APPENDIX I.

Pamphlet No. 18.

"Railway Brakes,"

BY

GEORGE H. BURROWS,

Member.

Read Wednesday, February 28th, 1894.

THE subject of Railway Brakes is a most important and interesting one to everyone connected in any way with railways. When the speed and weight of the present day trains are considered, it is seen at once that it is highly important that those in charge of trains when running, should have them under perfect control, and in their own interests, seeing the grave responsibility under which they act, the driver and guards should be given the best brake available. The object of the present paper is to trace the principles of the different brakes from the earliest to those in use at the present time, and then to give descriptions of some of the principal ones.

Railway brakes may be divided and sub-divided into different classes. They may first of all be divided into sectional brakes and continuous brakes. Sectional brakes are those acting on sections or parts of a train; as an instance, the hand brake is a sectional brake, as the guard or driver can only apply it on the brake van, tender or engine as the case may be.

Continuous brakes are those in which the application of the brake to any part of the train, must produce the simultaneous application of the brake to every other vehicle in the train. This class may be divided into non-automatic and automatic brakes.

An automatic brake, in case a train broke into two or more portions, should instantly act without the intervention of driver or guards. A non-automatic brake is, of course, one which is incapable of applying itself.

Each of these classes may be sub-divided again into three. (See tables, page 18.)

Class 1. Contains continuous brakes in which the force available for stopping the train is the manual power of one or more men applied to the hand wheels in the brake vans.

Class 2. Contains continuous brakes in which the force available for braking is derived from the motion of the train.

Class 3. Contains continuous brakes in which the available force for working the brakes is brought into action by the use of steam, air, or vacuum pressure on a piston working in a cylinder.

There are two methods of obtaining automatic action, by differential pressure, and by the use of separate reservoirs.

Differential Pressure brakes are those where a certain condition of high pressure or of vacuum is maintained on both sides of the brake piston, which is thus kept in unstable equilibrium. Brakes are applied when this unstable equilibrium is disturbed by allowing air to escape from one side of the piston in the case of pressure brakes, or to flow into the space on one side of the piston in the case of vacuum brakes.

Separate reservoir brakes are those in which a separate reservoir is used for vacuum or compressed air, and in the case of the Barker Hydraulic brake, a separate accumulator in which water is stored under pressure of powerful spiral springs. Communication between these reservoirs and the brake cylinders is effected by a valve which shifts its position when equilibrium is disturbed, whether purposely, or by accident to the brake apparatus.

Sectional Brakes. All the earliest railway brakes were sectional. The first known railway brake was invented by a Mr. Le Caan, of Llanelly, in about 1801. It was used on an ordinary trolley drawn by a horse and running on rails. When the trolley came to a falling gradient, the horse had to check the velocity of the wagon by pushing back, and in doing so very often fell and was hurt. To prevent this Le Caan's brake was applied. It consisted of a cast iron brake block extending a little more than half way round the wheel.

The top of the brake block turned upon a pivot fixed over the centre of the wheel, and the lower part was connected by a chain to the shafts, so arranged that when the horse was on its legs the block was kept off the wheel, but as soon as the horse fell the block was pressed by its own weight against the wheel, skidding it, and retarding the motion of the trolley.

Stevenson in 1833 patented a steam brake worked by a cylinder fixed to the frame on one side of the boiler. This brake being applied only on one side of the engine tended to make the engine ride the rails and travel in a circle. The flanges were removed from the driving wheels and the difficulty partially overcome. Slack couplings were then in use, and it was found that the brake gave a very jerky motion to the passengers when applied. This led to the invention of the tight coupling for railway vehicles.

A rather remarkable brake was brought out about this time by a Mr. Booth, of the Liverpool and Manchester Railway. He placed a throttle in the blast pipe with a rod attached to it extending to the footplate. When the driver wished to stop, without shutting off steam he partially or wholly closed the blast pipe, and throttled the steam, and the back pressure on the piston skidded the driving wheel.

Simple continuous brakes. (See table, page 140.)

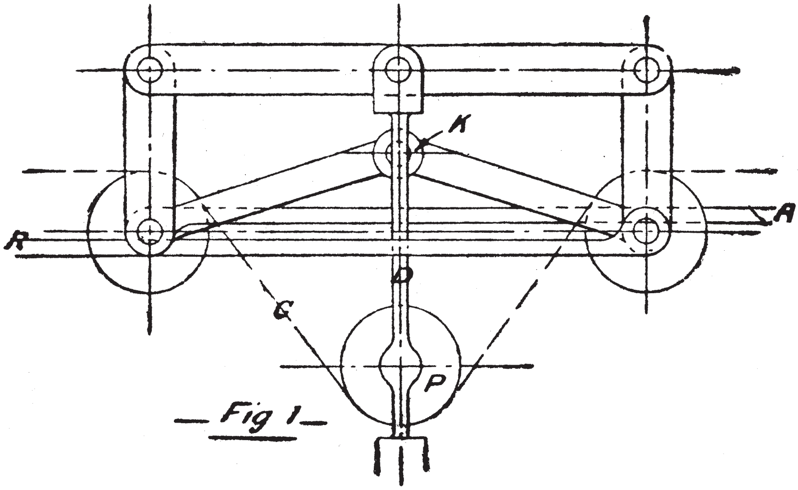
In the 1st class, brakes in which the power is derived from manual power, are the ordinary hand brake, and the continuous screw brake. The continuous screw brake was worked by means of bevel gearing from the guard's compartment rotating a shaft beneath the carriage. This applied the brake by means of a screw cut on the shaft working in a nut, and a system of levers. The shaft transmitted its motion through a coupling to the shaft under the next carriage.

In the 2nd class is Clark's Original Chain brake, which consists of a chain running underneath the carriages and passing over and under guide pulleys; one end is fixed to the end of the furthest carriage, and the other end to a revolving shaft on the brake van. This shaft carries a friction drum which when put in motion winds up the chain, raising the levers on each carriage and applying the brake. Brakes were applied by the guard releasing a weighted lever and bringing the friction drum into contact. This brake could not be regulated with regard to the amount of brake power applied. It was either "all or none," and moreover was not automatic, and again it could not be applied by the engine driver. This last fault was remedied by attaching a cord to the lever in the guard's van and extending it to the footplate. When the driver wished to apply the brake he pulled this cord and released the weighted lever in the guard's van. If the train broke loose from the engine the cord would be pulled and the brakes applied, but if the train divided between two coaches it would sever the chain and the brake power would be lost on the whole train.

In the 3rd class of non-automatic continuous brakes are the Smith Vacuum brake, Hardy Simple Vacuum brake, Westinghouse Simple Pressure brake, Westinghouse Simple Vacuum brake, Tell-tale Vacuum brake, and Kendall's Steam brake. As the principle of these non-automatic brakes is the same for each, a description of one will suffice for the remainder. In the Smith Vacuum brake a collapsible cylinder is placed under each carriage, and these cylinders are connected to a continuous train pipe running under the carriages. To apply the brake the driver exhausts the air from the train pipe and collapsible cylinders by means of an ejector placed in the smoke box of the engine. The atmospheric pressure on the outside collapses the flexible cylinder and applies the brake blocks by means of levers attached to the cylinders. To take the brake off, air is admitted into the train pipe through an air valve on the footplate of the engine. The great drawback to these brakes is that being non-automatic they are put out of action just when they are most needed. In the case of a train parting on an incline, the rear portion could run down the gradient and the brake would be powerless to stop it; also since the vacuum has to be made to apply the brake, this can only be done by the driver, and the guard is unable to apply it.

Automatic Continuous Brakes. (See table, page 18.)

In the 1st class is Clark's No. 2 Chain brake which is a modification of Clark's Original Chain brake, constructed on the principle of keeping the chain constantly in tension, whereby the brakes on each carriage are kept out of action. The automatic action is obtained by the breaking of the chain, but as it requires a winding up apparatus for the chain in the brake van, the brake is not applicable without the van.



— Fig 1 —

Class 2, Clark's No.3 Chain brake. The through chain is wound up and kept tight when the train is running by friction drums, one of these drums being keyed on the axle of the brake van. They can be thrown in and out of action by means of levers worked from the guard's van. Fig. 1 shows the automatic arrangement for applying the brake, which is fixed under each carriage. C is the chain attached to the furthest coach at one end and to a lever in the guard's department at the other. R.R. are the pull rods attached to the brake levers. On the rod D is a sliding bracket (not shown in sketch) which carries the pulley P at the lower end, and the pin K at the upper end. Between these two points on the rod is a spiral spring. The sketch shews the brake on. When the chain is tightened, the pulley P is raised, compressing the springs and raising the pin K, which moves the pull rods R and keeps the brake off. If the train divides and severs the chain, or if it is slackened by any means for the ordinary stopping of the train, or by the guard, the brakes are applied by the force stored in the springs. This brake was largely used in this country before the advent of the air and vacuum brakes, but since then it has been gradually superseded. It was generally worked by the guard and not by the driver.

The Heberlein Chain brake is similar in principle. A swing frame pivoted on a centre and carrying a friction wheel, is fixed under each carriage. The wheel is held out of action by the tension of a strong cord attached to the frame, and passing over guide rollers on the roofs of the carriages to a winding drum on the footplate. To bring the brake into action the driver pays out a certain amount of line, the swing frame carrying the friction wheels is thus lowered until they come into contact with those on the axle, when the brakes are applied. The brake as arranged can only be applied by the driver, the defect being as great as that in the brake last described which could only be applied by the guard.

The defects of all chain brakes are as follows:—

1. They can only be used on very short trains or portions of trains on account of the chain, so that they are practically sectional brakes and not continuous.
2. Seeing that the friction between the pulleys cannot be graduated, it is a case of "all or none"; the amount of brake power cannot be regulated.
3. It is influenced by the weather, and in winter the drums and pulleys become coated with ice, which makes the brake powerless, as there can be no frictional contact between the pulleys. Frequently the chain becomes frozen to the guiding pulleys when the brake cannot be applied or taken off.
4. The brake was generally arranged to be applied by either guard or driver alone.

Colquhoun's and Guerin's brakes are almost identical and are worked by direct traction from the engine, transmitted through the draw bar to laminated springs, similar to the springs in use now on ordinary rolling stock. When the train is standing and the strain is taken off the draw bars, the brakes are held on by the force of the springs. These brakes were designed for heavy mineral traffic, for use on inclines. As soon as the strain comes on the draw bar from the locomotive, the brakes are taken off, but if the train broke loose from any cause on an incline, the brakes are immediately applied by the force of the springs. It is certainly an automatic action, rather too much so, as neither the guard or driver has any control over it when running, but when required for shunting operations the brake may be thrown out of action by means of a lever at the side of the wagon. As this means a guard travelling the whole length of the train to take the brake off, it is at the best not a great advance on the ordinary hand lever brake.

Class 3 of Automatic Brakes, those in which steam, air or vacuum pressure is used, may be divided into two great classes, viz., differential pressure, and separate reservoir brakes. (See tables, page 141.)

Taking separate reservoir brakes first; there is the Hardy Automatic Vacuum brake, in which the prime mover is an ejector, the Westinghouse Automatic Pressure brake, in which the prime mover is an air pump fixed on the engine, and the Barker Hydraulic brake, in which the prime mover is a force pump for water.

Included in differential pressure brakes is the Automatic Vacuum, in which the prime mover is an ejector; Steel and McInnes Air Pressure brake, the prime mover an air pump; and the Wenger Air Pressure brake, the prime mover being an air pump.

Taking the Westinghouse Air Pressure brake first. This is the great example of the separate reservoir class of brakes. Plate 1 illustrates the Westinghouse Quick Acting brake. The sketch to the left of the vertical line shows the parts applied to locomotives only, and that to the right, shows the parts applied to tenders, carriages, or vans. The diagram is arranged to show the continuity of the parts, but the different parts are not in their relative positions. The air pump, of which A is the steam cylinder and B the air cylinder, is fixed on the side of the locomotive; the main reservoir C is generally fixed beneath the footplate, and the driver's brake valve D is fixed in the cab. The general principle of the action is this:—The air pump A B driven by steam from the. boiler of the engine, compresses air into a main reservoir C to a pressure of 90 to 100 lbs. When the engine is coupled to a train, the compressed air in the main reservoir is turned into the train pipe E from which it also passes through the branch pipes and fills on each vehicle an auxiliary reservoir G, through the triple valve F. The train pipe E, the triple valves F and auxiliary reservoirs G, are all charged with equal pressure of about 70 lbs., but there is no compressed air in the cylinders H so long as the brake is not in operation. The brakes are applied to all the vehicles in the train by a reduction of pressure, purposely or accidentally produced in the train pipe E. The brake can be applied by the driver admitting air through his brake valve D, or by the guard admitting air through his brake valve T, or by the train breaking away and severing the connections.

In the air pump the action of the steam is controlled by the movement of the main valve 1, of which the upper valve is greater in area than the lower valve. The top valve 2 on the same rod is greater in area than the upper valve 1. The steam chest C is connected with the chamber D by a small hole, so that these two chambers have always the same pressure in them. As the pump is shewn, steam is entering the bottom port and driving the piston up, which is connected with the air pump piston by a hollow piston rod. When the piston has nearly completed its stroke, the plate 4 strikes the shoulder of the rod 5 and raises the slide valve 6, closing the passage e to steam. At the same time it connects the exhaust ports f and g through which the steam from the top of valve 2 exhausts into the smoke box, as indicated by the arrows. Pressure being relieved on the top valve 2, the main valve 1 is forced upwards, closing the bottom steam port and opening the exhaust port; this commences the down stroke, and near its completion the plate 4 strikes the button at the bottom of the movable rod 5, and reverses the operation. In the air cylinder B, air is drawn in alternately through the receiving valves a, and delivered through the discharge valves b into the main reservoir C. The Driver's brake valve D is one of the latest pattern and is called the Equalising Driver's Brake Valve. The idea is to aid the driver in discharging the air gradually from the train pipe. Instead of allowing air to escape directly from the train pipe, he discharges it from the brake valve reservoir U, and the operation is repeated automatically for the train pipe by means of the piston valve shown. As soon as the pressure in the train pipe falls, the triple valve F allows air to escape from the auxiliary reservoir G into the auxiliary cylinder H, which forces the piston outwards, and by means of the connection R, to which the brake levers are attached, applies the brake.

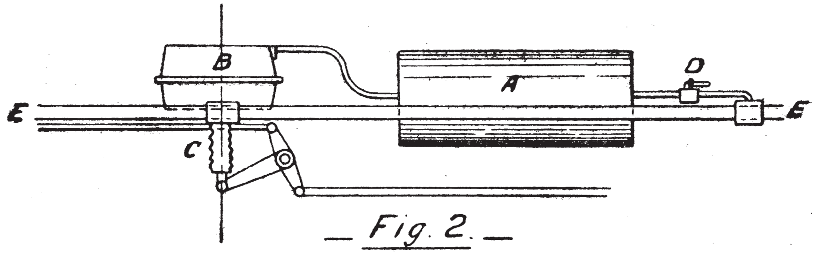
When the pressure is suddenly reduced in the main pipe, for instance in applying the brake in an emergency, the triple valve allows the compressed air to escape from the brake pipe into the brake cylinder as well as from the auxiliary reservoir, thus applying it immediately and with almost double the force as in ordinary application. As soon as the driver admits more air into the train pipe, the triple valve allows the air to escape from the brake cylinder H, and the piston is forced back by the spring behind it and relieves the brake pressure. At the same time the auxiliary cylinder is recharged.

By means of the cock in the lower part of the Triple Valve, the whole apparatus on a vehicle, or simply the "quick action," may be put out of use without in any way affecting the action of the brakes on other vehicles of the same train. In the vertical position of the cock handle, as drawn, the "quick action" is in use, in the intermediate position the brake is entirely put out of operation, and in the third position the apparatus works in precisely the same way as in the Ordinary Westinghouse Brake. The driver operates the steam cock P from the footplate, and steam is taken direct from the boiler. O is an ordinary displacement lubricator. A duplex gauge is shown, one hand giving pressure in the main reservoir, and one the pressure in the train pipe. W is what is termed a dust catcher, which consists of a tube of wire gauze inserted in the T connection. The guard applies the brake by means of the valve T. This brake is a very important one and is practically the only one used beside the Vacuum Brake.

The Steel and McInnes Compressed Air Brake is worked on the Differential principle. This does away with the auxiliary reservoirs and triple valves. A brake cylinder is fixed at each end of each carriage; the piston rod comes through the lower end of the cylinder and is connected by a short connecting rod to a lever on the brake shaft. The air pump is fixed to one side of the boiler of the locomotive, and is driven by a small engine on the other side of the boiler. This air pump is connected to a receiver which consists of rows of pipes arranged round the tender. A connection is made from this receiver to each brake cylinder by means of a continuous pipe. To apply the brakes, air is exhausted from the top side of the cylinder, when the pressure of air below forces up the piston, carrying the brake lever with it. To release the brakes, the pressure is restored on the top side of the piston by the driver, and the piston falls by the action of gravity. The automatic action is produced by the breaking away of the train, when the air escapes through the broken pipe from the top sides of the pistons, and applies the brake.

There are several objections to this brake. It requires a stuffing box for packing the piston. This is satisfactory on an engine where the stuffing box could be got at by the driver, but when it is used on thousands of carriages, it would be found impossible to keep all the stuffing boxes from blowing. A great amount of air is used at each application of the brake, as to apply the brake hard on, each cylinder has to be emptied. The brake is also slow in "going on," as an enormous volume of air has to be discharged at the engine through a pipe of small diameter. The brake has never been used very largely on account of these objections.

Aspinall's Vacuum Brake is worked on the Differential system. Vacuum is formed by a large ejector on the engine, and maintained by a small ejector. The brake cylinder is formed in two portions, in which work a leather diaphragm piston. Two train pipes are used, one connecting with the upper, and the other with the lower part of the cylinder.



— Fig. 2. —

Hardy's Vacuum Brake is a separate reservoir brake, and has a single line of train pipe. Two ejectors are used, one for forming, and one for maintaining the vacuum. In the diagram, Fig. 2, B is the brake cylinder in which is enclosed a diaphragm piston similar in construction to Aspinall's. The cylinder is connected at its top end to the reservoir A, which is connected to train pipe E; it is also connected at its bottom end to the train pipe. The piston rod is rendered air tight by a flexible sleeve C fastened to the lower end of the cylinder and to the piston rod. This sleeve is kept distended by internal metallic rings, and when the piston rises, the sleeve is compressed concertina fashion. To apply the brake, the vacuum is destroyed in the train pipe, and a cock D in the pipe between the reservoir end and the train pipe automatically closes, thus sealing the vacuum in the reservoir. At the same time, air is admitted at the lower end of the brake cylinder, raising the piston, and thus applying the brake. Attached to this cock D is a handle by which the cock can be opened to destroy the vacuum in the reservoir, and thus release the brakes. The brake does not leak off.

The Clayton Brake is almost identical with the foregoing brake, the only difference being that the reservoir surrounds the brake cylinder instead of being separate from it. These brakes are not usually applied to engines and tenders, but a separate steam brake is used for them.

The Eames Vacuum Brake is one of the Separate Reservoir system. Two ejectors are used, one for forming and the other for maintaining the vacuum. A metal piston is used in the cylinder, and the piston rod is packed by india rubber rings. The brake is attached to the bottom of the piston. The train pipes are used similar to Aspinall's. The brake is partially

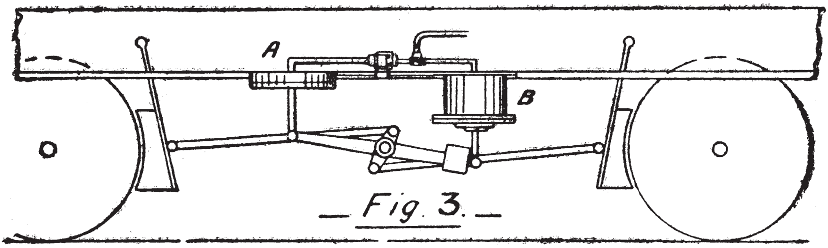


Fig. 3.

automatic.

The Sanders Brake is constructed on the Separate Reservoir system. The diagram, Fig. 3, shows the brake as originally applied to engine and carriages. The vacuum is obtained by an ejector placed in the smoke box and worked from the footplate, and is maintained when running by a vacuum pump. Two cylinders, A and B, are fixed underneath each carriage, and are connected on their top sides with a vacuum reservoir, which is connected with the train pipe. Each cylinder has a flexible piston of india rubber or leather. When running, the vacuum is maintained in the reservoir and in each cylinder, but the area of the cylinder A being greater than that of the cylinder B, the levers are pulled into the position as shown on the diagram. To apply the brake, air is admitted into the train pipe and reservoir. The pipe connecting the larger cylinder has a plain end offering no resistance to the passage of the air into the cylinder, but the pipe connecting the smaller cylinder with the reservoir has a valve opening outwards which seals the vacuum in that cylinder; air pressure being now on one piston and vacuum on the other, the position of the lever is reversed, and the brakes applied. In the latest arrangement of this brake, the two cylinders are replaced by one, in which a metallic piston works, packed by an india rubber ring.

In the brake used on the Great Western Railway, the vacuum is formed by the ejector on the engine, and maintained whilst running by a vacuum pump driven off the piston cross-head on the engine. In this case the brake lever is attached to the bottom of the cylinder (Plate 2), which is capable of moving freely up and down on the piston. The piston is fixed, and is connected by a hollow piston rod to the train pipe. To apply the brake, air is admitted into the train pipe by the driver or guard, or by the accidental severance of the couplings. Air rushes down the hollow piston rod, and acting with the vacuum on the lower side of the piston, raises the cylinder, and thus applies the brake. A small hole is provided in the piston so that the brakes gradually leak off after being applied. To release the brake, either the vacuum must be reformed on the top of the cylinder by the driver, or air must be admitted to the under side of the piston. A small valve is provided on each coach, so that the brakes may be released by hand if necessary, by admitting air to the underside of the piston. A valve or brake setter is provided in each guard's compartment, which acts automatically in the case of any sudden increase of pressure in the train pipe, and admits a supply of air.

The Vacuum Brake is only applied to the vehicles in the train, and a steam brake is applied to the engine and tender, but the action of applying the vacuum applies the steam brake as well. This automatic action is very fully illustrated by Plate 3. The ejector is studded on to the front of firebox within easy reach of the driver.

In the steam brake as applied to the locomotive, the cylinder or cylinders are fixed beneath the footplate. Where one cylinder is used for tank engines and tenders, it is of the oscillating type, and steam is admitted through the trunnions to the piston. The piston rod is attached to an arm on a rocking shaft, and the pull rods for the brake are attached to two other arms at the end of the rocking shaft. Where two cylinders are used, the piston rod of each is attached to the pull rod directly on each side of the engine. In the case of tank engines and tenders, provision has to be made for the hand brake to act on the same set of brake levers.

The Barker Hydraulic Brake is constructed on the Separate Reservoir principle. Water is pumped by a direct acting steam pump into an accumulator, and stored there under pressure of powerful spiral springs. Communication is closed between the accumulator and the brake cylinder by a valve which shifts its position when the pressure of water in the train pipe is reduced, and allows the water stored up in the accumulator to pass into the brake cylinder, and apply the brakes.

This brake is used very little on account of the difficulty with the water in cold weather.

The principal uses of a brake are briefly these :—

1. To stop the train at pre-arranged places of convenience.
2. For the prevention of accidents.

A powerful brake is not so necessary for the first as for the second condition, although for stopping trains at platforms, time is saved where a powerful brake is used.

For the prevention of accidents when a train is in motion, two qualifications are necessary :—the instantaneous application of the greatest amount of retarding force, and the continuous application of this force till the momentum of the train is destroyed. A train travelling at the rate of 60 miles per hour passes through 88 feet in a second, and with a train of say 200 tons weight going at this speed, it can easily be seen that it is of very great importance that the brake should be capable of being applied instantaneously. It was found in experiments conducted by Capt. Galton on the Brighton Railway, that the retarding force is greatest when the brake blocks are applied to the wheel with that amount of force so that the wheel is just on the point of skidding, and it was shown that:—

> "the friction between the wheel and the rail, when the "wheel is sliding on the rail," i.e., when it is being skidded, "is less than one third of the friction produced between the "brake blocks and the wheel, when the brake blocks are so "applied as to allow the wheel to keep revolving."

From the foregoing, it is necessary in order to stop a train in the shortest possible distance, that;—

1. The brake blocks should act upon every wheel in the train.
2. They should be applied with full force instantaneously.
3. The pressure on them should be regulated according to speed and other circumstances, so that the friction should be just under the amount necessary to skid the wheel.

From the first of these conditions it can be seen that the greater the number of wheels there are braked, the greater is the retarding force. From the second condition, it follows that for air pressure brakes, the more outlets there are provided for the escape of air, and for vacuum brakes the more inlets there are for the admission of air, the sooner is the brake applied. To fulfil the third condition, the brake should be capable of being applied with any certain amount up to its maximum, i.e., the driver or guard should be able to regulate the brake pressure as needed.

It was found from Capt. Galton's experiments that the co-efficient of friction between the brake blocks and the wheels varied inversely as the speed of the train; taking the averages of a number of experiments, the co-efficient at 10 miles per hour was found to be ·242, and at 60 miles per hour it was ·074, so that a higher proportion of brake block pressure to the weight is required at high speeds, and a lower proportion at low speeds. It was also found that at all speeds the co-efficient of friction was considerably less after some seconds of application than when first applied, irrespective of any change in speed, but that after from 1 min. to 1 min. 30 secs. application, it became constant.

The co-efficient of friction is also influenced by the kind of metal in the blocks and by the state of the weather. The adhesion of the wheels to the rails was practically constant as regards any change of speed, but it varied as the train was travelling on iron or steel rails, and also according to the state of the rails, whether wet, dry, or sanded. The co-efficient of adhesion on dry rails was generally over ·20, on wet or greasy rails ·18, and on sanded rails ·20. The experiments were made with steel tyres on iron rails. The retarding force of a brake is limited to the adhesion or resistance obtained between the wheel and the rail, therefore the greatest effect of stopping a train is produced when the friction between the brake blocks and the wheel amounts to a quantity just short of the adhesion, because as soon as the brake block friction exceeds the adhesion, the wheel becomes fixed and begins to slide. From Capt. Galton's experiments with a friction regulator—the brake block pressure being regulated by the adhesion of the wheels on the rails—it was found that the brake force necessary to produce the maximum retarding effect on each pair of wheels should be not less than one and three quarters to twice the weight on the wheels.

Considering the arrangement necessary to prevent accidents, the driver should be able to apply the brake, as he is in the best position for seeing danger ahead. The guard should be able to apply the brake in case anything happened to the train in the rear of the driver. If the train separated into two or more portions, the brake should act instantly on every portion. If anything happened to any essential part of the brake apparatus, the brake should apply itself at once.

To sum up the conditions of a perfect brake:—

1. It should act on every wheel on every vehicle in the train, including the engine and tender, and should be so regulated that the friction produced between the brake block and the wheel, should at all times be just short of that required to skid the wheels.
2. It should be capable of being applied by the engine driver or guard, and should apply itself in the event of the failure of any essential part of the brake apparatus; also it should apply itself on each portion in the event of the train

breaking away into any number of portions.

3. It should be capable of being applied with any degree of force up to the maximum.

Outside these conditions there are the questions of simplicity, first cost, and durability of the different parts.

There are practically only two brakes in general use now, viz., the Westinghouse, and the Automatic Vacuum. The Vacuum is the most favoured brake in this country, but as regards the rest of the world, the Westinghouse brake is used on most railways, while the vacuum brake is comparatively hardly used at all.

As far as regards the two brakes satisfying the conditions of a perfect brake, the Westinghouse is as near as possible a perfect brake. This perfection, however, is gained at the cost of a very complicated apparatus, although it is claimed that the failures of the brake due to the fault of the apparatus are no greater in number than the failures recorded for the vacuum brake. The first cost of the brake must be considerable, but as every detail is made by the Brake Co. on the interchangeable system, it is a good deal less now than some years ago.

The Vacuum brake is far simpler, has fewer parts, and therefore is less liable to get out of order. As to economy in working, there cannot be much to choose between the brakes. In the Westinghouse, steam is always being used when running, to maintain the air pressure, and in the vacuum where the air pump is not used, steam is always being taken by the ejector to maintain the vacuum. Where an air pump is used, as on the Great Western Railway, a large amount of work from the crank shaft is required to drive it.

The makers claim that the latest improvement in the Triple Valve makes the Westinghouse brakes absolutely instantaneous. This is a great argument in its favour for reasons previously mentioned.

On account of the difference of pressure used in the two brakes, 70 lbs. per square inch with the Westinghouse, and, at the most, 15 lbs. per square inch with the vacuum, smaller cylinders can be used with the former than with the latter to obtain the same pressure on the brake blocks, so that the apparatus is not so heavy with the Westinghouse as with the vacuum. As to the durability there is very little to choose between them. The parts which are the least durable in both brakes are the flexible couplings between the carriages. According to the last Brake Return, the number of engines fitted with the vacuum and Westinghouse Brakes in this country are respectively 4 to 1.

In countries where a standard gauge is used for railways, and where different companies send their rolling stock over each other systems, there is a very great advantage in having a standard brake, so that in the case of English railways for instance, vehicles would not have to be fitted up with apparatus for two different systems of brakes. It is thus almost as important to have a standard brake as a standard gauge.

For Tables, showing classification of Brakes, see next page.

Note:—In this digital rendering, the Plates have been moved to the end of the document instead of being inserted between the following pages.

SIMPLE CONTINUOUS BRAKES.

Class 1.	Class 2.	Class 3.
Continuous Screw Brake.	Clark's Original Chain Brake (Reynold's). Old Heberlein Brake.	Smith Vacuum Brake (Reynold's). Hardy Simple Vacuum (Engr. vol. 49, p. 291 and Reynold's). Westinghouse Vacuum Westinghouse Simple Pressure. Tell Tale Vacuum. Kendall's Steam (Engr. vol. 48, pp. 270, 272).

AUTOMATIC CONTINUOUS BRAKES.

Class 1.	Class 2.	Class 3.
Clark's No. 2 Chain Brake.	Clark's No. 3 Chain Brake. The Barker Brake (Engr. vol. 45, pp. 73, 76). Guerin Brake. Achard Brake. Colquhoun's Brake. Wilkin and Clark's. Heberlein Chain. Smith Friction Brake. (earlier and later pattern). Wiseman Brake. Naylor Brake.	Aspinall Vacuum Brake Barker Hydraulic Brake. Hardy Automatic Brake. Clayton Brake. Eames' Vacuum Brake Sander's ,, ,, Smith ,, ,, Steel and Mcinnes' Air Pressure. Vacuum Automatic. Wenger Automatic Air Pressure. Westinghouse Automatic Air Pressure.

DIFFERENTIAL PRESSURE BRAKES.

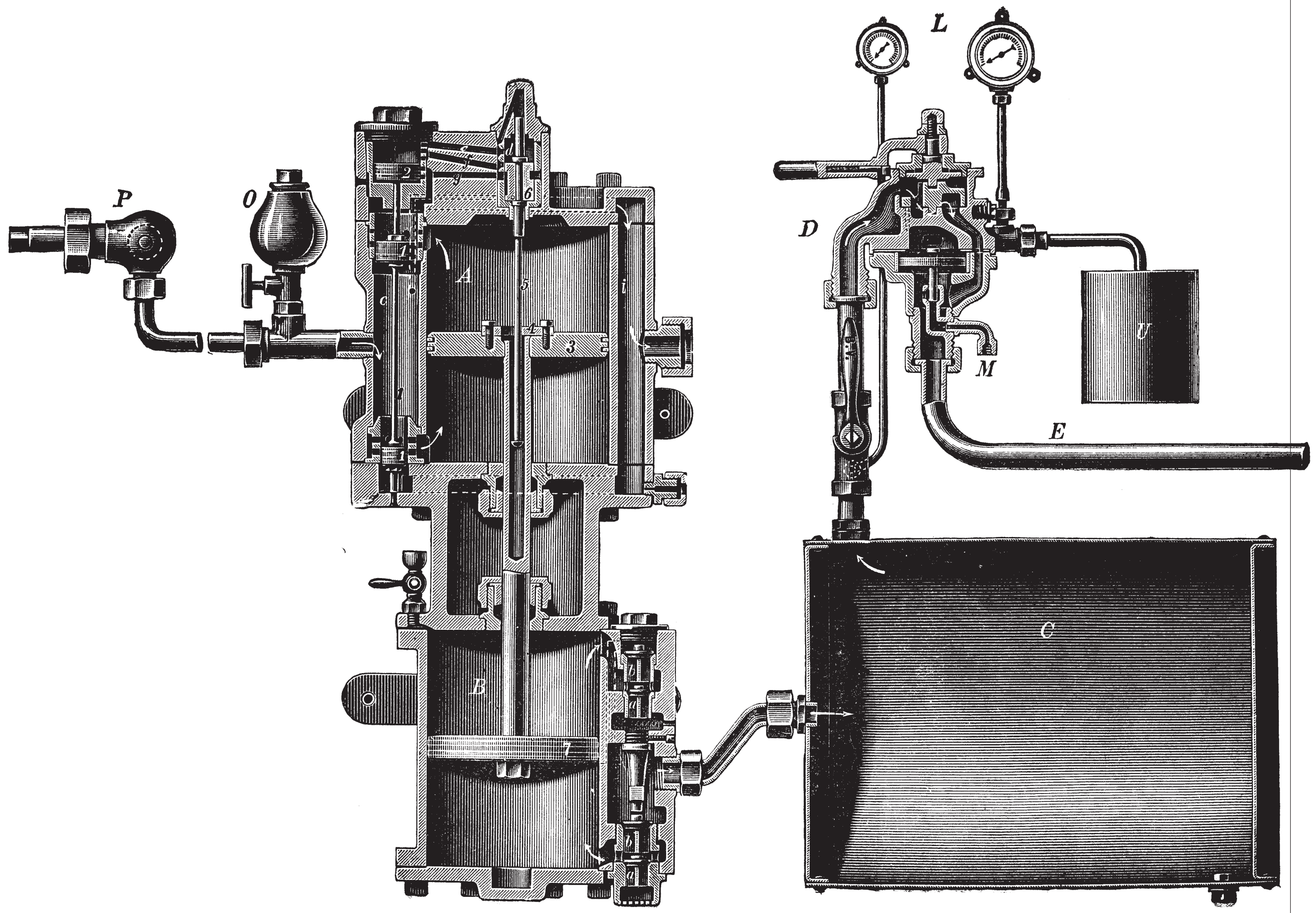
	Eng. Fittings.	Continuous Coupling.	Carriage Fittings.	
Brake.	Prime mover for exhausting or compressing air.	Form of Coupling.	Receiver.	Valve or other device used for retaining vacuum or compressed air on Brake piston.
Vacuum Automatic.	Combination Ejector.	Train Pipe.	Brake Cyl.	Ball Valve.
Steel & Mc-Innes Air Pressure.	Air Pump.	Ditto.	Ditto.	Valve.
Wenger's Air Pressure.	Ditto.	Ditto.	Double piston bk. cylinder.	Leather piston packing rings turned so as to retain the pressure.
G. W. R. Vacuum Brake.	Ejector.	Ditto.	Brake Cyl.	

SEPARATE RESERVOIR BRAKES.

	Eng. Fittings.	Continuous Coupling.	Carriage Fittings.	
Brake.	Prime mover for exhausting air from, or compressing it in the reservoir.	Form of Coupling.	Reservoir.	Valve which controls connection between reservoir and side of Brake piston.
Hardy Auto-maticVacuum.	Ejector.	Train Pipe.	Vacuum Reservoir.	Double seated diaphragm valve.
Westinghouse Automatic Pressure.	Air Pump.	Ditto.	Compressed Air Reservoir.	Triple Valve.
Barker Hydc. and Automatic.	Force pump for water.	Ditto.	Accumulator.	Auxiliary Piston Valve.

PLATE I

Parts Applied to Locomotives Only.



Parts Applied to Tenders, Carriages, or Vans.

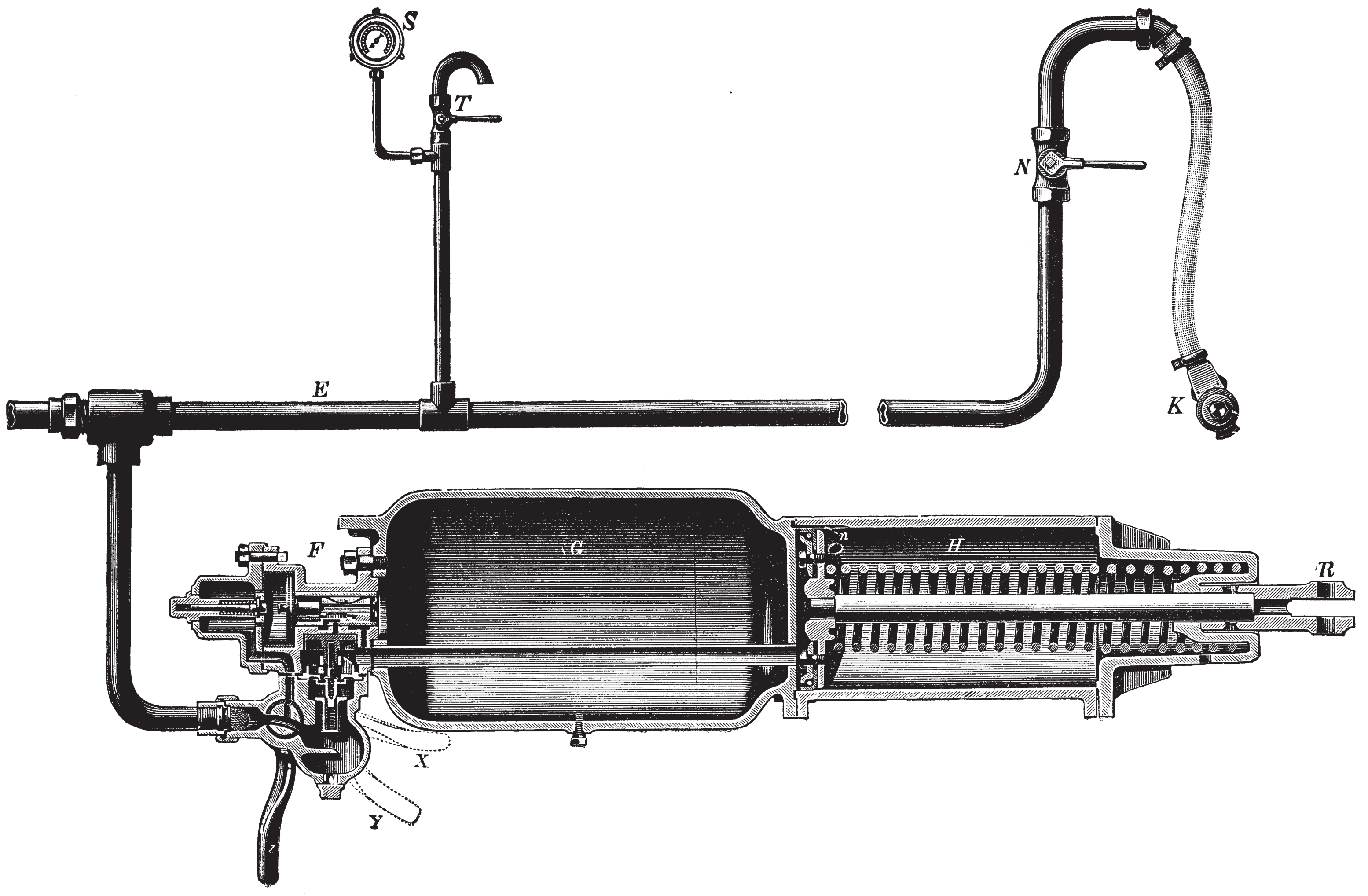
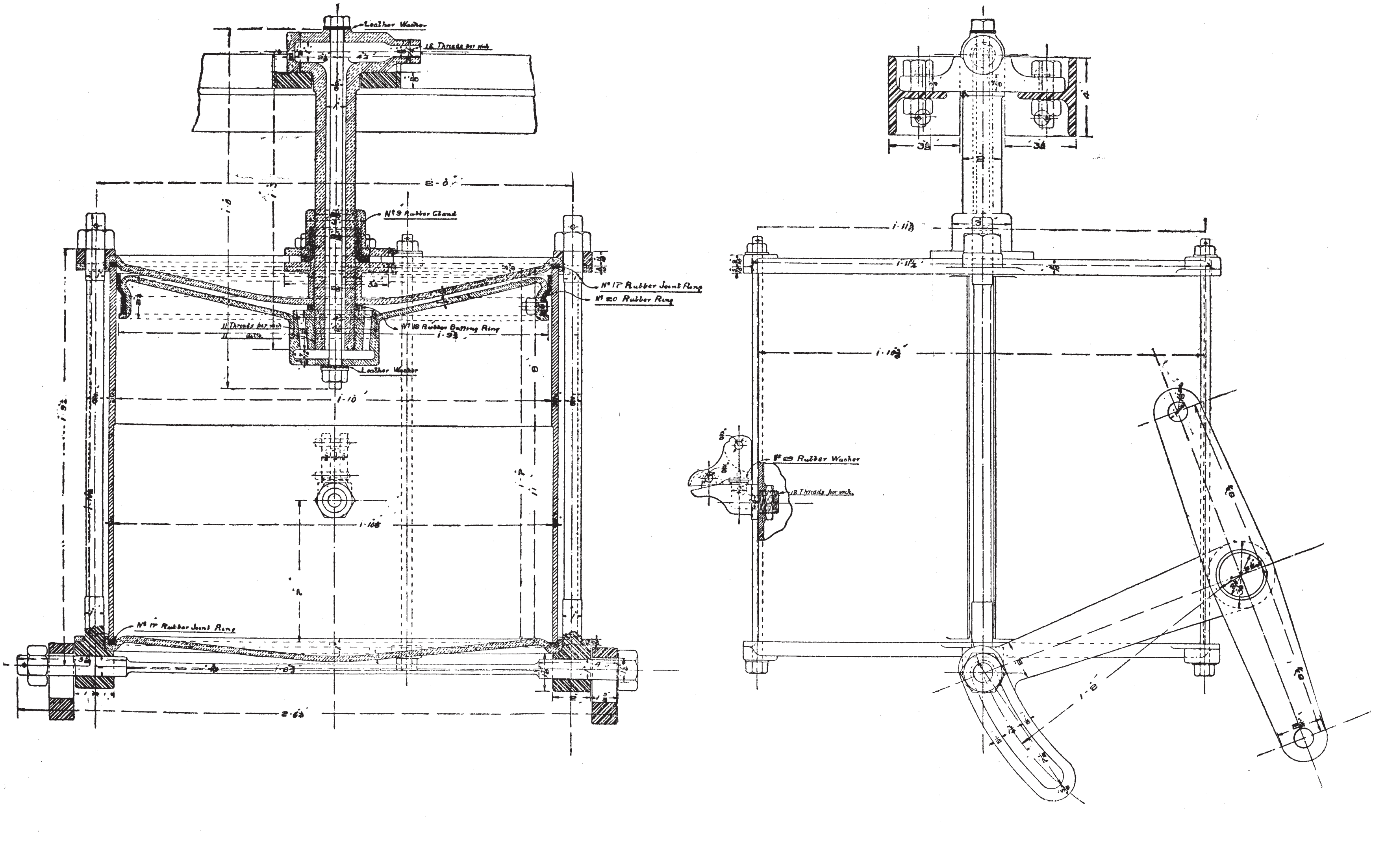
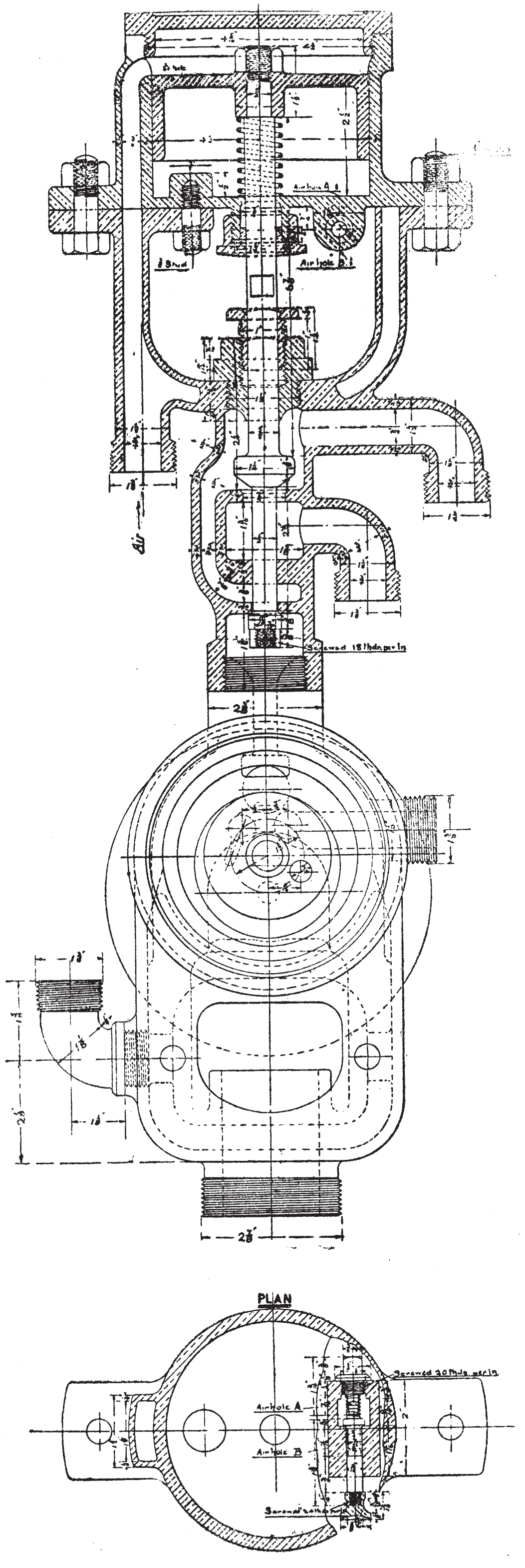
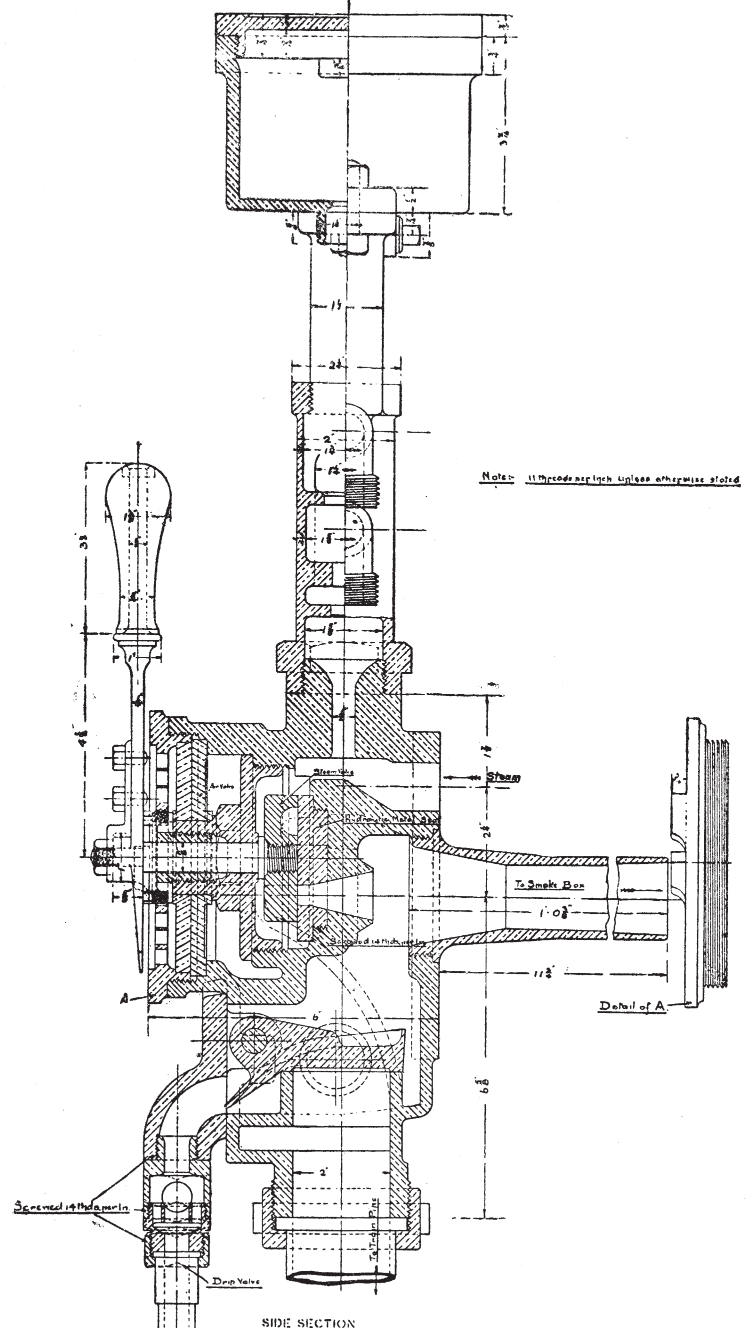


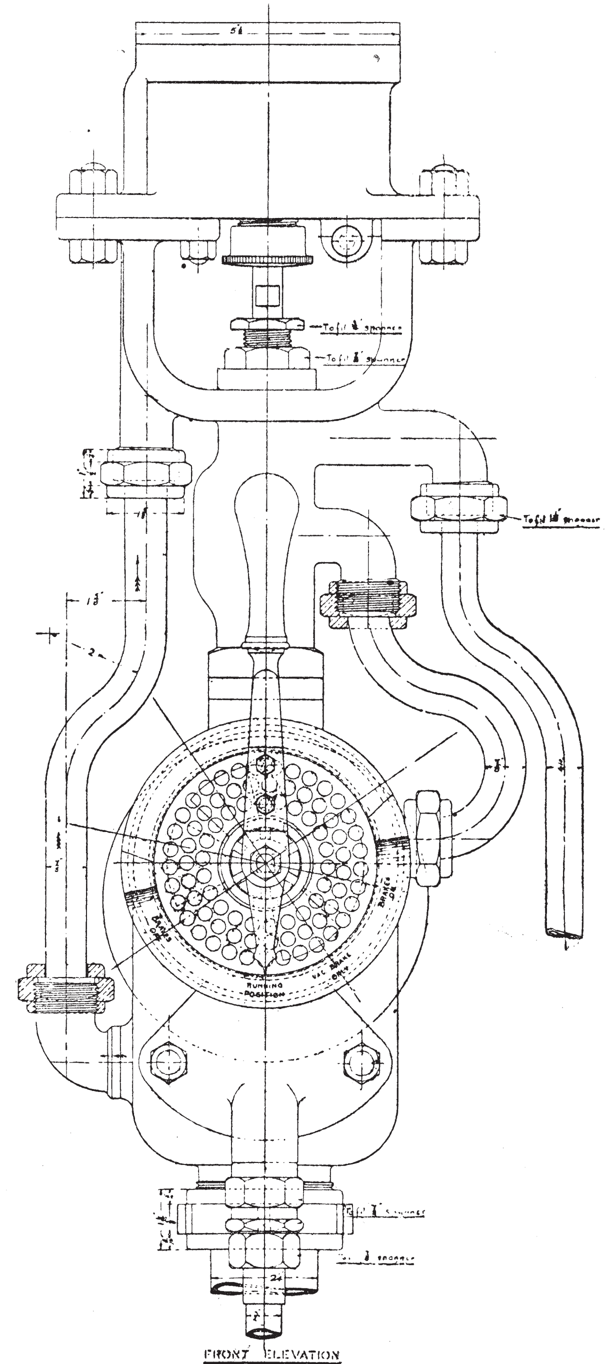
PLATE II



Leather Washer
16 Threads per inch
No 9 Rubber Gland
No 17 Rubber Joint Ring
No 20 Rubber Ring
No 18 Rubber Butting Ring
11 Threads per inch
ditto
Leather Washer
No 17 Rubber Joint Ring
No 29 Rubber Washer
12 Threads per inch







— G.W.R. —

— COMBINED BRAKE VALVES & EJECTOR —