graduating, and exhaust. Why the front is shown as a port instead of shortening the slide by an amount equal to its length, plus the metal at the end, it is not easy to discern. For rather more than a third of its length the valve face is reduced at the reservoir end to half its width, which permits a communication from the reservoir to the quick action valve when required. While the brake is inactive, the piston is kept to the left by the pressure in the train pipe, and permits air to pass through a confined passage at the bottom left hand side of its cylinder, and thence into the subsidiary reservoir keeping it charged. Upon a reduction taking place in the train pipe, the piston is forced to the right and with it, by means of an enlargement on the end of the piston stem, the slide valve. Sufficient play is allowed in the piston's connection with the slide valve to permit of a slight reduction in the pressure within the train pipe to cause the unseatment of the graduating valve, as well as the closing of the confined passage by the independent movement of the piston. This independent movement of the piston is an advantage owing to its lesser friction as compared with the slide valve, for it is obvious that a very slight reduction will instantly operate the piston, while the adhesion of the slide valve to its face requires more time and work to dislodge it, which would entail serious loss if the confined passage were not closed beforehand. The graduating valve has its seat in a convenient portion of the slide, and seals communication from the reservoir with the graduating port, this port leads from the seat to the slide valve's face, and, upon the piston making about half its stroke, is brought into communication with the passage leading into the brake cylinder. In this position the piston comes into contact with a graduating stem, whose resistance to the further forward motion of the piston assists in preventing the slide valve opening port to the quick action valve piston. The graduating stem has a collar at a certain distance from the end, acted upon by a spring, which keeps it against the right side of a partition at the right of the piston, one end of the stem protrudes through the partition, and, during the process of the graduation, receives the piston upon a slight reduction being made in the train pipe. The stem is so adjusted that when the piston comes in contact with it, the graduating port is full open.

To make an ordinary application of the brake, the air pressure is reduced in the train pipe causing the piston to move to the right. The movement simultaneously closes the confined passage, and opens the graduating valve, and presently moves the slide valves, closing the exhaust from the brake cylinder, and then opening the graduating port to communication with it. When the pressure on the left side of the piston has fallen to a little below that in the train pipe, owing to the expansion of air from the reservoir into the brake cylinder, the piston moves back again but not the slide valve, and closes, by means of the graduating valve, the communication to the brake cylinder. Further reductions in the train pipe operate only the piston and graduating valve, for the graduating port is now open. The slide valve remains stationary after its first movement, during the progress of graduating on. When, however, the pressures in the reservoir and in brake cylinder correspond, the brakes are fully applied, and further graduation is of course impossible.

It is important to remember with this brake, the natual property of expansion, common to all gases, is taken advantage of for graduation, and it is worthy also of remark that the pressure supplied to the brake cylinder for a given reduction of the train pipe pressure depends upon the size of the subsidiary reservoir. Releasing the brake is a simple matter; it is only necessary to restore the pressure in the train pipe, when the piston in the valve rises to its full limit. This movement places the brake cylinder to exhaust, and the reservoir in communication with the train pipe. Provision is made in the triple valve exhaust for connection to a pressure retaining valve. This instrument, in size 2in. by 4½in., is generally brought into use upon steep inclines, and limited to engine, tender and van for the sake of convenience. Its use is to retain a certain pressure in the brake cylinder, while the subsidiary reservoirs are being charged. It is simply a small valve loaded with a dead weight of sufficient size to retain 15lb. per sq. in. in the brake cylinder, and is operated by a three-way cock, the handle of which has a horizontal position when the valve is in operation, and a vertical one when closed. The valve may be said to be equivalent to temporarily bushing or contracting the exhaust port of the triple valve.

A brief description will now be given of the quick action mechanism which, as was said above, is in association with the triple valve, and is operated by it. It comprises a cylinder placed vertically in which works a secondary piston immediately under the seat of the triple-slide valve. The piston rod, which is hollow, projects downward, and into it protrudes the stem of a leather faced disc valve, called a central valve. The stem of this valve also projects downward into a lower one, called a check valve. This last valve is bored out to accommodate a spring which, while keeping the central valve up against its face, ensures its own seating. Although the triple and the quick action valves have been described separately, they are really dependent upon each other and are in one casing. The following remarks, therefore, refer to the valves as comprising one piece of mechanism. Air is admitted from the train pipe through a three-way cock, either to the triple valve only or to both triple and quick-action valves. The cock can also shut it off altogether. It will be remembered that in describing the action of the triple valve, in graduating on, a small reduction of the train pipe pressure caused the triple valve piston to come in contact with the graduating stem, and move the slide valve sufficiently to fully open the graduating port only. When, however, a large reduction is rapidly made in the train pipe, the triple valve piston moves the slide valve to the right with great rapidity, bringing the graduating port past the inlet into the break cylinder before it has time to admit sufficient air to check the progress of the piston, and the slide valve at its reduced portion in communication with the port leading into the top of the secondary piston, which is immediately forced down. This movement opens the central valve against the train pipe pressure below it, which pressure is thus allowed to pass direct into the brake cylinder which is now open to the greater reservoir pressure through the end port in the slide valve. When the pressure in the brake cylinder and train pipe correspond, the check valve is seated by the spring and prevents the return of air into the train pipe. This sudden reduction of pressure in the train pipe accelerates the action of the triple valve all along the line of carriages, at so rapid a rate as to render them practically simultaneous in their action.

To release the brakes after the emergency stop has been made, air is readmitted into the train pipe, which moves the piston and slide valve to the left. and brings the exhaust port into communication with the top of the secondary piston, which is then forced up by the brake cylinder pressure, while the spring in the check valve closes the central valve. Subsequently the slide valve opens the exhaust port to the brake cylinder, and the operation is completed. The subsidiary reservoirs are now in communication with the train pipe through the confined passage past the piston.

At Penrith trials, made in the middle of 1891, the brakes fitted with the quick action valves, to forty-eight waggons, were fully applied in two and one-third seconds. Fig. 3 shows the triple valve as patented May, 1874; propably the form used at the Newark Experiments in 1875. Shortly after it was altered to the form illustrated in Fig 2. Of this valve, Mr. T. E. Harrison, in the report referred to, said :—" As the most important, I will particularly draw your attention to the 'triple valve,' which has been made a regular bugbear by the opponents of the system, and has been called complicated, delicate, and liable to get out of order, &c. The original triple-valve used at the Newark Experiments—a drawing of which I have now before me—has three distinct valves, and hence its name 'triple-valve,' and it might, in it original construction, have to some extent deserved the term 'complicated.'" The report goes on to say:—"But the valve, as altered shortly after the Newark trials, and as now constructed (1879, and shown Fig. 2), differs so entirely from the original valve that, although I think it desirable to continue the term 'triple-valve,' its present construction would not have suggested or justified that term. It is in fact as simple a piece of mechanism as well can be imagined, certain in its action, of durable material; and there is nothing about it that can justify the term complication; on the contrary it is a model of ingenuity and simplicity." A short description of valve, Fig. 2, referred to by Mr. Harrison in such glowing terms, will, no doubt, be interesting. The most important feature in connection with it is a Graduating Stem. This Stem has a collar at a certain distance from its upper end, acted upon by a spring which keeps it against the upper side of a partition below the piston. The upper end of the stem protrudes through the partition, and during the first processes of graduation receives the piston upon a slight reduction being made in the train pipe. The stem is so adjusted that when the piston rests upon it, all the communications are closed. As the reductions continue, the piston forces the stem down against its spring, and allows the air from the reservoir to expand into the brake cylinder until the pressure in the former nearly equals that below the piston, when the spring immediately causes the closing of the communication to the brake cylinder, and prevents further expansion of air into it from the reservoir. Further graduations necessitate further reductions in the train pipe.

It will be noticed of the air feeding into the subsidiary reservoir past the piston, as it now does, it passes through the centre of the piston, and is shut off by a shoulder on the graduating stem which receives the piston. It is also worthy of note that with this valve a smaller slide was used which, although allowing of a lighter application of the brake in the first place, did not permit of such perfect graduation afterwards as the present valve. The important defect in the Westinghouse Brake is suggested by the latter part of the title given to the valve on which so much of its action depends, viz., a graduating *on* valve. It will require little reflection to perceive that a brake which will only perform the one operation is an imperfect brake. As a substitute for the all important quality of being able to graduate *off*, the Westinghouse Brake must be entirely released and again applied at a reduced pressure. This operation, it is evident, involves a large waste of compressed air. For instance, assuming that it would require four distinct pressures to properly graduate off the brake, a corresponding number of distinct applications (not including the initial one) involving the consumption of 26½ cubic feet of air, must be made upon a train of similar proportions to that mentioned when treating of the Hascom Brake. The presence in the brake of this defect renders it incapable of properly fulfilling the last qualification of a good brake as mentioned above. Another prominent defect in the brake is suggested by what has already been said regarding graduating off. Applications of the brake at reducing pressures in quick succession on an incline, dissipates all the useful power stored in the subsidiary reservoirs, and necessitates the brake being released for 20 to 40 seconds to re-charge. At trials conducted near Thornleigh on the 3rd September, 1887, the time taken to fill five small reservoirs with the main reservoir pressure, varying from 73 to 71 lbs. per square inch, was as follows:—First half-minute the pressure rose to 35lbs., and in the second to 48½lbs., but it took four minutes to rise from 48½ to 68½lbs. The train in the meantime may attain a dangerous velocity, and frustrate all efforts of the driver to regain control at a critical stage of its career. The length of time occupied in re-charging the reservoirs, is due to the very small passage which has already been referred to in connection with the triple valve. For obvious reasons this passage cannot be enlarged, and must therefore remain a standing defect. Its failure to fulfil the fourth condition set down in the early part of this paper is another prominent defect in the Westinghouse Brake, for should the brake pistons be leaky, the brake power may be impaired without being discovered, except indirectly through the motion of the train. The driver would have, however, some idea of the pressure in the subsidiary reservoir when the brakes are on. For, should the pressure in the train pipe exceed that in the subsidiary reservoir, the brakes would be released. From what has been said above regarding this widely used brake it will be apparent, that when used on trains working over heavy inclines, careful manipulation to ensure its safe working will be required of it.

HEBERLEIN AUTOMATIC FRICTION BRAKE. (Plate VI.)

This brake, the author believes, is somewhat extensively used on the Prussian and other railways, and is at once ingenious and well designed. A reference to the illustration will afford a clear conception of its general working. It will be seen that the whole of the brake is operated by the driver from a friction winch, to a drum on this winch is attached the actuating or brake rope which passes up and over the line of vehicles to the end one, were it is anchored to an ingenious device capable of easy dis-attachment from the rope in the event of emergency. The rope in passing over the different carriages is *c·inked* by a couple of sheaves, the top one of which revolves on a fixed axle, and the lower one upon a pin at the end of bent lever. This lever is attached by means of rods, &c., to a swinging frame under the carriage, upon which are three drums and a friction wheel. The large one is called the multiplying drum, and receives motion from a smaller one at the side of the friction wheel to which it is attached. A flat linked chain, of peculiar construction, operates the large drum from the smaller one when the friction wheel is in gear. At the side of, and attached to, the large drum is a small drum upon which the chain is wound for actuating the brake block rods. The illustration shows the brakes on. They are brought into this position by the slacking of the brake rope, which permits a friction wheel on the swinging frame to come into contact with another keyed to the axle, and the drums are thus revolved and the brakes applied. The driver's friction winch deserves some notice, it comprises a frame carrying two different sized rope drums in one casting. The interior of the large drum is turned to fit a cone-clutch, on the outer edge of which is formed a ratchet wheel. The cone-clutch revolves in a bearing on one arm of the frame, while the drums revolves on a spindle between a cone and a collar. The spindle cone forms a second friction clutch. A screw on the spindle, where it passes through the cone-clutch, enables the driver, by turning a handle, to disengage the clutches from the drum, or the reverse. The small drum permits the rope being wound up with greater ease when required by receiving the rope through slots in the flanges of the large drum. The ratchet wheel prevents unwinding. The spring in the interior of the cone-clutch bearing is supposed to act as a brake upon the spindle, and prevent its revolving from the adhesion of the large drum

When required to release the brakes the handle is turned to the right, a movement which engages the drum with the friction clutches, causing it to revolve and wind up the rope, the various levers, with the swinging frame, are thus raised, and the pressure released from the brake blocks, a spring or counter-weight withdraws them from the wheels. An arrangement for enabling the guard to both apply and release the brakes is placed in his van. This brake is render automatic by the separation of the actuating rope.

Although the brake, as was said before, is ingenious and well designed, and secured, in conjuction with the Westinghouse and Vacuum Company's brakes, a gold medal at the Inventions Exhibition, it is, nevertheless associated with some defects.

For instance, the brake blocks throughout the train would not come into simultaneous contact with their respective wheels, as will be seen by referring to the crinking apparatus in connection with the actuating rope. This will have the effect of causing unpleasant bumpings, and, probably broken couplings. Another defect presents itself when the brakes are on. The periphery of the friction wheels on the the swinging frames, being stationary, would be liable to wear unequally from the rubbing of the other friction wheels. Climatic influence, such as presence of ice, would seriously impair the frictional contact. Further, no provision appears to be made for putting on the brakes when the train is stationary.

The author will now describe a brake, which, he ventures to think will commend itself to the intelligent investigation of members of this Association, as well as those having charge of our great railway traffic systems, where so much life and property are involved. The author invites the candid criticism of member upon the

HUMPHREY AUTOMATIC AIR BRAKE. (Plate VII.)

which was invented 3½ years ago. The only brakes at that time available to the author, and from which he drew some assistance, were the Westinghouse, Eames' No. 2, and the Gresham. The objects sought to be attained by the invention are: firstly, to provide a reliable means for graduating off railway brakes, while, at the same time, affording the driver an accurate knowledge of the varying pressures in the brake cylinder; and secondly, to be able to release, and again apply the brake, two or more times in succession on any vehicle detached from the main source of supply. The first of the above objects it is proposed to effect by the combination of a pressure registering and graduating off valve and a constant pressure reservoir; and the second by the introduction of a release valve, all of which would work in connection with the usual main reservoir, train pipe, small reservoir, and brake cylinder. The pressure registering and graduating off valve consists of a cylinder or casing containing three pistons operating together. One of the pistons is any size larger than the other two, while the latter are of equal diameter. One of the small pistons on one side of the larger one acts as a valve, affording communication from the small reservoir to the brake cylinder, and from the latter to the exhaust. The constant pressure reservoir is a vessel of any convenient shape, and is kept in constant communication with the top side of the large piston of the valve mentioned. It is also connected with the train pipe in such a manner, that by the intervention of a check valve, the pressure in the reservoir is not affected when the pressure in the train pipe is reduced. The release valve is an ordinary three way cock, placed on the pipe connecting the valve above mentioned and the brake cylinder. It is operated by a two-ended lever, one end of which receives motion from a small piston in communication with the train pipe, and the other end is worked by hand at any convenient position. The illustration shows a general arrangement of the brake apparatus in connection with the ordinary main and subsidiary reservoirs, and the brake cylinder, as commonly used in the railway service. From the foregoing description, it will be seen that when air is admitted into the train pipe, both the reservoirs are charged through the non-return valves, that in the constant pressure reservoir is in permanent communication with the upper side of the large piston, while its under side is charged from the train pipe. If now a reduction of pressure be made in the train pipe the pressure below the large piston is reduced, the permanent pressure above it immediately moves down the pistons and opens communication between the small reservoir and the brake cylinder, and, at the same time, to the under side of the small piston situated below the large one, which is raised as soon as the statical load under it becomes equivalent to the statical load that had been previously reduced under the large piston. For example, suppose the available area on the large piston to be 5 square inches, and that on the smaller one 1 square inch.

Suppose, further, a reduction of 1 pound to the square inch be made under the large piston, representing a statical load of 5lb., it will be apparent that a pressure of 5lb. per square inch in the brake cylinder, and which acts under the lower small piston having the 1 inch area, will cause the valve to move up and close communication between the reservoir and the brake cylinder. Again, suppose sufficient air to have been exhausted to fully apply the brakes, and it is desired to gradually release them without removing the blocks from the wheels. It will be readily seen that by increasing the pressure in the train pipe by 1lb. per square inch, the upward pressure on the large and small piston will exceed the permanent downward pressure on the former, and thereby raise and open the exhaust to some air from the brake cylinder, while at the same time reducing the upward pressure on the small piston. When the upward pressures on the large and small pistons again equal the permanent downward pressure of the former, they fall and close the exhaust; any further increase of pressure causes the operation to be repeated. Assuming a vehicle to have been shunted and brought to rest by allowing the air to escape from the train pipe, thus applying the brake with full force, the method of operating the release valve mentioned is as follows:—The two-ended lever, which is operated by hand, forces a piston into the cylinder, and at the same time turns a three-way cock, thus allowing the air to flow from the brake cylinder into the atmosphere, while still retaining that in the small reservoir available for future applications. Should the cock be accidentally left open to the exhaust, the re-supplying of air to the train pipe causes the piston to be forced back to the end of its cylinder, thereby restoring communication between the brake cylinder and the graduating valve. The inventor of the above brake does not confine himself to the exact form, or size, or method of construction illustrated, nor to the use of one train pipe.

A few remarks will be justified respecting the comparative