right at 80 m.p.h., it resulted in a 250% braking ratio at slower speeds, causing the brakes to lock up and the wheels to slide. A new diaphragm was ordered, installed, and now the relay operates as it should.

There are several morals and conclusions to be gleaned from this story. Undoubtedly, the most important point is that no one has an more interest in the brakes on your car than you do. Another is that there are few people left who have any real knowledge of how the brakes work on a passenger car, and even fewer who will remember that many cars at one time had electropneumatic systems on them with a greatly increased braking ratio potential. Another is that if there is a problem in the braking system, it is probably not due to any mechanical defect, but instead is due to a breakdown in one or more of the pneumatic devices. Another lesson learned was that there are no readily available charts which show you what pressures are to be expected at any particular point for your particular car. More pressure is to be ordinarily expected if the car had been rigged for an F-1 relay. Many passenger cars are so rigged. With 20-20 hindsight, it is felt that the solution to the problem should have been obvious to anyone with a thorough knowledge of passenger car brakes, yet no one remembered that the braking ratio was substantially greater on cars which had at one time utilized an electropneumatic system.

Perhaps the greatest lesson learned from all of this was that any braking Problem can be solved with sufficient study and with knowledge of what should be expected and where. The place to begin is in your public library — and the person to begin the study is you.

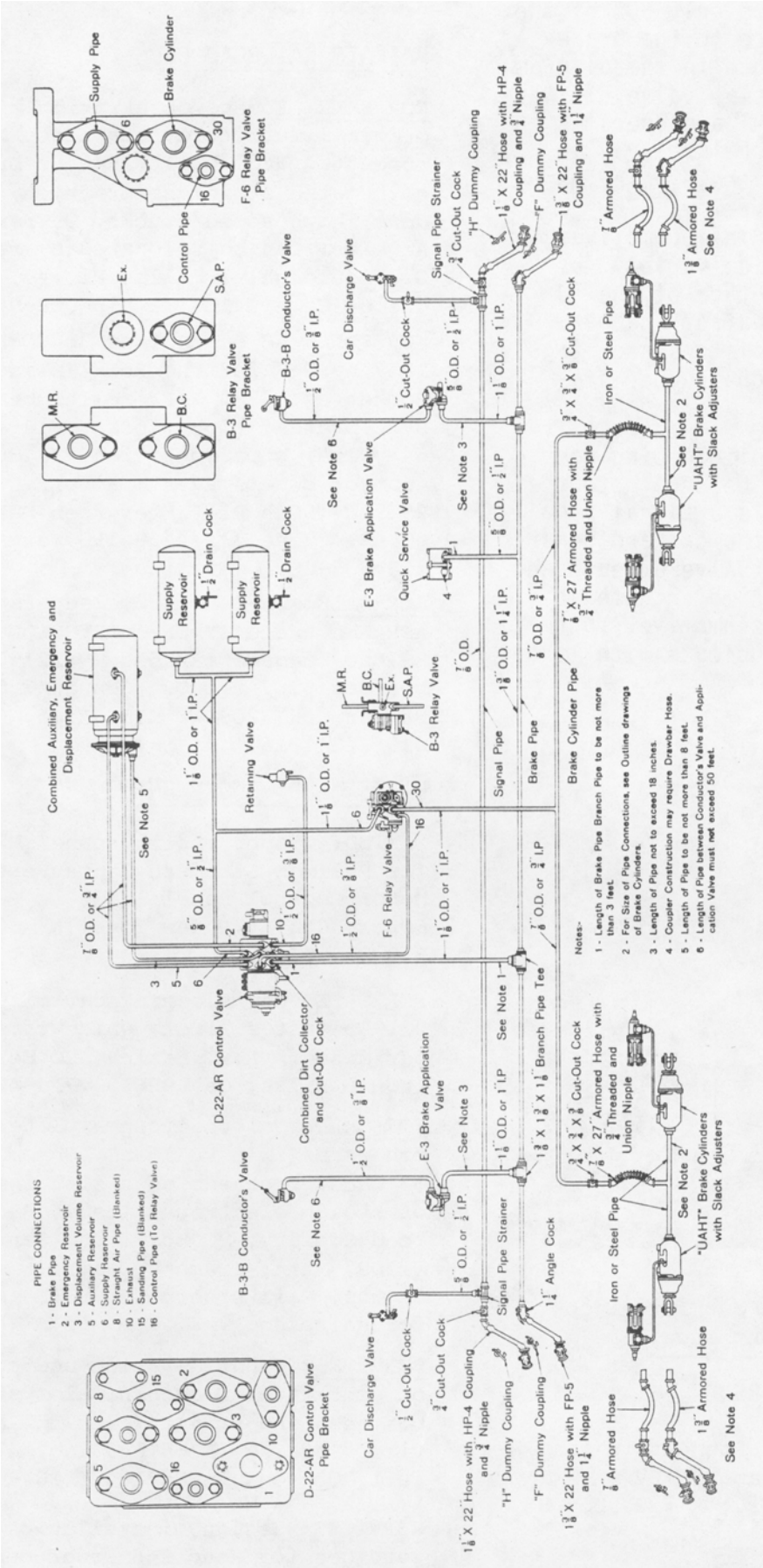

Figure 1: D-22-P Piping Diagram (Westinghouse Air Brake Company).