11th AUGUST.

W. D. CRUICKSHANK, PRESIDENT, in the chair.

The following candidate was balloted for and duly elected as

MEMBER:

Dr. JOHN STORER.

The President welcomed the large number of members present to the new rooms in No 5 O'Connel Street, and thought the Association might be congratulated upon having secured most suitable premises at a moderate rental. Mr Norman Selfe then read the following paper:—

ON RAILWAY BRAKES.

BY NORMAN SELFE, M.I.C.E., M.I.M.E., &c.

THIS paper is not intended to be anything like so exhaustive as that on "Compressed Air and its Applications," which the author had the honor of presenting to the last session of The Association.

For the purpose now in view, it is unnecessary, to investigate the scientific principles involved in the action of railway brakes, as they all centre in one object, and that is, to get rid of the accumulated energy as soon as possible. In practice, this is accomplished by converting the energy into heat, and dissipating it to the atmosphere through the medium of the brake blocks by their pressure on the tyres of the wheels, which, of course means a most wasteful operation.

It must be borne in mind that the quantity of work stored in a moving train is equal to the weight of that train multiplied by the height a body would have to fall by gravity to acquire the same velocity; and thus, by the laws of gravity, a given weight at 20 miles an hour has not twice, but four times the work stored in it than it has at ten miles an hour, and at forty miles an hour it has sixteen times instead of four times the work in it.

In round numbers it may be said that for each ton of weight in a moving train the accumulated energy is as follows:—

at 60 miles an hour	- - -	120 foot tons.
40 ,, ,,	- - -	53 ,, ,,
20 ,, ,,	- - -	13 ,, ,,
10 ,, ,,	- - -	$3\frac{1}{4}$,, ,,

so that a train of the moderate weight of 200 tons only, at sixty miles an hour, has about 24,000 foot tons of work stored up in it, or, in round numbers, what is equivalent to 1600 horse power for one minute, or 160 horse power for ten minutes; this makes it evident what an enormous waste of power takes place in train stoppages, when made at high velocities, and explains the production of the fragments which result from a sudden stoppage or collision.

Although many schemes have been tried, on a small scale, to store up some of the power lost in stoppages, by means of springs or compressed air, which could be used to assist in starting again, there is only one practical way in actual use on railways, and that is to throw it away in heat, generated between the wheels and the brake-blocks. This paper will, therefore, only deal with the mechanism used for moving the blocks on and off the wheels.

At speeds of, say, 10 miles an hour, the friction of railway wheels skidding on dry rails is about one-fifth of the weight, and when very dry one-fourth.

The friction reduces as the speed increases, and as the rails are lubricated by moisture. From experiments made on the District Railway in London, at a speed of twenty miles an hour on damp rails, the co-efficient of friction was reduced to one-ninth.

If a train could only be stopped by arresting the revolution of the wheels and allowing the tyres to skid on the rails, the co-efficient of friction and the velocity would give us the distance in which it would come to rest; but the result would soon be to make polygons out of the wheels instead of circles, from the flats that would be worn on the tyres. It is, however, found in actual practice, that the retarding power of brakes is greatest when the wheel revolves with a friction on the brake blocks just less than that which would cause the wheels to skid. In a memorable series of experiments conducted by Captain Galton in 1878, the advantage of non-skidding as against skidding the wheels was conclusively proved, and many points which were up to that time matters of opinion only, were set at rest by actual trials.

It is now settled that the best method of braking a train is to apply blocks to the peripheries of the wheels. It will be thus seen that, to stop a train as soon as possible, it is necessary to retard, or arrest all the wheels in the train, with as much pressure as possible short of stopping them, and that this possible pressure is variable, increasing with the velocity. What has to be considered now is the working of certain contrivances which will bring the brake-blocks into contact as forcibly as required, and as surely as possible, and remove them when no further required, viewed from the standpoint of the practical engineer accustomed to the use and keeping in order of machinery.

When railways were first introduced, it was quite sufficient to apply brake power to the engine or tender by means of a screw and levers, and then to the guard's van; but as the system developed, with increased weight of trains and higher speeds, the necessity of more brake power became manifest; and in England the special attention of the railway companies was called to the matter by the Board of Trade in 1858.

It would be quite impossible this evening to give a history of the Battle of the Brakes, or even to describe all the leading inventions that have had a trial in actual practice, if it was desirable to do so, but reference will be made to the four leading classes of brakes which have been introduced during the last twenty years, and the most prominent ones only be more fully described.

First, Chain Brakes. It is easily understood that a winding drum can be affixed to the engine, the tender, or the guard's van in such a way that it will wind up a chain when a clutch or friction wheel brings it into connection with a revolving axle, and that this chain can be passed around sheaves attached to levers under each carriage from end to end of the train, so that the effect of winding it in from either one end or the other will be to force the brake-blocks against the wheels. Some years ago, before the author knew anything of Wilkin and Clarke's, or Clarke and Webb's chain brakes, he worked out a brake, in conjunction with a gentleman in the New South Wales Railway Department, and after it was brought to what was then thought a pretty perfect condition, it was found to be almost identical with Clarke and Webb's brake, as used formerly on the London and North-Western, and tested at the Newark trials, in 1875. Since then the author has paid no attention to chain brakes, although there are several varieties that have had their day, but they appear to be fast becoming things of the past.

Secondly, Hydraulic Brakes. A number of hydraulic brakes have been invented, tried, and successfully worked. In Australia they have been brought under notice from the fact of the Hon. Mr. Woods, of Melbourne, having a patent which has had an extended trial on the Victorian railways, but the title is somewhat misleading, as the water used is only the connecting link, and compressed air actually stores and gives out the power to set the brakes.

In the Wood's brake a cylinder and piston is fitted to the vehicle for putting on the brake, and water is pumped from the engine through a train-pipe and special valve into an accumulator, where the air is compressed by the water and becomes a spring. On the release of the pressure in the train-pipe the regulating valve allows the water to pass from the accumulator into the brake cylinders, and set the brakes with the pressure of the compressed air. On the restoration of pressure, when a further supply of water is pumped into the pipe, it refills the accumulator, and at the same time alters the valve and lets the water escape from the brake cylinder so that the brakes come off. The author knows nothing of the actual results in efficacy and cost of the Wood's brake; but as the comparitive friction of air and water is as the weights of the two mediums, it seems to him to be impossible that a water medium can ever be made to operate so quickly as air. Its want of elasticity is also against it. There are other hydraulic brakes such as Barker's, but as instantaneous and simultaneous action on all the vehicles are important points of a modern brake, the hydraulic system will be no further referred to.

The principal battle now taking place in railway brakes is between rival systems all using air, but divided into two broad classes—viz., those working with pressure much above the atmosphere, and those working with less than the atmosphere, or vacuum brakes. The best known vacuum brakes at the present time are, the author believes, the Smith or Adams brake, very largely used in England on the London and South-Western, and over thirty other companies in one form or another, and which brake was shown in actual work at the association's exhibition in Prince Alfred Park; the Eames vacuum brake and the Westinghouse vacuum, which last seems to be practically abandoned, as it is not heard of now. The former two brakes—the Eames and the Adams—both operate by the pressure of the atmosphere on a piston or diaphragm when there is a vacuum or partial vacuum on the other side.

The principal pressure or plenum brakes, operated by air pressure above that of the atmosphere, are, perhaps:

The Westinghouse Non-automatic, as formerly used on the New South Wales lines.

The Westinghouse Automatic, now in use in New South Wales.

The Carpenter Automatic.

The Hanscom Automatic.

These automatic brakes are also made as electro air brakes, the two first of them having been fitted with electro pneumatic attachments for instantaneous application, and tested in May last near Burlington, Iowa, U.S.A.

The Westinghouse non-automatic brake was working in America in 1869, and on the Caledonian Railway in 1872. A very full description is given in "Engineering," vol. xiii. It then had a duplex train pipe, for simplicity of coupling up, and for providing extra security. This non-automatic brake is going out of use, although it is, in some respects much safer for mountain ines than the automatic brake, and for reasons well set forth in a recent number of the Journal of the Society of Arts.

Vacuum Brakes.

The Eames vacuum brake, on the Sydney tramways, is a very simple affair, but an effective apparatus for the purpose Each vehicle has a large iron basin with a flexible diaphragm attached to the periphery, this diaphragm having a large plate washer and chain connection to the centre of it, leading to the brake levers. An ejector is placed on the engine, and two valves are fitted with levers so arranged as to come into one hand of the driver. On opening one valve it admits steam to the ejector which exhausts the pans, draws in the diaphragms, and sets the brakes; opening the other valve admits the atmosphere to the pans and lets the brakes off. This brake is, of course, not automatic, and it is not wanted so for the purpose it is there applied to.

The Eames Vacuum Brake Company have, however, recently introduced an automatic brake, with electric attachments, which has made some good records, stopping a train at 41 miles an hour in 616 feet, but the apparatus is extremely complicated, and hardly seems likely to find general favour.

The Adams brake has probably been examined by every member present, so that it seems superflous to describe it. It will be remembered that the cylinder is contained in a casing or reservoir, and that by means of an ejector on the engine a vacuum is formed on both sides of the piston, which is packed by means of a special rolling india-rubber ring. When the train-pipe is exhausted, a vacuum is formed on both top and bottom of the piston; it therefore drops by gravity, and the brakes are then off. When air is admitted to the train-pipe either by the driver, the guard, or by the train separating, the atmosphere rushes into the pipe; but by means of a small automatic valve it is kept from getting to the reservoir above the piston, and only gets to the bottom of the piston, which it accordingly lifts, and thus puts the brakes on with the pressure due to the area of cylinder and difference of pressure on its two sides. As the air is at a low tension in vacuum brakes, much greater bulk is necessary with this system, both in cylinders and reservoirs, than is necessary with pressure brakes; and as the air has to pass through the train pipe to set the brakes, the pipe is necessarily very large, being two inches diameter in actual practice. The fittings of this vacuum brake are, however, extremely simple as compared with the Westinghouse brake, and it has also the advantage of being able to control the brake-blocks pressure more gradually and softly, as power can be put on or taken off to increase or reduce the brake power at the driver's will.

Pressure Brakes.

In the Westinghouse automatic brake air is stored in a main reservoir on the engine and passes through a drivers valve to the train pipe, this valve having an opening to the atmosphere. On each vehicle the train-pipe is connected to a small reservoir, a brake cylinder, and the atmosphere through the medium of an apparatus termed a triple valve. When pressure is turned into the train-pipe from the main reservoir by the movement of the driver's valve, a piston in the triple valve is forced up until a passage allows the air to get past and charge the small reservoir, at the same time a small slide valve attached to the triple-valve piston makes a communication between the brake cylinder and the atmosphere, which allows any air in the cylinder to escape, and the brakes come off by the pressure of a spring acting on the front of the brake piston. When the driver lets air escape from the train-pipe by opening it through his valve to the atmosphere the pressure is reduced under the triple-valve piston, which is then forced down by the reservoir pressure, and by its movement opens the slide valve to allow air to pass from the reservoir to the brake cylinder to put on the brakes. A small valve is fitted in the stem of this triple-valve piston which is intended to enable the driver to increase the pressure on the brakes or to graduate it, by graduating the reduced pressure in the train-pipe; the triple-valve piston floating between the reservoir and the train-pipe pressure. This triple valve is a most beautiful piece of design but it is very intricate and complicated. No doubt it can be made to work very gradually in an experiment, although it is the reservoir and not the brake pressure which controls its action. Some of you may remember how beautifully the attendant manipulated it at our last exhibition with the apparatus comfortably set up as a show, and with no doubt long practice on his part, but from the author's every day experience of the working of the train brakes as a passenger, he is much afraid that this power of gradation is very seldom practically operative, or railway travellers would not be jerked about so much at every stoppage as they actually are. The author understands that there was at the Inventions Exhibition during the time he was there, a triple valve that had a glass front to show the working of this graduation valve, but, however well it may have worked there under the manipulation of an expert, it is doubtful if it really does what is required of it in daily practice, and as it is probable that the rolling stock is more smashed up, and worn out by the shocks of stopping than it is by fair running. It is highly desirable to have a brake that will go on with the maximum of smoothness, and that will give the nicest gradations of power under the control of the driver, both for reducing the pressure on the brakes as well as increasing it, even if it does not act at full power with such a small reduction as the Westinghouse claims to do; that is, to go on full with 20 per cent reduction in the train-pipe.

Owing to the Westinghouse brake using a pressure of from 60 to 80 lbs., it has the advantage over the vacuum brake that a one-inch train-pipe can be used, as against the two-inch pipe used in the Adams vacuum system, and the apparatus is also much lighter for each vehicle.

In some correspondence on railway working in the Sydney press, since the lamentable Peat's Ferry accident, a well-known gentleman complained of the "jerky" stoppages on the New South Wales lines, and referred to the smooth working of the brakes in London, but it appears that some of the lines he referred to have the Vacuum, and not the Westinghouse brake applied.

The "Carpenter" brake is somewhat like the Westinghouse brake but has a very different regulator to the triple valve, and a combined reservoir and cylinder; it can be worked by the air pipe like the Westinghouse and also by electro-magnets for sudden stoppages, it was tested in the recent Burlington trials with good results, for freight train stoppages, and is essentially an Electro air brake.

Leaving for the present the point of smooth and gradual application of the brake blocks, it will be well, after our recc nt experiences, to consider a quality which it must be admitted is a most important desideratum in brakes intended to be used on railways with heavy and long inclines, such as there are in New South Wales, which quality or power *is not possessed by either the "Westinghouse, Automatic," or the "Adams Brake,"* and that is the power of *maintaining the brakes continuously on, and of increasing or reducing the pressure when they are on*, or *the power of making up for leakage in the reservoirs and brake pistons after the brakes are applied.*

It is not the intention of the author to make this Association the medium of re-opening the question as to the cause of the Peat's Ferry accident. He will not take one side or the other, and he trusts that in any discussion members will not deal with any disputed points of fact that are not positively settled with regard to that matter. One section of the daily press has written strongly for a particular view of the case, and although I believe it has every desire to be impartial, and the writer is certainly well-posted on certain phases of the brake question, his writings are a good imitation of special pleading for the Westinghouse brake. It will be better for *this Association* to look at the whole question of railway brakes from a much broader point of view than the interests of brake proprietors, and consider if any improvements are necessary to prevent a repetition of that accident (which was after all only one that had been foreseen and expected sooner or later), and if improvements are considered desirable, then what direction they should take.

It must be admitted that the Westinghouse automatic brake is a marvellously ingenious invention or series of inventions, and that the triple valve, more especially in its latest form, which exhausts the train pipe into the brake cylinder (probably not yet introduced into the colony), is a triumph of mechanical skill. The Adams brake also, in its more massive and grand simplicity, is the outcome of many minds working for years which have brought it to its present development, but still both these appliances, with all their