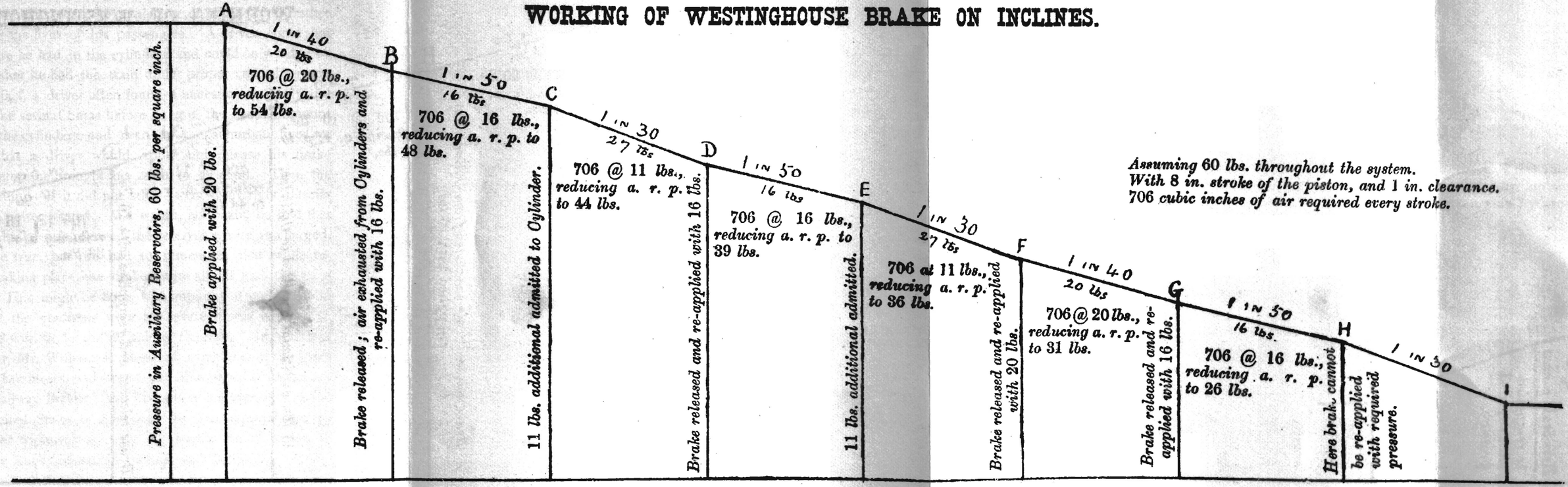
N.S.W. Railways.
Cylinders, 10 in. diameter, 12 in. stroke.
Reservoirs. 11½ in. diameter, 22 in. long.
Cubical content, 2284 inches.
(2¼ times that of the cylinder.)

DIAGRAM

SHOWING

WORKING OF WESTINGHOUSE BRAKE ON INCLINES.

Assuming 60 lbs. throughout the system.
With 8 in. stroke of the piston, and 1 in. clearance.
706 cubic inches of air required every stroke.



At H required controlling pressure should be 27 lbs., but only 23.6 lbs. can be obtained.

graduating valve? Oh, no; he knew a safer graduating valve than that. His graduating valve was the hand-brake. That was where he got his other 4 pounds. Of course, this punished the engine-tyres unduly, and turning up engine-tyres cost more than carriage-tyres, but it was the lesser of two evils, and he considered that a driver evinced a cuteness worthy of the highest praise in choosing the lesser of two evils, viz., the punishing of engine-tyres rather than the risking the lives of his passengers. A driver could not tell what pressure he had in the cylinders, and could only judge by experience whether he had the train under proper control or not. As a matter of fact, a driver often found it necessary to apply and release his brake several times before he got the desired amount of pressure in the cylinders, and even on the suburban lines we might notice that a driver would apply and release his brake several times before he brought his train to a stand. Then the good-natured pump—if it did not stick—went away right merrily to make up the power wasted. We would, no doubt, be told that as soon as the brake was released, the reservoirs were re-charged. That was quite true, but we had to remember that while re-charging was taking place, the brakes were all off and the train uncontrolled. This might be done with impunity at stations or on the level, but if the gradients were too severe, it was impossible, because in so doing, we let go our hold of the train. In March of the present year, Mr. William P. Marshall, a member of the Institution of Civil Engineers, had read a very able paper at the Society of Arts on "Railway Brakes," and had stated that during a recent visit to the United States of America, "he had observed that the intermediate (or triple-valves) were all thrown out of action in descending the Rocky Mountain incline, and the brakes worked non-automatically during the descent. On his return to England, he wrote to the Westinghouse Brake Company in London on the subject, giving them the particulars of what he had observed on the Rocky Mountain incline, and the answer received from them was that "the use of the non-automatic brake for descending long inclines is not at all necessary. On some lines in the United States there is still the practice of using the non-automatic brake

for descending grades, but we think this is owing to the fact that the direct pressure brake was very largely used there before the automatic form was adopted." As this did not accord with what had been observed upon the line, he applied to the locomotive engineer of the line, asking the reason for the intermediate valves being thrown out of action in descending the incline, and his reply (which was given in the paper) is that:—"Auxiliary reservoirs cannot be re-charged without releasing all the brakes on the train, and the train will, during this short time of release—fifteen to twenty seconds—gain such a speed on a down grade of 211 feet to the mile (or 1 in 25) that it is nearly impossible to regain control over it, especially when the rail is bad. For this reason, the triple valves and auxiliary reservoirs are cut out on steep grades down." Here we had two reasons given for the converting from the automatic to the non-automatic Westinghouse for descending long and steep inclines, and they may be said to be "as wide apart as the poles." The one was given by the engineer responsible for the safe working of the trains, the other by those who "profit by the sale of brakes." It appeared to him that the reason given by the Westinghouse Brake Company for changing from the automatic to the non-automatic brake, viz., "that the non-automatic was largely used before the automatic was adopted," was altogether too thin. What did the change necessitate? It necessitated (on arriving at the summit of the mountain) a man going to each vehicle and turning a three-way cock, by which he shuts off communication to the triple valve and opens a direct passage between the cylinder and main pipe. It meant that the driver had to work his brake-valve the reverse way to what he had done a few minutes previously. It meant that in the event of a burst hose-pipe occuring during the descent, that the train was no longer under the control of a continuous brake; and we should remember that the last Board of Trade Returns issued, for the six months ending December, 1886, contained no less than 352 cases—all of which occurred in traffic—and he thought we would agree with him that there was some reason other than that "the non-automatic was largely used before the automatic was adopted." Pursuing the

same line of argument, why did they not revert to the use of the hand-brakes, which were also largely used before either the automatic or non-automatic were adopted. He was aware that latterly a statement had been published that the locomotive engineer stated that they were now using the automatic brake on their lines, but whether they had reduced the exhausting difficulty by putting on larger pumps and reservoirs, as they had done on the Hungarian mountain lines, or had resorted to other devices, we were not at present aware, but there still remained one very ominous fact to face. The Paris, Lyons, and Mediterranean railways passed through some very mountainous country, and some years ago they had adopted the Westinghouse automatic brake. Shortly after it had been introduced, the engineer of these railways, M. Henri, had found it necessary to run an additional pipe through the train to obviate this defect in the Westinghouse system, and to this day all the trains were running with the Westinghouse brake, as improved by the locomotive engineer, M. Henri, with the re-charging pipe.

Now, although this overcame the difficulty in a measure, it added further complications to an already complicated piece of mechanism, but this appeared to be the usual fate of the Westinghouse brake. Too high a pressure was carried by drivers, causing flats on the wheels, and inconvenience to passengers, and the "governor" was introduced to prevent the air pressure getting too high. Hose pipes did burst, causing delays and accidents, and a double set were introduced, with the addition of two valves, four seatings, and two extra couplings for each vehicle, to obviate this difficulty. But these would sink into oblivion when we considered that a series of metallic pipes, with six moveable joints to each carriage were introduced, and to prevent waste of air and obtain quicker action, a new triple valve, with additional valves and springs had been schemed, adding "a sum of more to that which hath too much."

What the end of all this would be it was impossible to say, but it would be well if the inventors of the Westinghouse brake

were to remember the words of one, but for whom we should probably not be here to-night. He meant James Watt. His words were simply prophetic, and as true to-day as on the day he uttered them: "In all things, but proverbially in mechanism, the supreme excellence is simplicity."

Mr. Shellshear said that in the paper Mr. Selfe came forward as the special pleader for the Hanscom brake, and under the circumstances it was not to be wondered at that he should endeavour to show up the Westinghouse and Vacuum brakes in the most unfavourable light, and when comparing these with the Hanscom brake they always came out second best in his estimation. There were a few matters in the paper which were so much at variance with the experience of every-day working, that he thought it necessary to draw attention to them. Mr. Selfe made the following statement: "This non-automatic brake is going out of use, although it is, in some respects, much safer for mountain lines than the automatic brake." For any man to advocate a non-automatic brake for mountain traffic was, to say the least of it, the height of madness; for with the non-automatic system—either pressure or vacuum—a bad leak, a coupling separating, or a burst hose pipe, would deprive the driver of all control over the brakes of his train, to say nothing of a coupling breaking when ascending a steep grade. The whole tenor of the paper was to try and prove that the Automatic Pressure and Vacuum brakes were not suitable for long down grades, but what was the experience of the working of these brakes on long grades. If Mr. Selfe would refer to the Engineering of 27th of May, he would find that some of the steepest and longest grades in the world had been worked successfully for years with the automatic pressure brake, and Mr. J. N. Choate, of the Pacific Railroad, who had used this brake for some years on continuous grades of 1 in 25, for 19 and 30 miles at a stretch, stated that: "Since using it I do not know of a single instance in which any damage has occurred through its failure, or of a time when it has not worked properly, when handled by competent persons."

The extent to which the automatic pressure-brake was used on these steep grades on the Rocky Mountains, would be seen from the following tables:—

UNION PACIFIC RAILROAD.

30 miles ... ... of 1 in 25
19 miles ... ... of 1 in 25

ATCHISON TOPEKA, AND SANTA FE.

5 miles ... ... of 1 in 28½
11 miles ... ... of 1 in 50

DENVER AND RIO GRANDE.

21 miles ... ... of 1 in 25

The Northern Pacific worked three grades of ten miles each of continuous 1 in 25, and were shortly going to use this brake on grades of 1 in 18. Nor was the successful experience of the use of the Automatic Pressure brake confined to America, for we found that it was in successful daily working on the severe inclines on the Paris, Lyons and Mediterranean Railway, and that trains run down the long inclines on the line just named without any difficulty being felt. Mr. T. E. Harrison, of the North Eastern railway, who had, perhaps, the largest experience in the use of the Automatic Pressure brake of any engineer in England, stated that "it has been found especially useful for working steep inclines, of which there are many on the North Eastern system; in some the gradients being as steep as 1 in 37," one of the grades on this line being five miles in length altogether. The Automatic Vacuum brake had not been used to any great extent on steep down grades, yet he understood that on some of the long down grades of 1 in 50 in Victoria, this brake was now in daily use, and giving satisfaction.

Again, we had the experience of this colony, where the same brake had been used successfully for years on the steep grades over the Mountains, and if we took the Melbourne express, which had been worked over the steep grades of the Southern line at an average speed of something like 30 miles an hour for years without accident, he did not think we could have a stronger proof of the absurdity of Mr. Selfe's argument, that this brake was not suitable for working heavy grades.

Looking at the brake question from a broad standpoint, the case was reduced to this, to use the words of Mr. Clement E. Stretton: "That at the present time there are but two systems that can be considered efficient, or that are at all likely to come into permanent use—viz.:—the Westinghouse Automatic air brake, and the Vacuum Company's, or Gresham's automatic vacuum brake." Although, to say that either of these systems was perfect, would be to announce that mechanical skill was played out. The two systems had their weak points, which were capable of being more or less improved upon. The one system also had certain advantages over the other, and *vice versâ*. Thus, in the case of the Westinghouse, the pump might be simplified with advantage, and there was the trouble of an occasional burst hose pipe. The triple valve, although spoken of by Mr. Selfe as being "very intricate and complicated," was, after all, only a simple piston with a slide valve working on one spindle, which was certainly not calculated to puzzle or over-tax the brains of an apprentice boy, who took the trouble to try and understand. The rest of the apparatus was simple, light, and with even slight attention, was not likely to give trouble, or be costly to maintain in a state of efficiency. As to the Automatic Vacuum brake, the apparatus was simple, but it was not so quick in its action as the pressure brake, and was undoubtedly a good steam eater. Mr. Selfe insinuated in his paper "that the Westinghouse brake had been known to come off in three minutes." If there was any truth in this insinuation, it could only be said that it did not reflect very great credit to those in charge of it wherever such a thing occurred. Although there was no doubt that neither the Pressure or Vacuum brakes would remain on for ever, but would leak off in time, according to the state of the piston packing, but the packing in either system should retain the air long enough for all practical purposes, if it received a moderate amount of attention. A serious leak in the packing in either system would be detrimental to efficiency, although it would be of more importance in the case of the Vacuum than the Pressure brake, as the latter could be re-charged with far greater rapidity from the main reservoir than was the case

with the Vacuum brake, where the air had to be exhausted by the large ejector. A statement had been made at the last meeting that the Vacuum brake would remain on for five hours before leaking off, but he should very much doubt if such was the case, and it would be interesting to see a gauge fitted on the vacuum chamber of some of the cattle trucks fitted up with the Vacuum brake some time back. From the rapidity with which rubber deteriorated in this climate, he would be very much surprised if the cylinders of these trucks would now retain the vacuum for fifteen minutes with the brake applied, unless new packing rings were put in. From the fact that a large amount of rolling stock in England had been fitted up with the now obsolete Non-Automatic Vacuum brake, there was little doubt that this stock, on the ground of economy, would be converted into the automatic system, as the expense would simply amount to a new brake cylinder and a different form of ejector for the engine.

But in the case of our railways, the wisdom of complicating the working by introducing two or more systems of brakes would be very questionable, more especially as the practice of running mixed trains was on the increase, and there was certainly no advantage in the Hanscom or Vacuum brakes that would warrant such a complication on the one hand, or the general substitution of either of these brakes for the one which had been used with marked success for so many years on our passenger stock.

To return to the Hanscom brake, it was certainly amusing to read Mr. Selfe's remarks as to the cost of this brake. He stated "it would probably cost one-half of the Westinghouse." Now, comparing the two brakes, he was afraid Mr. Selfe would not get much change out of the transaction if he undertook to supply his brake at that price. He thought he would be rather nearer the the mark in his estimate if he put it at about 50 per cent. more than the Westinghouse. The Hanscom brake in its simple form was admittedly slow in its action, and it was interesting to see how Mr. Selfe proposed to make it quicker in action by introducing rather a bad copy of the so-called intricate and complicated