

LONDON MIDLAND AND SCOTTISH
RAILWAY COMPANY

**THE AUTOMATIC
VACUUM BRAKE**

L.M.S.R.
C.M.E. Dept.

E.R.O. 63454

LONDON MIDLAND AND SCOTTISH
RAILWAY COMPANY

THE AUTOMATIC
VACUUM BRAKE

L.M.S.R.
C.M.E. Dept
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L.M.S.R.

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PREFACE.

This Handbook is issued for the guidance of the C.M.E. C. & W. Section, Outdoor Foremen, Examiners, Brakesmen and others, who are called upon to examine and maintain the Automatic Vacuum Brake Equipment on the Company's Coaching and Freight Stock Vehicles in proper order.

While the principles outlined are applicable to all British railway-owned rolling stock fitted with the automatic vacuum brake, the description and diagrams illustrating the various arrangements and fittings are based on L.M.S.R. equipment and practices.

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THE AUTOMATIC VACUUM BRAKE.

Part I.

GENERAL DESCRIPTION.

Vacuum, a simple definition.

A vacuum is a space absolutely devoid of any matter capable of exerting pressure; in other words, a truly empty space.

For everyday purposes it is not possible to obtain a perfect vacuum, because, although there is no difficulty in making a vessel which is capable of withstanding the external pressure of the atmosphere after a vacuum has been created inside the vessel, there is no means of exhausting the vessel completely, and a little of the air, or whatever gas the vessel contained, is always left behind.

The measurement of vacuum.

For experimental or test purposes, a special type of gauge is used, and this consists of a "U"-shaped tube containing mercury (see Diagram No. 1). It will be appreciated that if air is withdrawn from one leg of the tube, the pressure of air in the other leg of the tube will force the mercury down in that leg and it will flow up the leg from which the air has been taken. Therefore, the height to which the column of mercury rises in the "exhausted" leg of the tube will reveal the extent to which a vacuum has been created.

The principle upon which the measurement of vacuum is based, therefore, is that at the mean atmospheric pressure of 14.7 lb. per [sq. in.](#), a column of mercury 30" high is balanced in the "U" tube when an almost perfect vacuum is obtained on the "exhausted" leg of the tube.

Accordingly, it is usual to refer to the measurement of vacuum in inches, and all industrial vacuum gauges are calibrated to read in "inches of mercury". It is also usual to use a figure of 15 lb. per [sq. in.](#) in referring to atmospheric pressure for all practical purposes.

For industrial purposes it is, of course, impossible to use the "U" tube as a means of measuring vacuum, and

instead, gauges of the "Bourdon" type are used. In appearance and construction, these resemble the familiar designs of pressure gauge, but are arranged to operate under conditions opposite to those under which a pressure gauge is used. From an industrial point of view, "Bourdon" gauges give a high degree of accuracy and reliability.

The application of vacuum for power purposes.

From what has been said in the previous paragraphs, it will be seen that a pressure of 15 lb. per sq. in. will support a column of mercury 30" high in a "U" tube. Therefore, a pressure of 10 lb. per sq. in. would support a column 20" high, and, in other words, every inch of vacuum is equal to a pressure of $\frac{1}{2}$ lb. per sq. in.

Therefore, if we take a cylinder or tube and fit inside it a movable piston and then exhaust the air from one end of the cylinder until 20" of vacuum is achieved, the atmosphere in the other end of the cylinder will exert a pressure of 10 lb. on every sq. inch of the piston's surface, and, assuming that the piston is free to move easily along the cylinder, it will be seen that by connecting the piston to suitable levers the power exerted by the atmosphere can be utilised, and all modern vacuum brake cylinders embody this principle.

The utilisation of vacuum equipment for braking purposes.

The utilisation of vacuum was early recognised as being a convenient method of securing power for the operation of a continuous brake on railway vehicles.

In the original designs, a vacuum was created in the brake equipment when it was desired to *apply* the brake, and the system was known as the "Simple Vacuum" system. This system had many disadvantages, however, not the least of which was the time required to create sufficient vacuum to apply the brake, and in the course of time the system was devised which is now known as the "Automatic Vacuum Brake". This system is used on the majority of steam trains in Great Britain and is also widely used on trains in many other parts of the world.

The Automatic Vacuum Brake has many advantages over the early Simple Vacuum Brake, and perhaps the most important of these advantages is that in the event of damage to any of the vacuum equipment, or upon a train becoming divided, the brake is automatically applied throughout the train.

This is due to the fact that in the Automatic Vacuum Brake system, a vacuum is created and maintained in order to *release* the brake, and the admission of air to the equipment after the vacuum has been created, causes the brake to be applied with a force proportional to the amount of air admitted.

The degree of vacuum upon which the design and operation of the Automatic Vacuum Brake is based is a partial vacuum equal to 20" of mercury, and the L.M.S. Company's regulations provide that in the operation of the equipment the vacuum created must show a reading of not less than 19" nor more than 21" on the engine vacuum gauge, and not less than 17" on the gauge in the rear brake van or brake compartment of the train.

Automatic Vacuum Brake equipment.

General.

The brake is required to be continuous throughout all trains composed of coaching stock, engines and tenders, and all vehicles comprising the train are fitted with a main train pipe, to which flexible pipes and universal couplings with joint washers are attached to enable vehicles to be coupled and uncoupled and to allow for the relative movement of the vehicles when running.

After a train has been made up, and the pipes between the vehicles connected, the train pipe as a whole has, of course, to be made air-tight, and for this purpose a dummy plug is provided on each end of each vehicle (with the exception of the intermediate positions on certain coupled set trains composed of old type vehicles), so that the flexible pipes on the front end of the engine and the end of the last vehicle can be sealed off.

Figure 2 shows the general arrangement of vacuum brake equipment on an engine and coaches, and Figure 3 shows a flexible hose pipe coupling and joint washer.

The degree of exhaustion, or vacuum, required to operate the Automatic Vacuum Brake on steam trains is created by a steam ejector on the engine, and although ejectors may differ in design on the various railways, the principle is identical.

All coaching stock vehicles are fitted with a self-contained brake, but freight vehicles are not always so fitted. In order to make the difference in vehicles clear, therefore, the following definitions are given:-

Freight stock.

"Fitted vehicles" A "fitted" vehicle must be understood to be a vehicle which carries its own brake equipment and in which the brake blocks are operated by the Automatic Vacuum Brake system.

"Piped vehicles" A "piped" vehicle must be understood to be a vehicle which is fitted only with a continuous pipe from end to end, and in which the brake blocks are operated only by hand levers.

It will be understood that in certain types of freight trains only a certain number of vehicles are required to have vacuum controlled brake gear, but in order to make the main train pipe continuous throughout the train it is necessary for all the vehicles in the train to have a train pipe, flexible connections and dummy plugs.

Under normal conditions, a reduction in vacuum of 5" is *sufficient* to apply the brake, and the driver's brake valve on the engine is designed to allow a controlled admission of air to the train pipe and so permit sensitive control of the braking of a train.

A full opening of either the driver's or guard's brake valve results in the vacuum in the train pipe being totally destroyed and gives the maximum braking effect in a minimum of time.

Engine equipment.

The type of ejector most commonly used is the combined type which combines a large and a small ejector. These ejectors work independently of each other and are designed to create and maintain the required vacuum in the brake equipment with a minimum consumption of steam.

The large ejector is powerful and creates a vacuum quickly, but uses a lot of steam. It is used, therefore, to ensure rapid creation of vacuum prior to starting a train, or after an application of the brake. The small ejector, on the other hand, is designed to overcome the small leakages which are inevitable in a system having numerous valves and flexible connections, and ensures that the degree of vacuum required is maintained whilst using a minimum amount of steam. The small ejector is kept in operation so long as control of the brake equipment is required.

Certain ex L.N.W.R. engines and certain engines belonging to other Companies are fitted with a vacuum pump and a single ejector, the purpose of the pump being to maintain vacuum in the brake equipment so long as the train is running.

A vacuum gauge is provided on every engine, and records the degree of vacuum in the train pipe, and a driver's brake valve is fitted which regulates the admission of air to the train pipe and enables the driver to control the application of the brake throughout a train with a high degree of sensitiveness.

Coaching stock equipment.**Brake cylinders.**

Four-wheeled bogie vehicles are fitted with two 18" diameter brake cylinders of the type shown in Figure 4. This type of cylinder combines the cylinder and reservoir in a common outer casing.

Six-wheeled bogie vehicles differ somewhat in design, in that the brake cylinder and reservoir are separate units connected together by suitable piping. The principle of operation, however, is identical with that of the combined type of cylinder.

On the outer case of each type of cylinder are attached two pivots or trunnions, which allow the cylinder to be suspended in suitable brackets attached to the vehicle underframe. This arrangement allows the cylinder to swing in a small arc, and ensures that the piston rod remains in line with the cylinder throughout the range of its movement, and is not subjected to any bending forces as would be the case if the cylinder were rigidly fixed.

The piston, which has a deep head, fits easily in the cylinder, and the piston head is recessed at the top and bottom to contain a rubber ring. This ring is known as the rolling ring and serves the same purpose as the piston rings of a steam or gas engine piston. As the piston moves up or down in the cylinder, the ring rolls between the piston and the cylinder wall, and being compressed firmly between the two, prevents air passing from one side of the piston to the other. The recesses at the top and bottom of the piston head are provided to prevent the rolling ring from getting out of alignment and causing the piston to stick in the cylinder.

The piston rod is fastened to the piston head, and at its lower end it is connected by means of a pin to the lever mechanism which operates the brake blocks. In passing through the cylinder casing, the rod is surrounded by a rubber packing gland, the purpose of which is to prevent air entering the cylinder at this point, whilst at the same time permitting the piston rod to move in and out of the cylinder.

The diagram, Figure 4, shows the piston in the "Brake on" position, and it should be noted that when the "Brake off" position is reached, the measurement from the packing gland to the boss end of the piston rod is 82".

Occasionally the older types of vehicle may be found to be fitted with a diaphragm type of cylinder. This type differs from the "rolling ring" type in that a rubber diaphragm is used instead of a rolling ring to seal off one side from the other. The principle of operation, however, is not altered.

Ball valves.

Fitted to the bottom of each cylinder and connecting the cylinder to the train pipe by means of an iron branch pipe and a small flexible hose, is a ball valve of the type shown in Figure 5. This valve is one of the most important fittings in the whole of the equipment, as its purpose is to control the passage of air to and from the reservoir portion of the brake cylinder.

The passages in the valve body are so arranged that the underside of the cylinder is always in communication with the train pipe, whilst the reservoir portion of the cylinder is open to the train pipe only when the ball is unseated. So long as the ball is pressed on to its seat, therefore, the reservoir portion of the cylinder is isolated from the train pipe.

Reference to Figure 4 will show that when air is withdrawn from the train pipe by the engine ejector, any air in the reservoir portion of the cylinder will flow past the ball into the train pipe until an equal vacuum exists on each side of the piston. The ball will remain unseated so long as this equality of vacuum exists, but as soon as air is again admitted to the train pipe it will enter the ball chamber and press the valve firmly on to its seat, thereby sealing off the reservoir portion of the cylinder and maintaining the vacuum which exists there.

The automatic action of the ball valve continues in this way so long as the brake equipment is under vacuum operation, but circumstances arise in which it is necessary to have a hand-operated means of equalising the conditions on each side of the brake piston. For instance, when a train is detached from an engine, the vacuum in the train pipe is completely destroyed, but by the action of all the ball valves in the train the vacuum in the reservoir portions of the brake cylinder is maintained, and so long as this vacuum remains the brake will remain "on" throughout the train.

Embodied in the ball valve casting, therefore, is a sliding cage in which the ball is contained, and the outer end of this cage is connected to a cross lever. The action of pulling this lever pulls the cage outward, and this in turn pulls the ball off its seat. Air then flows into the reservoir portion of the cylinder until conditions are again equal on both sides of the piston, and the piston falls under its own weight to the bottom of the cylinder and the brake is released.

In order that this release action may be carried out from the side of the coach, a wire or cord is taken from each side of the coach to one end of the cross lever, and to ensure that the cage returns to its normal position when vacuum operation is resumed, a diaphragm is connected to the cage. This diaphragm forms an air-tight gland where the cage spindle passes through the body of the ball valve, and as it is open to the atmosphere on the outside, any withdrawal of air from the ball valve interior causes the atmospheric pressure on the outside of the diaphragm to move the diaphragm inwards, thus returning the cage to its normal position.

Direct admission valves.

From time to time devices have been patented for accelerating the speed with which vacuum is destroyed, thereby reducing the time lag in the brake application between the front and the rear of long trains.

The valve adopted for this purpose by the **L.M.S.R.** is the Direct Admission Valve, which is shown diagrammatically in Figure 4, and in detail in Figures 6 and 6a.

The principle employed is that air entering the train pipe simply actuates the **D.A.** valve, and does not enter the brake cylinder, so that in effect each cylinder has an independent air supply and the operation of the brake gear as a whole is speeded up in consequence.

The manner in which the D.A. valve operates is as follows:-

In the creation of a vacuum in the brake equipment, air is drawn from the cylinder, through passage C2, past non-return Valve "A" into the train pipe. At the same time air is extracted from chamber "B" past the flats "D" on the spindle until equal vacuum exists in chamber "B" and in the train pipe.

Upon the reduction of the vacuum in the train pipe by the admission of air to the pipe, the diaphragm "E" is raised by reason of the higher degree of vacuum existing in chamber "B", and as the rising diaphragm carries with it the spindle, valve "F" is pushed open and admits air to the underside of the brake cylinder through passage "C1". When sufficient air has been admitted to reduce the vacuum in the cylinder, and, therefore, in passages "C1" and "C2", to the level of that in the train pipe, the diaphragm "E", being again in equilibrium, is restored to its original position by the spring "G", and valve "F" closes and prevents further flow of air to the cylinder.

In the event of a D.A. valve requiring to be isolated, this can be achieved by reversing the cap "H" as shown in Figures 6 and 6a.

Guard's brake application valves.

To enable the guard of a train to apply the Automatic Vacuum Brake in case of emergency, a special guard's

brake valve is provided in all passenger brake vans and brake compartments. The valve is not a graduable valve,

in other words the lifting of the valve lever brings about a full application of the brake and no partial application of the brake is possible as is the case with the driver's brake valve on the engine.

The type *of* valve shown in Figure 7 was used originally and contained automatic features. The majority of this type have, however, now been rendered non-automatic and are marked "N.N." to denote this. The vacuum chamber which is shown does not now serve any useful purpose.

The type of valve shown in Figure 7a has now been adopted as the standard valve, and as the diagram shows it consists of a simple lever-operated flap valve.

Passenger communication apparatus.

Emergency communication apparatus is fitted to all passenger-carrying vehicles, and is as shown in Figures 8 and 8a.

The apparatus consists of a small diameter branch pipe connected at one end to the train pipe, and having at the other end a small flap valve. A horizontal shaft, suitably supported at each end, passes through the valve casing, and a cam is attached to the shaft in such a manner that a partial rotation of the shaft causes the cam to lift the flap valve into its "open" position.

A continuous chain passes through the full length of the coach, and a small portion *of* this chain is made accessible in each compartment, and as the end of the chain is connected to the cross shaft previously mentioned, the action of pulling the chain at any point causes rotation of the cross shaft and so operates the flap valve. The valve is so designed that the amount of air admitted to the train pipe by the opening of the valve is sufficient to cause only a gradual application of the brake, and this, together with the resultant drop in the vacuum registered by the engine and brake compartment vacuum gauges is an indication to the driver and guard that something is amiss which calls for the train to be stopped.

In order to give a clear indication of the vehicle in which the chain has been pulled, the cross shaft which operates the valve is provided with a disc at each end. Normally, these discs lie in the horizontal position, but when the shaft is operated it turns through an angle of 90°, and the discs accordingly assume a vertical position and enable the affected coach to be found easily.

Vacuum gauges.

All passenger brake vans and brake compartments are fitted with a vacuum gauge in order that a guard may see at all times that the degree of vacuum called for under the Company's regulations has been created and is maintained.

Many of these gauges are of the Duplex type, that is, they have the dual function of recording the degree of vacuum in the reservoir side as well as that in the train pipe. It should be noted, however, that the needle marked "Reservoir" only indicates the vacuum existing in the reservoir side of the cylinder to which it is connected; it does not indicate the conditions in the reservoirs of the other cylinders in the train.

A single needle type of gauge only records the degree of vacuum existing in the main train pipe.

Brake block operating gear.

Figure 9 shows the general arrangement of the brake rigging on a modern 4-wheeled bogie, and although the diagram shows one bogie only, the rigging on the bogie at the other end of the coach is identical.

The power obtainable from the brake cylinder is transmitted through the rocking shaft to the main pull rod, and this main pull rod is in turn connected to a series of levers which operate the beams on which the brake blocks are mounted.

The levers are arranged so that in addition to transmitting power from the brake cylinder, they equalise the power applied to the brake blocks so that each block is applied to the wheel with equal force. Adjustment is provided in the link connecting the vertical levers by means of a series of holes which permit a graduated variation in the distance between the pins connecting the link to the vertical levers.

In designing a railway coach it is the aim to allow sufficient braking power to brake the vehicle efficiently without giving too severe, or too gradual a retarding effect, and experience has shown that the most satisfactory arrangement is that which gives a brake power equal to 75 to 80 per cent. of the weight of the vehicle. Thus, in a coach weighing 30 tons, a brake power of 22 to 24 tons is provided for in designing the brake equipment.

It was shown on page 2 that with a partial vacuum equal to 20" of mercury in the reservoir side of a brake cylinder, a pressure of 10 lb. per sq. inch is obtained on the side of the piston which is under atmospheric pressure. With an 18" diameter cylinder, therefore, the total pressure on the piston under these conditions will be:-

$$\begin{aligned} & 10 \text{ lbs.} \times \text{total area of piston} \\ & \text{which equals } 10 \text{ lbs.} \times 254.5 \text{ sq. in.} \\ & = 2,545 \text{ lbs. pressure on piston.} \end{aligned}$$

By making the rocking shaft, to which the piston is coupled, so that a 2 to 1 leverage is obtained, this figure of 2,545 is doubled at the short arm of the rocking shaft, and by coupling the main pull rod to the short arm, a pull of $2 \times 2,545 \text{ lbs.} = 5,090 \text{ lbs.}$ is obtained in the main pull rod.

The system of levers between the main pull rod and the brake block beams then multiplies this force even further, until the total of the forces on the sixteen brake blocks is equal to 22 to 24 tons

The operation of the Automatic Vacuum Brake.

Before a train commences its journey, the operation of the vacuum equipment must be tested, and whilst the following describes L.M.S.R. practice and may differ slightly in detail from the practice of other Companies, the general principles are identical.

First, the engine is tested as an independent unit before it leaves the shed, and it is the duty of the driver to ensure that the vacuum equipment is in good working order.

Subsequently, when the engine has been coupled to a train, the train pipe flexible hoses between vehicles coupled, and the flexible hose at the end of the last vehicle correctly seated on the stopper, the driver admits steam to the engine ejector and exhaustion of the vacuum equipment throughout the train commences.

This action releases the brake throughout the train, and the guard must observe the vacuum gauge in the brake compartment until a reading of at least 17" is noted. He must then lift the handle of the emergency brake valve, thus applying the brake throughout the train, and after returning the valve to the closed position again must watch the vacuum gauge whilst vacuum is being restored until the reading is again not less than 17".

This test must also be carried out whenever a vehicle is detached from a train, or when an additional vehicle is attached to a train, and in fact it should be the practice to carry out the test whenever train pipe flexible hoses are disconnected for any purpose.

The test completed satisfactorily, the train is ready to proceed, and the requisite vacuum having been created, as described above, to release the brake, the application of the brake is now normally under the control of the engine driver.

Part H.**EXAMINATION AND TESTING OF
A.V.B. EQUIPMENT.****Examination and adjustment.**

The trouble-free operation of A.V.B. equipment on coaching and freight stock depends upon careful examination and maintenance of the equipment. It is essential, therefore, that trains or loose vehicles which are placed in carriage sidings and are left under the control of the Automatic Vacuum Brake should be examined upon arrival, and particular attention directed to the following points:-

Brake block adjustment.

The state of adjustment of the brake blocks must allow the maximum stroke of the brake piston to be available. The efficiency of the gear is dependent upon its being adjusted as closely as possible to the limit allowed, as otherwise much of the power available in the brake cylinder is lost before the brake blocks come into contact with the wheels.

Any brake blocks which have worn down to scrapping size must, of course, be replaced without delay.

Use of clearance gauges.

Before the clearance between brake blocks and wheels can be checked, the brake must be fully released, i.e. the brake piston must be in its lowest position, and where equalising links are fitted, these should be close up to the stops.

Steps must, of course, be taken to prevent vehicles moving in either direction when the brake has been

4-wheeled bogie.

The brake block adjustment on 4-wheeled bogies should allow free movement of the 1" gauge between the brake blocks and wheels. In the case of vehicles having the long and short arm type of triangular brake beam, the gauge should be inserted on the "long" arm side; on other types it is immaterial on which side the gauge is used.

6-wheeled bogie.

The adjustment of brake blocks on a 6-wheeled bogie requires the use of *two* gauges which must be inserted between the brake blocks and tyres of two wheels.

Care must be taken in the examination or adjustment of brake gear to ensure that the gear as a whole works freely, that all portions of the gear are properly secured and that the legs of all split cotters are well opened.

Hand brakes.

The hand brake on all vehicles so fitted must be examined and tried as vehicles come to hand at carriage depots or freight sidings, to ensure that the brake is properly workable. If found to be in need of adjustment, the adjustment must be carried out before the vehicle is again allowed into traffic.

Vacuum equipment.

In the examination of vehicles standing under control of the Automatic Vacuum Brake, attention must be directed to the air-tightness of the equipment and any tendency to "leak-off" noted. Particular attention should be paid to piston rod glands and D.A. valves.

When opportunity permits, brake piston rods which are not protected by flexible stockings should be cleaned with dry spun yarn. Under no circumstances, however, must any abrasive cleaning compound be used on the spun yarn.

Flexible hoses and branch pipes should be examined for such defects as worn hoses, defective or damaged couplings or defective joint washers. The clips securing flexible hoses to couplings and train pipes should be examined and left secure and in contact with the hose throughout the circumference. Any clips having a damaged tongue must be changed, and the coupling pins and chains must be left in good condition.

Passenger communication apparatus.

At monthly intervals the passenger communication apparatus must be operated to ensure that the apparatus works freely, and all parts must be left in a clean condition and in good working order. Any worn, hardened, or otherwise defective valve seating washers must be changed and defective chains renewed.

Guards' emergency application valves.

Guards' emergency valves must be tried to ensure that they operate freely and that the valve seating washer is in good condition.

Vacuum gauges.

Vacuum gauges must be examined for such visible defects as loose connections, bent needles, broken glasses or bent or defaced dials, and when tested under vacuum, care must be taken to see they are registering correctly.

Brake cylinder release valves.

Release valves having defective cords or wires, or showing any sign of diaphragms leaking, should be noted and attention given.

Adverse weather conditions-frost.

Whenever severe frost is anticipated, steps must be taken to prevent the brake blocks of vehicles stabled in exposed positions from becoming frozen to the wheels.

Brakes must, therefore, be released by operating the release valves, but care must be taken to ensure that the vehicles are properly secured and are unable to move in any direction which might result in their fouling other roads.

Testing and irregularities.

Every effort should be made to test the brake equipment on vehicles before they are brought into use in order that irregularities in the operation of the equipment or leakages may be located and rectified.

Test apparatus.

The standard apparatus for testing A.V.B. equipment consists of:-

- (a) Leak discs, for testing the efficiency of the engine ejector.

These are circular discs having either a -&" or v" diameter hole in the centre, and their overall diameter is such that they will cover the open end of the flexible hose coupling which is shown in Figure 3.

- (b) Isolating cocks for isolating portions of the A.V.B. equipment and recording the degree of vacuum existing.

These cocks have a standard flexible hose coupling of the type shown in Figure 3 at either end, and can, therefore, be used to connect the flexible hoses between an engine and train or between vehicles, or can be used in connection with a leak disc.

As the cocks embody a vacuum gauge, they can be used:- (1) To test the ejector equipment on the engine.

- (2) To isolate the train pipe on a train after the engine has created a vacuum and to show what vacuum is maintained after isolation of the train pipe.
- (3) To test conditions on the engine and train when coupled together.

Test cocks must be carefully handled to avoid damage to the gauges, and the cocks must be periodically tested in accordance with instructions against a master vacuum gauge or mercury column to ensure that they are in good working order and their gauges registering correctly.

Irregularities-testing of equipment.

The failure of an engine to create and maintain the regulation degree of vacuum throughout a train may be due to one or more of the following defects:-

- (1) Front flexible hose on engine or rear flexible hose on train not seated correctly on stopper.
- (2) Leakage in flexible hose couplings between vehicles.
- (3) Passenger communication valve or valves partly open.

- (4) Leakage at brake cylinder piston rod gland packings.
- (5) Leakage at brake cylinder release valves, D.A. valves, guards' emergency valve, or joint washers.

During examination of a train, steps must, whenever necessary, be taken to determine whether the vacuum gauge in the rear brake or brake compartment is registering correctly.

It may occur, however, that the defect cannot be located during examination, and the action to be taken by the C. & W. examiner in these circumstances is as follows:-

1.-Engine equipment (failure to create the requisite amount of vacuum throughout a train).

If the cause of the trouble cannot be located during examination of the train, the examiner must first ascertain that the boiler pressure is within 10 lbs. of the working pressure, and the actual pressure indicated by the boiler pressure gauge must be noted by the examiner and the driver.

Accompanied by the fireman, the examiner must then make a leak disc test in the following manner:-

- (a) *Engines fitted with combined large and small ejector.*

Uncouple the engine or tender flexible hose from the train and couple this hose to the isolating cock. Place a -&"leak discover the open end of the isolating cock and hold this in position.

The driver must then create 20"-21" of vacuum with the large ejector and must maintain this degree of vacuum with the *small ejector only*.

This must be recorded by the vacuum gauge attached to the isolating cock, and if no difficulty is experienced in maintaining 20'-21" of vacuum as stipulated, the engine is not at fault.

- (b) *Engines fitted with a single ejector and a vacuum Pump.*

Proceed as in (a), but use a 4" leak disc.

The driver must then create 20"-21" of vacuum with the ejector, and if this is recorded on the gauge attached to the isolating cock and can be maintained without difficulty, the engine is not at fault.

No test of the vacuum pump is required, as this comes into operation only when the engine is running.

If an isolating cock is not available the foregoing tests can be made using the leak discs only. In this case the discs should be applied direct to the coupling of the engine or tender flexible hose, and the degree of vacuum obtained should be observed from the vacuum gauge on the engine and noted by both the examiner and the driver.

If the engine is unable to fulfil the conditions stipulated and is, therefore, at fault, the Station Master must take steps to have the fault remedied or to have another engine provided.

If some time is likely to elapse before an engine is available, steps should be taken by the Station Master, during the waiting period, to have tests continued throughout the train by using any suitable engine which may be available, as cases have occurred where both engine and train have been at fault; such further tests should, whenever practicable, be made from the leading end of the train.

2.-Train equipment.

Having ascertained that the engine equipment is satisfactory and the train equipment at fault, the examiner must proceed to test the train in the following manner:-

Couple the engine or tender flexible hose to the train flexible hose with the isolating cock inserted between the two hoses.

Use the engine ejector to create a vacuum of 20"-21", as indicated by the isolating cock gauge, and then turn the cock so that the train is isolated from the engine.

If the gauge needle falls rapidly, indicating a leakage in the train equipment, repeat the test process between vehicles, in groups of three or four vehicles, until the defect is located.

Irregularities-remedial action.

Flexible hoses.-Defective flexible hoses, whatever the defect, should be replaced, and care must be taken in fitting the replacement hose to see that the clip is in contact with the hose throughout its circumference and the tongue not in any way distorted.

D.A. valves.

D.A. valves found to be defective should be blanked off by removing the top wing nut and cap, placing an old repair card slightly smeared with oil on top of the valve, and replacing the cap in the *reverse* position, finally screwing down the wing nut securely.

\$rake cylinders.

Should a "rolling ring" type of brake cylinder be found to be defective, the flexible branch pipe from the ball valve to the D.A. valve should be disconnected at the ball valve and the pipe plugged on the train pipe side with the special type of plug which is provided for the purpose.

The defective cylinder should then be equalised by pulling the release wire to the ball valve and holding this until all vacuum existing in the cylinder has been destroyed.

Where a brake piston sticks in the cylinder it is not desirable to uncouple the piston rod, and the action outlined above will generally suffice. Should the piston be held fast with the brake hard on, however, and cannot be moved towards the "off" position, the piston must be disconnected from the rocking shaft by removing the connecting pin.

When such action is taken, the cylinder must be prevented from turning over by securing it suitably through the piston rod pin-hole.

The long arm of the rocking shaft must also be secured so that it cannot fall downward and foul the permanent way. Steps must also be taken to see that the brake blocks affected are left clear of the wheels, and that the wheels have not sustained any damage through prolonged braking or skidding which would result in the vehicle being unfit for traffic.

In the event of a diaphragm type of cylinder being found to be defective, it should be isolated by disconnecting the branch pipe and inserting a suitable plug to render the train pipe air-tight.

It should be understood that in all the foregoing cases, or whenever any action is taken to temporarily isolate or render ineffective any part of the vacuum equipment of a vehicle, a "for repair" card must be attached to each side of the vehicle concerned before it is allowed forward, and a comprehensive repair must be made at the earliest opportunity.

Excessive vacuum in reservoirs.

It may occur that upon an engine being coupled to a train, the creation of 20"-21" of vacuum does not fully release the brake. This is due to the fact that the engine previously attached to the train created more than 21" of vacuum, and the reservoir portions of all the cylinders

are therefore left with more than the stipulated degree of vacuum, and do not balance with the 20"-21" created by the second engine when the latter is connected to the train pipe.

In these circumstances, equilibrium must be restored in all the cylinders of the train by operating each release valve in succession, and when this has been done, re-creating vacuum throughout the equipment in the normal way.

Safety precautions.

The attention of all concerned is directed to the necessity of complying with the Company's regulations for the protection of staff working on carriages and wagons, **E.R.O.** 10444 and 10445, whenever called upon to effect any repair or adjustment, etc., to the Automatic Vacuum or Hand Brake on either coaching or freight stock.

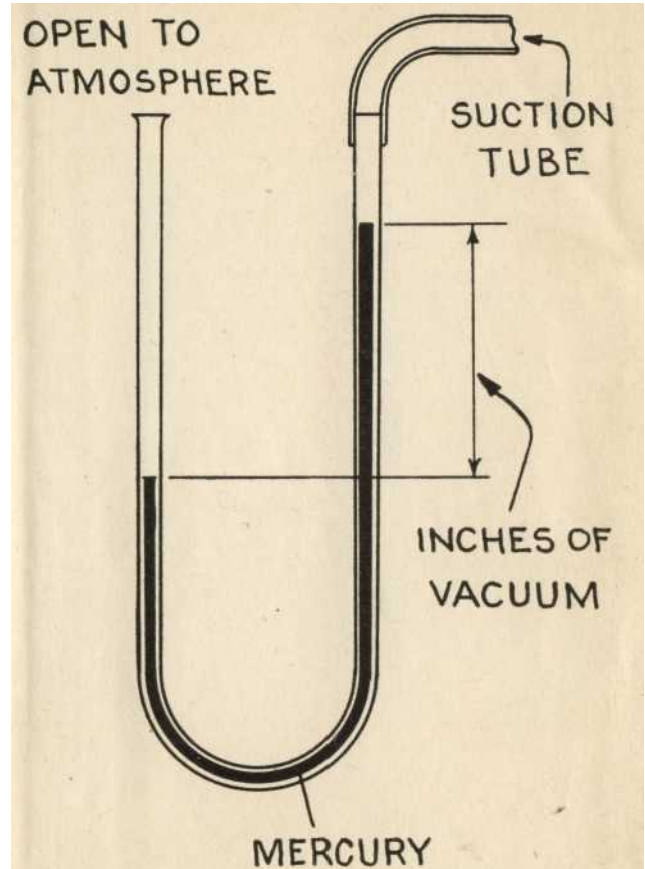
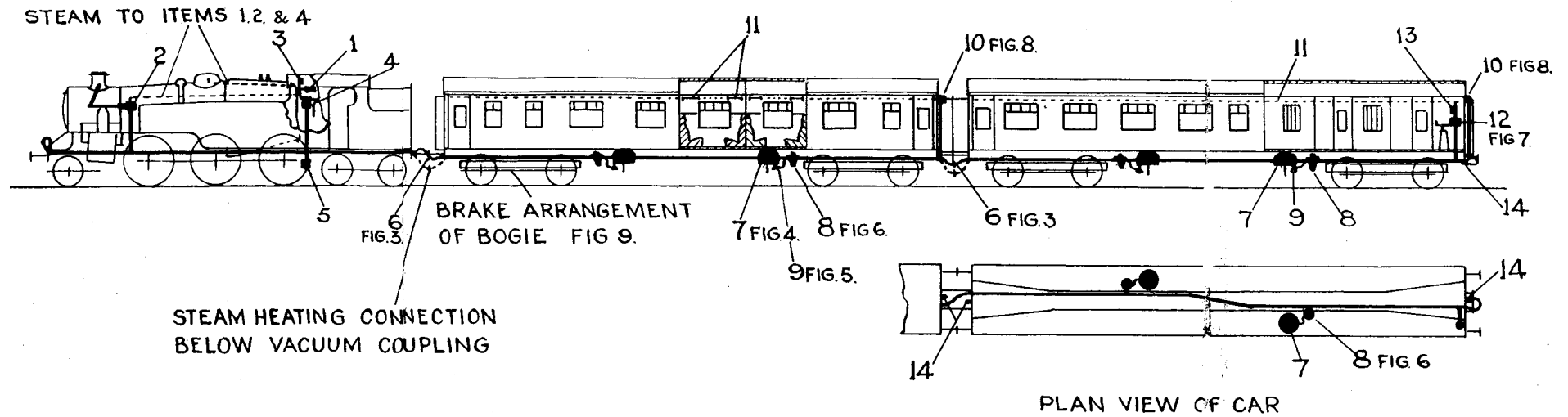


FIG 1
"U" TUBE.



DESCRIPTION

- 1- STOP VALVE. 2-22½-20 M/M. EJECTOR. 3-VACUUM GAUGE. 4- BRAKE VALVE.
 5- DRIP VALVE. 6- VACUUM COUPLING. 7- BRAKE CYLINDER. 8- DIRECT ADMISSION VALVE.
 9- BALL VALVE. 10- COMMUNICATION VALVE. 11- COMMUNICATION CHAIN.
 12- EMERGENCY VALVE. 13- VACUUM GAUGE. 14- DUMMY PLUG.

FIG 2

ARRANGEMENT OF VACUUM BRAKE.

SCALE. 0 3 6 9 18 FT.
 MAY. 1946 R.L.S.

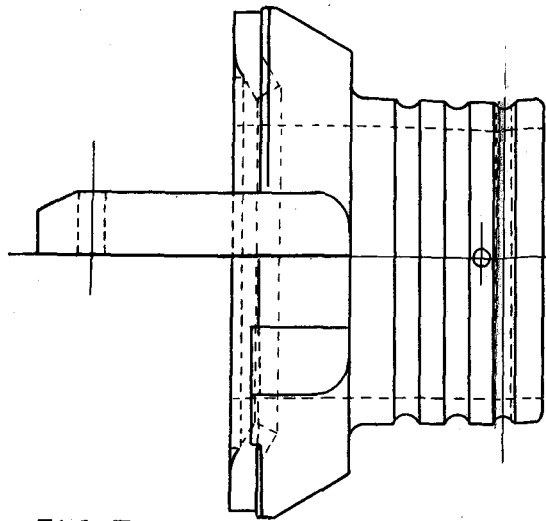
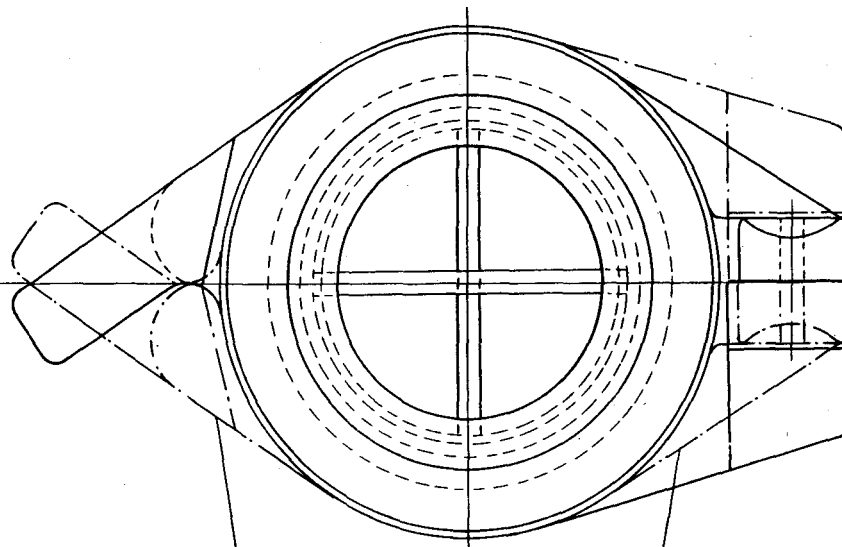
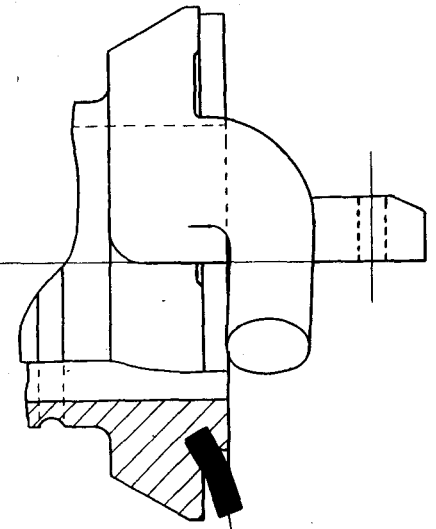


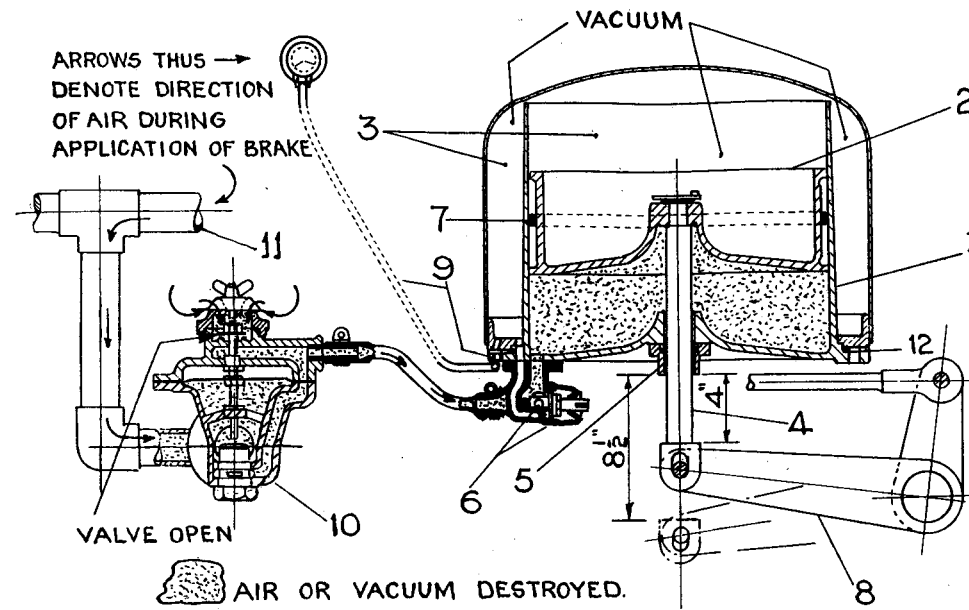
FIG 3
VACUUM HOSE COUPLING.



CHAIN-DOT SHOWING MADE UP COUPLING



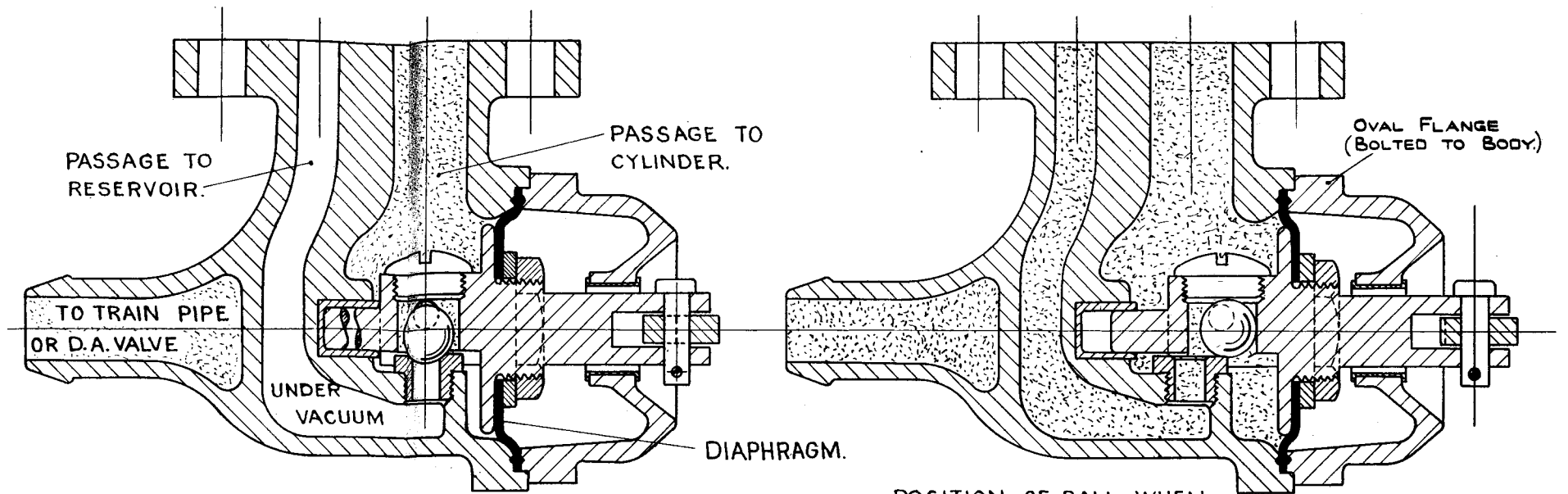
R 14. COUPLING WASHER



NOTE
CYLINDER SHOWN AT "BRAKE ON" POSITION.

- DESCRIPTION
- 1 VACUUM CYLINDER
 - 2 PISTON
 - 3 VACUUM RESERVOIR
 - 4 PISTON ROD
 - 5 PACKING GLAND
 - 6 BALL & VALVE
 - 7 ROLLING RING
 - 8 BRAKE SHAFT
 - 9 CONNECTION, DUPLEX GAUGE
 - 10 DIRECT ADMISSION VALVE
 - 11 TRAIN PIPE
 - 12 SEALING RING

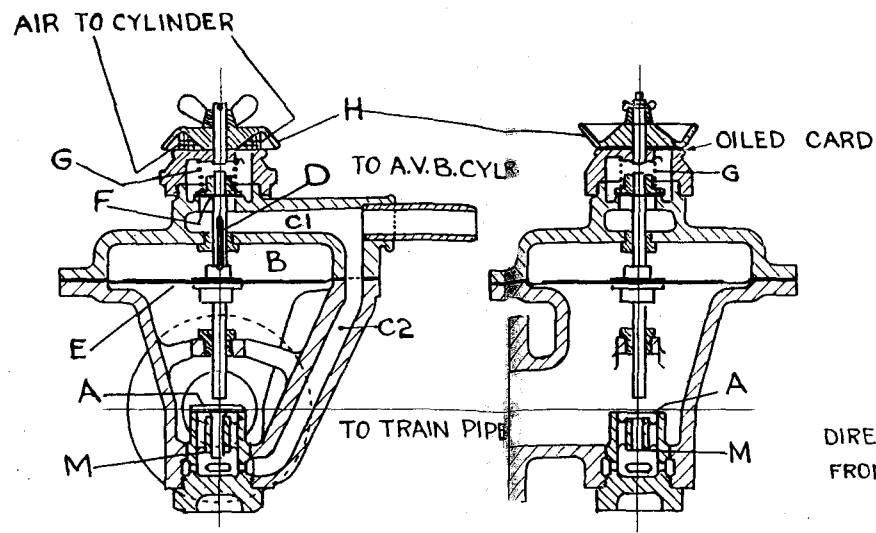
FIG 4
ARRANGEMENT OF VACUUM BRAKE.



 AIR FROM TRAIN PIPE OR D.A. VALVE.

POSITION OF BALL WHEN CORD IS PULLED.

FIG 5
 BALL VALVE.

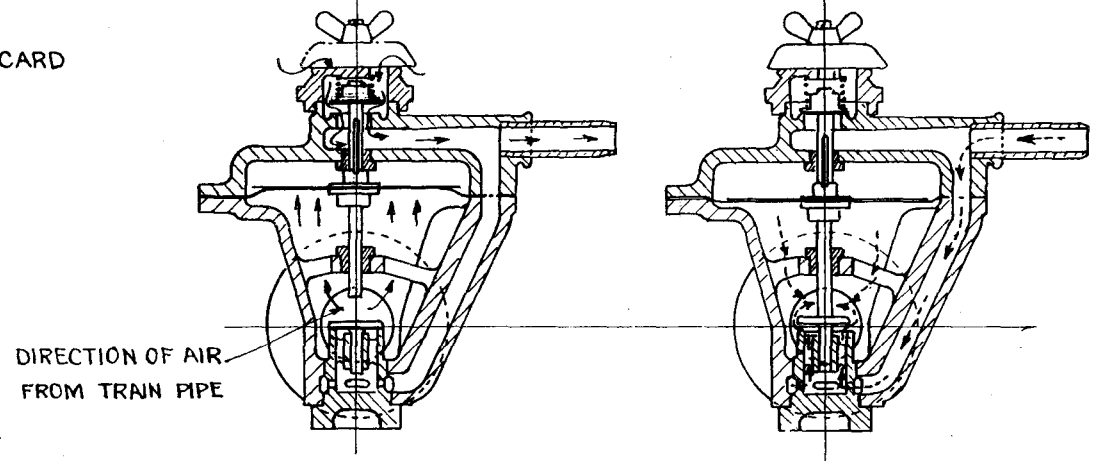


DESCRIPTIVE
LETTERING

DEFECTIVE D.A. VALVE
BLANKED OFF

ARROWS THUS → DENOTES
DIRECTION OF AIR TO CYLINDER

ARROWS THUS ---→ DENOTES
DIRECTION OF AIR TO TRAIN PIPE.



BRAKE
APPLICATION

BRAKE
RELEASE.

FIG 6.
DIRECT ADMISSION VALVE.

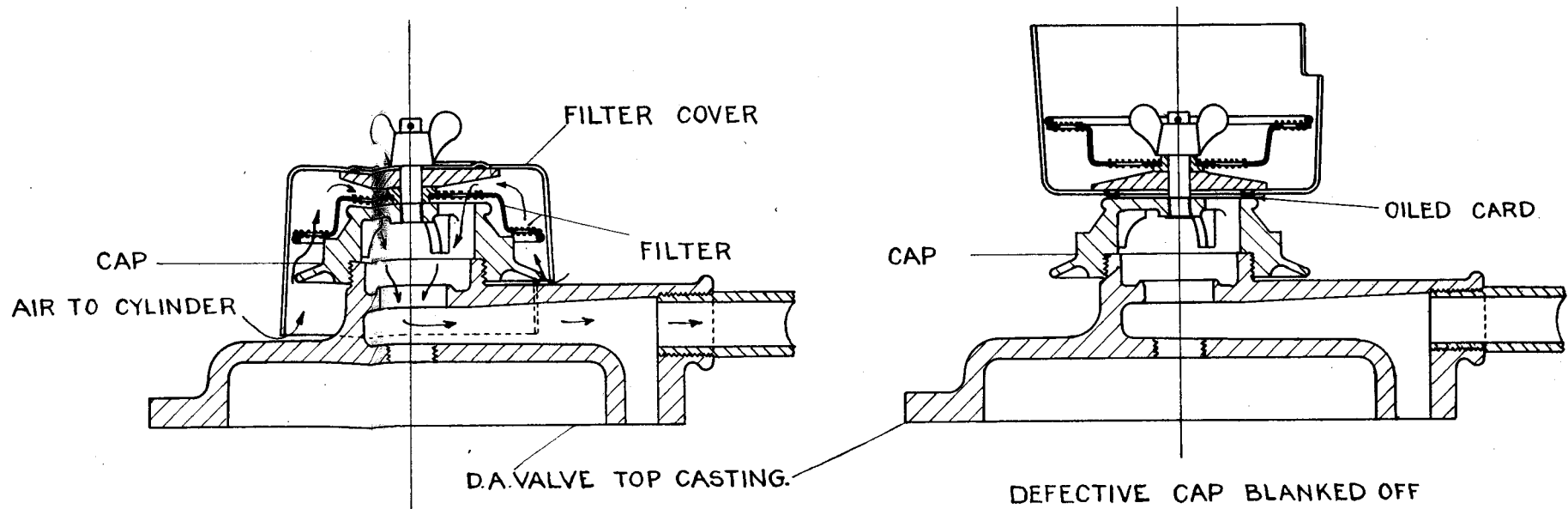
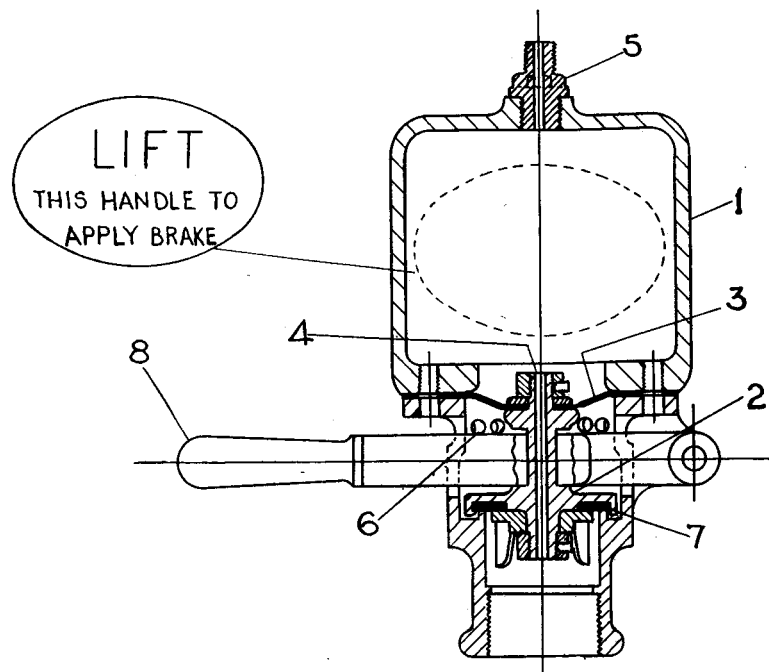


FIG. 6A
 NEW TYPE FILTER & CAP TO D.A. VALVE.

SCALE 6"=1FOOT. MAY. 1946. RLS.



DESCRIPTION

- 1 RESERVOIR
- 2 VALVE
- 3 DIAPHRAGM
- 4 HOLLOW SPINDLE (NIPPLE REMOVED)
- 5 CONNECTION TO GAUGE
- 6 AIR INLET HOLES
- 7 RUBBER VALVE
- 8 OPERATING HANDLE

FIG. 7
EMERGENCY VALVE. (NON-AUTOMATIC.)

SCALE $\frac{3}{8}$ " = 1 FOOT, MAY 1946. RLS.

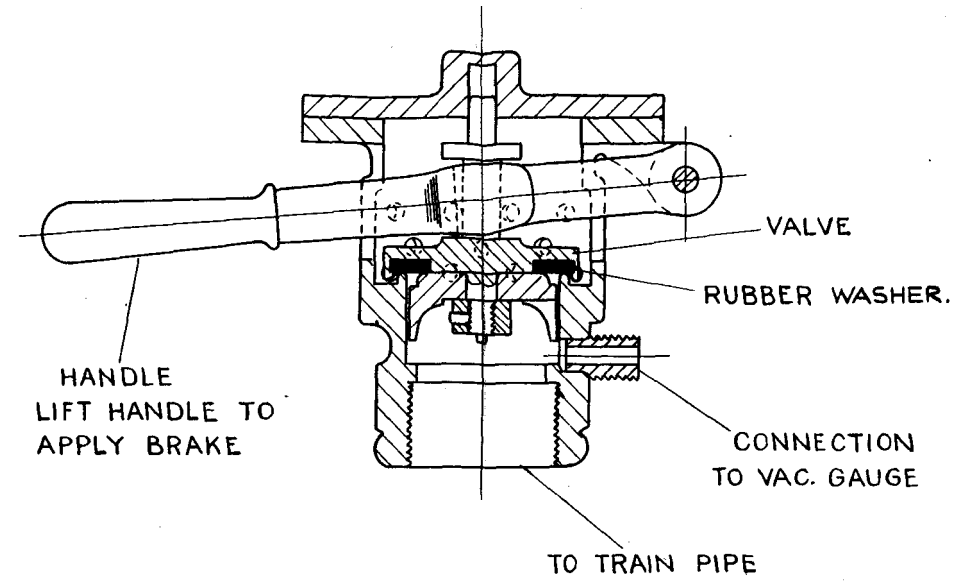


FIG 7A
EMERGENCY VALVE. (NEW STANDARD.)

SCALE 6" = 1 FT. MAY 1946 RLS.

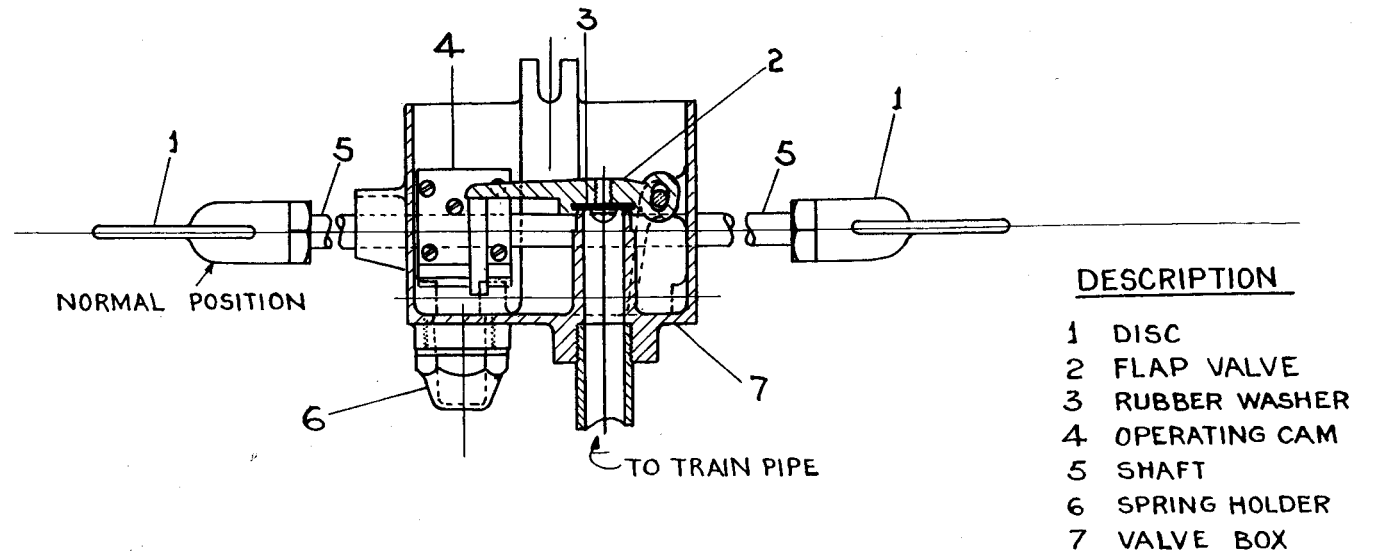
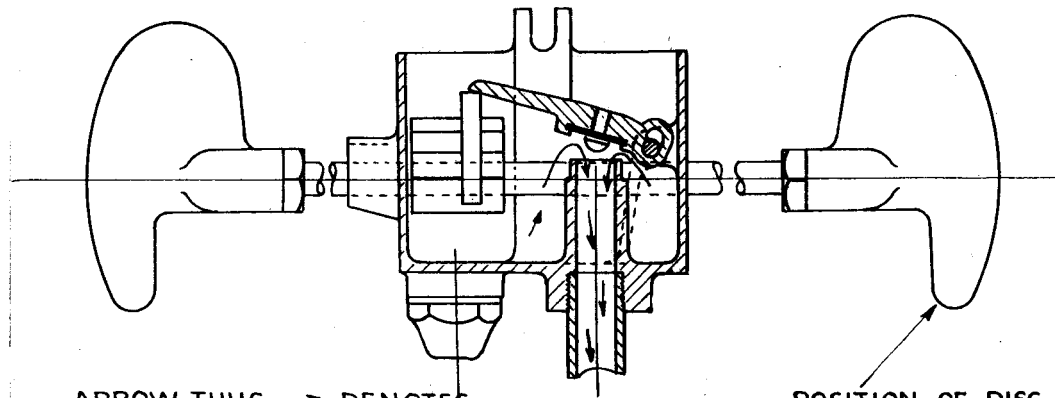


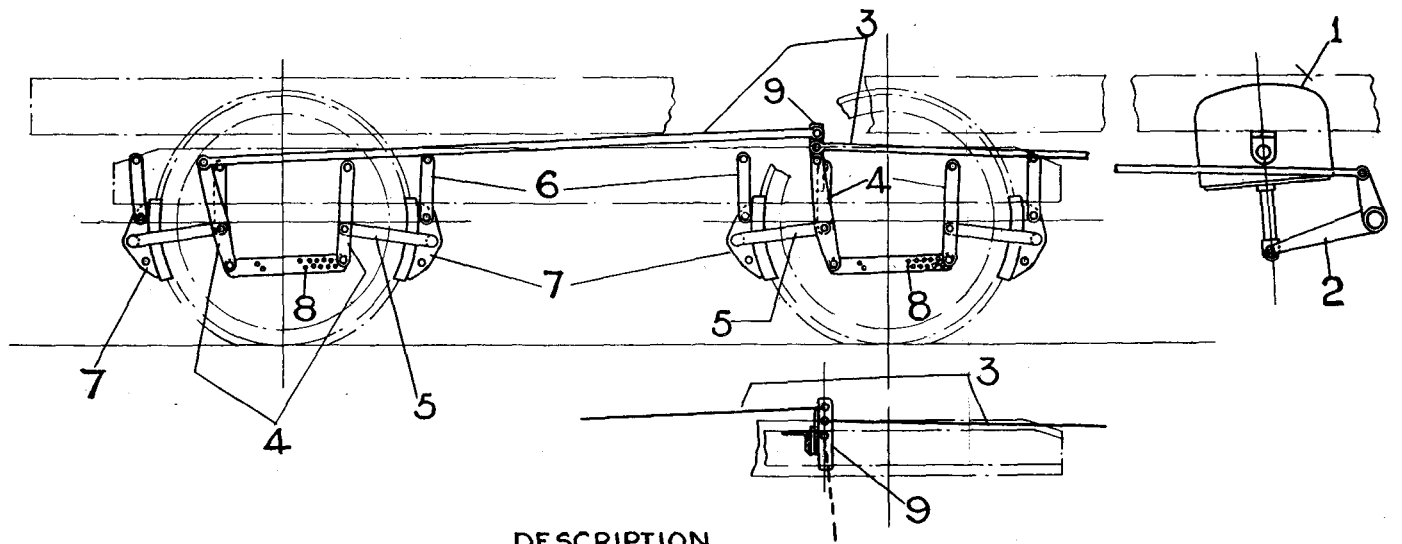
FIG 8
COMMUNICATION VALVE & DISC -CLOSED.



ARROW THUS → DENOTES
DIRECTION OF AIR TO TRAIN PIPE.

POSITION OF DISC WHEN
COMMUNICATION CHAIN IS
PULLED & FLAP VALVE OPEN

FIG 8A
COMMUNICATION VALVE - OPEN.



DESCRIPTION.

- 1-A.V.B CYLINDER. 2-BRAKE SHAFT. 3-PULL RODS.
 4-SUSPENSION LINK. 5-CROSSBAR OR BRAKE BEAM.
 6-BLOCK HANGER. 7-BRAKE BLOCK.
 8-ADJUSTING PULL ROD. 9-EQUALIZING LEVER.

FIG. 9
 BOGIE BRAKE ARRANGEMENT.

SCALE $\frac{1}{2}$ " = 1 FOOT. MAY 1946. RLS.