

without at the same time destroying the hose connected, and as the particular hose and tap in question were both new, and were found perfectly uninjured, there can be no doubt but that it was closed before (and hence) the accident, and all the evidence I have heard and read, fully bears this out.

“Mr. Selve, in introducing the Hanscom brake to us, has also pointed out many of its defects, thus forestalling criticism. I fully recognise and appreciate the advantage which the addition of a second line of piping gives, and it was used many years ago by Mr. Westinghouse, in some of the first installations of his brake. It can easily be applied again to the existing brake, without impairing any of its existing attributes, should our railway authorities deem it desirable.

“It is significant that to overcome the more obvious defects in the Hanscom brake, Mr. Selve has improved it by adding pure and simple, a Westinghouse triple valve.

“On studying the mechanism required for railway brakes, two principles may be recognised—(first) that for automatic action the power must be stored on every vehicle on which it is to be used, and (second) for the most efficient action the power must be conveyed to the brake pistons, as quickly and consequently through as short a travel as possible. To obtain this second desideratum, a valve on the principle of the Westinghouse triple valve must be used, which Mr. Selve appears to have very clearly recognised.

“A Westinghouse triple valve is also used with the Vacuum brake, in order to make it more efficient. It is placed in the guard's van, and by its action helps to apply the brake more rapidly, from which it may be reasoned, that if one was placed upon every carriage its action would be still further improved, but then it would be practically a Westinghouse brake.

“I regret that I was not present to hear Mr. Adams' remarks at our last meeting, but I have since read what appears to be a very full account of them, and with your permission I will address myself to some of the statements he has made.

“It is perhaps unnecessary either for Mr. Adams or myself to advise the members of this Association as to the source of the

data to which they will give credence ; but inasmuch as he has not contradicted my statement respecting the failures of the Automatic Vacuum brake, taken from the Board of Trade returns, for the six months ending June, 1886, and which differs so widely from his own statements, set forth as being drawn from the same source ; but in defence turns round and challenges the correctness of his own authorities. I think this sufficiently demonstrates that my warning respecting the statements of interested parties was not uncalled for. Personally, I do not attach much importance to the Board of Trade returns, because in several instances we have gentlemen reporting on their own inventions, and had Mr. Adams not introduced them I might have not done so either, but since our last meeting I have waded through all the Board of Trade returns I possess, and the following table is a story they tell of the working of the Westinghouse and Automatic Vacuum brakes."

Half-year ending.	WESTINGHOUSE.		VACUUM.	
	Average time of delays.	Average of delays to Stock fitted.	Average time of delays.	Average of delays to Stock fitted.
30th June, 1884	3'75 min.	1 in 45'4	5'7 min.	1 in 20'3
June, 1885	4'57 "	1 in 25'54	6'4 "	1 in 21'85
June, 1886	4'13 "	1 in 48	6'3 "	1 in 24
Dec. 1886	4'59 "	1 in 40	6'14 "	1 in 44
Average for 4 half-years. Westinghouse ...			{ Time, 4'26 minutes.	
			{ Stock, 1 fault in 39'76.	
" " Vacuum ...			{ Time, 6'13 minutes.	
			{ Stock, 1 fault in 27'7.	

"This comparison is made from the working of the Vacuum brake on the Lancashire and Yorkshire, and London and South Western Railways, and the Westinghouse on the North Eastern, London, Brighton, and South Coast, Caledonian and North British Railways.

"To the railway man, anxious to get on with his journey, it is a matter of little consequence whether his delays are caused by burst hose pipes, or twisted rolling rings, it is the number and extent of his delays that is to him important, and these returns incontestably prove that the Automatic Vacuum brake is a far greater defaulter than the Westinghouse. It is to be remarked,

also, that while the great percentage of Westinghouse delays take place from the simple hose pipes, the Vacuum are chiefly from the more vital parts of the apparatus.

“Regarding Mr. Adams’ claim for a similarity of principle between the Hanscom and Vacuum breaks, it will be remembered that, on the night this claim was made, it was made generally, now it is thinned down to the engines and tenders only, sixty-five per cent. of which are not fitted with the Vacuum brake at all, but only the apparatus to work the train brakes.

“My remark respecting the triple valve seems to have been misunderstood. What I said was that they would probably work better after being two years in use, than when new, and for this reason: these valves move as often in one year as the valves in the locomotive move in a day, and, as is well known, it is only after an amount of use that slide valves, pistons, and similar parts, get the surface which enables them to work best.

“I come now to the very remarkable diagram which was distributed at the last meeting, and even now I am in doubt whether it is only one of Mr. Adams’ little jokes, or put forward in seriousness. The language is plain. “At the point marked *r* the brake cannot be applied with required pressure.” I cannot imagine by what manner of calculation this result has been arrived at, but as a matter of fact, not fancy, this pressure, and a great deal more than this pressure, is being obtained daily, and for the last ten years, over similar grades on our mountain roads. To put the matter beyond a doubt, I have made the experiment suggested by the diagram, on the apparatus erected by us in Messrs. Morris Bros. yard, in Wattle Street, in the presence of Messrs. Key, Kidd, Christy, Kendall, and others, members of this Association, and taking all the chances against ourselves, the result invariably was that we had the same pressure at the bottom as at the top. So much for Mr. Adams’ diagram in connection with the Westinghouse brake. Let us now consider how his own brake would work over his own diagram. And we will first supply one or two necessary figures which have been omitted.

“Let us suppose the grades to be one mile long each, the speed thirty miles an hour. Now, according to all authorities, the problem of controlling a train, at a constant speed, requires that you should be able to supply a brake force sufficient, at the lowest co-efficient of friction, to cause a retardation equal to the force pulling onward. This co-efficient of friction, at thirty miles an hour, will be $\cdot 07$, and taking the weight and brake leverage of our New South Wales ordinary bogie carriages, which are $16\frac{1}{2}$ tons, and $5\cdot77$ to 1 , respectively (which figures appear to me to be those which Mr. Adams has taken to calculate the required air pressure in the diagram), it follows that the pull of gravity on the first grade of 1 in 40 , on this weight, will be 924 lbs., or one-fortieth of the weight. To supply a retardative force equal to this with a co-efficient of friction of $\cdot 07$, will take $\cdot 07 \times x = 924$ lbs., or $13,200$ lbs. of brake force. Let us see now, if the Vacuum brake, with same leverage, can supply this power. Assuming an initial vacuum of twenty inches, which, by the way, it will be difficult to get readily on our mountain tops, at 6-inch travel of piston, the power on the piston will be $7\frac{1}{2}$ lbs. per square inch. To be generous to an opponent, and certain in our results, I will give them 8 lbs. The diameter of piston is 18 inches, or $254\cdot4$ square inches in area, then $254\cdot4 \times 8 \times 5\cdot77 =$ brake force = $11,743$ lbs., or $(13,200 - 11,743)$ $1,457$ lbs. less than what is required under theoretical conditions, to control this weight over the first grade of 1 in 40 , then if there be no hand brake power, the Vacuum brake will never control it.

“Mr. Selfe has told us of three grave defects in the Vacuum brake—(first) the power on the brake piston is not certain; (second) it is heavy and cumbersome; and (third) it is slow; and the only set-off to these defects is that it is ‘gentle.’ I trust that if any of you are in a railway train, and the question of stopping becomes a matter of salvation or destruction, you will have something better than a gentle, slow-acting brake to interpose in your behalf.

“The Vacuum brake has other deficiencies besides those enumerated by Mr. Selfe. First, or perhaps fourth, it is peculiarly

sensitive to leakage, and those who have any experience in the creation of a vacuum by means of an ejector will bear me out in that. As an instance: On one of the express trains, fitted with the Vacuum brake, running between Melbourne and Albury, the driver for two months could obtain no more than 15 inches of vacuum, though every effort was made to discover the cause of the loss. With the Westinghouse an incident of this kind would be impossible, and when taken into consideration with the next defect, it becomes very serious indeed. Fifth: A reduction of the initial or standard vacuum (as above) causes a much greater proportionate loss of power. For example: Should a driver not be able to get more than 10 inches of vacuum with 8-inch stroke of piston, and the present proportions of the carriage mechanism, no power whatever could be put on brake blocks, or, with 50 per cent. loss in the initial vacuum there is 100 per cent. loss in the power. Sixth: In the Vacuum no means are provided to prevent the brake being automatically applied when a train is intentionally broken up; and our Assistant-Traffic Manager (Mr. Kirkaldy), speaking on this point, said that such a means is absolutely necessary and indispensable in railway working. Seventh: Should the mechanism go wrong on one carriage in the Vacuum system, that carriage and all behind it are incapacitated from being worked, and should this happen on the first carriage of a train coming down the mountains it might be very serious for the train. In the Westinghouse system, as is well-known, any defect on a vehicle may be limited to that vehicle.

“Generally considered, I think it will be admitted that, for the many purposes of a continuous and automatic brake, the Westinghouse is a more complete machine than either the Hanscom or Vacuum systems.

“Regarding the element of cost, which is so important to us now in our day of large deficits, Mr. Selfe has left the cost of the Hanscom brake to be estimated by the members, each man for himself; but as in this class of mechanism a good part of the price is made up of patent royalty, for our complete information, he should tell us what Messrs. Hanscom and Selfe's royalty is likely to be.

“The cost of one set of Westinghouse and Vacuum mechanism is the same, but there is this difference, that for the money the Westinghouse supplies 48,000 inch pounds of force, while the Vacuum only supplies 20,624, so from this manner of comparison the Vacuum is over twice as costly as the Westinghouse, and it will be found in practice that this comparison stands good.

“The Vacuum brake consumes more steam, which means coals, which means money. The Vacuum Company have frequently tried to throw doubt upon this fact, but it is one that will not be denied, and a striking proof has just come to my notice. At the Exhibition in Adelaide, steam is supplied and charged for as consumed. The Vacuum Company have four sets of apparatus, similar to those at the Exhibition in Prince Alfred Park, their stand is in a corner, a little out of the way for sightseers. The Westinghouse Company exhibit fifteen sets of apparatus, with about 300 feet of piping. For two months' supply the Vacuum Company have been charged £9 12s., the Westinghouse Company, £4 17s.

“Again, the dead weight of the Vacuum mechanism is much greater than the Westinghouse, and in this country, where the carrying capacity is so much diminished by the heavy gradients, it would be very bad policy indeed to carry unnecessary dead weight on the bottom of our waggons, instead of profitable merchandise inside.”

Mr. Adams handed in the following statement, having reference to the recently published returns by the Board of Trade upon the subject of brakes.

“Mr. Campbell has chosen to select from the English railways using the Westinghouse brake, two only, viz., the London, Brighton, and South Coast, and the North Eastern, and these, together with two Scotch railways, he compares with the Lancashire and Yorkshire, and the London and South Western railways, using the Automatic Vacuum brake. Now, although such a comparison may suit Mr. Campbell, I think I shall be able to show you that, from a scientific point of view, it carries no weight whatever. In the first place railway companies vary considerably in what

they consider should come under the term fault. Some companies state the length of the delay, others do not mention it. Some return faults to both the patented parts and the ordinary brake rigging, others do not. Some return under the heading, "neglect of servants," a fault against the brake, others do not. Mr. Campbell has chosen just those railways that suit his own purpose. As Sir Henry Tyler, one of the directors of the Westinghouse Brake Company, recently said at a discussion on brakes, when the figures brought forward did not suit him, "Nothing was more easily distorted than facts, except figures," and having quoted Mr. Campbell's director in my favour, I will, with your permission, call your attention to a few facts, drawn from the Board of Trade Returns, for the year 1886. I find there that, in the half-year ending June 30th the Westinghouse brake ran an average of 125,000 miles to 1 fault on the London, Brighton, and South Coast Railway, but on the London, Chatham and Dover they only ran 7,000 miles to 1 fault,—what does this mean? Is there any difference in the design of the Westinghouse brake on these two railways? None, whatever; and yet we find this brake failing on the London, Chatham and Dover Railway 18 times oftener than on the London, Brighton and South Coast Railway.

"Now, let us take two similar cases with the Automatic Vacuum brake. On the Belfast and Northern Counties Railway we find that this brake runs 223,000 miles to 1 fault, whereas on the Glasgow and South Western a mileage of only 11,000 miles per fault is attained. Here we find this brake failing 20 times as often on the Glasgow and South Western Railway as on the Belfast and Northern Counties Railway. I think that this is sufficient to show the folly of picking out individual railways for the purpose of comparison, and applies equally to the Westinghouse as to the Automatic Vacuum.

"I have taken the trouble to analyse the whole of the returns for both half-years, and find as the result, that for the half-year ending June 30, 1886, the Westinghouse brake ran an average of 42,000 miles per fault, and the same for the Automatic Vacuum brake. But for the half-year ending December, 31, 1886, the

Blue Book reveals that the Westinghouse brake ran average of 38,000 miles per fault against the Automatic Vacuum brake 72,000 miles per fault, or an average in favour of the Vacuum of 2 to 1. But the Board of Trade Returns reveal practically everything against the Automatic Vacuum brake. With this brake no instructions are given to periodically examine, clean and lubricate the various parts. No such attention is necessary, and they go on working until worn out. With the Westinghouse brake, however, special instructions are given to examine, clean, and lubricate the various details, as, for instance, the triple-valves, pumps, driver's valves, governors, cylinders, etc., every three months; yet, in spite of all this, we have the numerous failures reported."

Mr. Selve, in reply, said that he could not reply to the discussion that had taken place on his paper, and which had now extended over three nights without referring a great deal to the important places which the relative merits of the Westinghouse and Vacuum brake systems had occupied in the consideration given by members to the subject. Since he introduced the "Brake Question" to the Association, some of our members had been invited to see the Westinghouse brake worked on a train under special conditions, and the controversy which had been excited had no doubt induced the agents of the Company to erect the outfit for a train of ten carriages which had been on view at Ultimo, in order to give interested persons an opportunity of witnessing the actual working of their brake apparatus. He had here to acknowledge the courtesy of Messrs. Imray and Co. in sending him a special invitation to see it, which he availed himself of with much pleasure, although he proceeded to wreck the imaginary train at once, when he tried to handle it himself.

The most noticeable and important point in the whole discussion was the fact that the representatives of both the Westinghouse and Vacuum brakes, candidly admitted that in many important points the Hanscom brake was better than their own, and that was more than he could (as the introducer of Mr. Hanscom's invention to notice) have reasonably expected. He was prepared to admit, and would show presently, that in one feature the

Westinghouse brake had, for the present, an advantage, but as it was a feature that could be incorporated into the Hanscom system without infringing patent rights, he should, he thought, be able to bring the Hanscom out first of the three by a long way.

One or two members had evidently not quite understood the simple efficacy of the Hanscom brake enough to appreciate its merits fully, while admitting many of its good points; but Mr. Shellshear stood quite alone in his ideas of its practical value, and its cost. Unless he misunderstood that gentleman, he did not think it was automatic, but he did think a very dull apprentice would see that its cost must be 50 per cent. more than the Westinghouse per vehicle. He should, however, be able to show him if he had not already recanted, that there were in it only about one-third of the parts per vehicle (and those were of the most simple kind) that there were in comparison with those used in its great rival.

To come to the specific points raised during the discussion, it would be useless for him to reply to arguments taken *in globo* from trade circulars, or by extracts from the speeches of the Chairmen of brake companies, although such persons may have been Board of Trade officials at one time; because, however one-sided such arguments might be, they were often so specious, that it would take a book to refute them fully. But, he proposed to notice a few of the objections that had been taken to the Hanscom brake, and consider the special pleadings of the Westinghouse agents and engineer.

Mr. Adams, of the Vacuum brake, admitted the advantages of the Hanscom brake for working inclines, and in a very quiet way disposed of much of the pretentious claims of the Westinghouse representatives, but believed that he had an improvement that could be applied to his brake, and which he would be happy to show him, and that would make it much more instantaneous than it was now for emergent stoppages. Professor Warren showed conclusively that in the recent trials at Adelaide and Melbourne, the Vacuum brake, with all its simplicity, had in several ways the advantage over the Westinghouse, and he thought he admitted the