theoretical superiority of the Hanscom system to either. Mr. Campbell, of the Westinghouse Company, had spoken twice; first by courtesy and invitation, and (since his recent election) as a member. Mr. Campbell's first speech had been directed to show that from the Board of Trade returns, the Westinghouse was a better brake than the Vacuum, and that the Vacuum brake was not in use on so many lines as is represented. The second speech dealt with the reduction in the co-efficient of friction after the brakes had been applied, made some fun of the speaker's reference to the "gentle" application of the Hanscom brake, and went into a rhetorical rapsody about a train in the "inky blackness of night" dashing into a "Cootamundra chasm," after the bridge had gone, and further claimed that he had in his paper endorsed certain views adverse to the Westinghouse. He (Mr. Campbell) had produced at the same time a train-pipe cock and a length of hose and coupling, and had stated that the train-pipe cocks all had stops on them, to prevent the levers moving more than 90 degrees. So, he maintained that the cock (to the shutting of which his party attribute the late accident), could not have been shut by the telescoping of the carriages, but was never opened again when the train was recoupled. Now, he must, of course, give attention to a representative man like Mr. Campbell; more, indeed, than time would allow him to devote to any other parties to this discussion, and to take his points *seriatim*. From Mr. Hanscom's point of view, of course, he did not care a fig about the Board of Trade returns, because they had never yet had the privilege of dealing with the Hanscom brake. When they did so, there would certainly be fewer burst hose-pipes recorded against them than the Westinghouse now had, for the former's working air pressure was only about half that of the latter. The co-efficient of friction and its variation applied to all brakes alike, and he hardly understood why it was introduced at so much length, but this variation must be met much better in a brake like the Hanscom and Vacuum, that could graduate directly on and off, more or less, as desired, better than it could be done by an indirect acting brake with an intermediate regulator like a triple valve. The harrowing description given by

Mr. Campbell of a train going to destruction, and only a "gentle" brake to pull it up, was effective as a piece of bye-play, but was not relevant to the argument. If the action of a brake in bringing a train to rest in a given distance was represented by the train being caused to run up an incline to such a height as would consume the energy stored in the moving weight, then he maintained that a hollow or concave hill starting in a fair curve from the plane (as in the centrifugal railway) would, speaking comparatively, stop it gently, and that a convex hill rising abruptly from the plane to the same height in the same distance would bring it to rest in the same time, but with this difference—that while in the latter case, to say the least, the passengers would all be thrown out of their seats; whereas, in the gentle stoppage, equally sudden and effective, they would know nothing of what was going on. He wanted Mr. Campbell to understand that as long as the train was brought to a standstill in a given time and distance from the first application of the brakes, the apparatus that applied them directly, instantly, and gently, and then with gradually-increasing power up to the maximum, must be better, both for passengers and rolling-stock than the one that lets them on indirectly at second-hand, with a jerk, by means of a trigger, or triple-valve.

As regarded the shut-cock theory, he did not admit that he took any side in his paper, but was now forced to refer to it, because several government officials stated just now in reply to Mr. Campbell's assertion as to the stops on the cocks that *the cock on the wrecked train had no stops*, and that it *was supplied by the Westinghouse Company;* it was of course very curious to find out that during the inquest, the official enquiry, and in the reams of discussion that had appeared in *The Telegraph*, this point should not have been before settled. It was one certainty that had resulted from the discussion, and it confirmed the impression he had had all along, and that it was not necessary to believe that someone shut that cock the reverse way to the ordinary way when the carriage was uncoupled, and that he forgot to open it at all when the train was recoupled, to account for the accident or the cock being found shut afterwards, because the floor of that carriage went

twenty or thirty feet over the bed of the next one in the telescoping that took place, and the possible exhaustion of the air would render the brakes practically inoperative. The President's statements as to what he and Mr. Pollock actually witnessed confirm the Board's experiments and the opinions he had held from the day of the accident, and proved first that in a similar train to the one wrecked at Peat's Ferry the air could be exhausted from the small reservoirs in three minutes, and secondly that when the air was not exhausted, one carriage, the tender, and the engine hand-brakes would stop a similar train on that incline. He had been forced to refer thus to the accident at last by the action of the Westinghouse people, who should not have made him take sides in the accident question details, and should have been contented with their brake's undoubted merits, without claiming for it an infallibility that was a more suitable attribute of a simple machine like the Hanscom; and they should not have stated that he was championing the Vacuum brake when he did nothing of the kind.

Mr. Nelson had read from Reynold's work a long extract from somebody's paper in favour of the Westinghouse brake, and he summed up by saying—"It won't go wrong if it is worked fairly" now, talk about damning with faint praise, though that was a heavy fall for an advocate to give the brake.

Mr. Fischer remarked that he had not described the Herberlein brake, and gave some interesting information about it. He agreed with him, and he had had some particulars in his draft paper, but found it was extended too long, so he only referred generally to the chain-brake and similar systems.

Mr. Kerle had witnessed the agent working the Westinghouse brake, and had said no doubt the small reservoirs could be exhausted if unproperly used, and he admitted the Hanscom was better for working inclines. This gentleman had spoken of the flexible hose being responsible for 75 per cent. of the accidents recorded to the brake; but had forgotten that the Hanscom had a much lower pressure, and, therefore, less liability to burst hose. He (Mr. Kerle) was also wrong, he thought in referring to emergent stops being relatively so frequently required, on the whole he

had paid a good tribute to the advantages of Mr. Hanscom's invention.

Mr. Davies had defended the Westinghouse from being responsible for all the violent jerks attributed to iton our suburban lines, and to a large extent he was right; but it was not always the brake rigging and bogie frames which caused the disagreeable jerks referred to.

Mr. Key had taken exception to the friction of the piston-rod in the Hanscom brake; but as the Vacuum brake was successfully worked with less than half the pressure, there was nothing in that objection, the long-sleeved stuffing box being merely for a protector to keep the main packing clean and free from dust, and the friction need only be very little.

Having disposed of the criticism his paper had been subjected to, he might now say what he considered were the functions which a brake was called upon to perform, and that, in his opinion, its qualities should be considered under four separate heads, although in all the literature on the subject he had never yet seen them so separated. He recognised four separate and distinct duties that were required from a railway brake, the same special points or qualities *not being the first essential in all of them.* First, service stoppages; secondly, emergent stoppages; thirdly, automatic stoppages; fourthly, braking down inclines.

Now, what he recognised as the first essentials were:—In the first case, smoothness of application and release, and absence of sudden jerks and simultaneous application throughout the train.

In the second one, instantaneous application; in the third, certainty of action; in the fourth, the power of graduating the brakes on and off under the direct and positive control of the driver's lever.

It would be granted by all that the brake that would go full with the least reduction of train-pipe pressure should be the best to stop a train in an emergency; but if it was operated by a series of triggers in the shape of triple-valve pistons, which only came down when the variation of pressure overcame their friction in their cylinders at different times; and further, when the reduction of

pressure under them was insufficient, stuck up, and let the air out the same way that it went in; then, he maintained, such a brake should be the champion for jerking the passengers out of their seats, for dislocating vertebræ and for damaging rolling stock generally.

The very quality which made the Westinghouse brake good for emergent stoppages placed it last for service stops, as so much depended on the skill and judgment of the driver, who could, and generally did, handle it well. But while he put the Westinghouse brake first at present for emergent stoppages, it had to be remembered that for still more sudden stoppages than it was alone capable of, electro-magnetic attachments were indispensable; and as these could be applied to other systems equally well (as recently exemplified at Burlington, Iowa), this point was only of temporary importance.

With regard to the manipulation of the Westinghouse brake, the drivers had a book full of rules laid down for their guidance by the Westinghouse Company, and when they had thoroughly learned these rules and had long and careful practice, they could handle a train very smoothly and beautifully if nothing went wrong; but he would undertake to say that Mr. Shellshear's obtuse apprentice would learn to stop a train smoothly and effectively with a Hanscom brake in less time than he would require to understand what all the holes in a triple value were for. In the case of automatic stoppages he would grant that the three brakes were about equally effective, as one application only being required at a time, there was no advantage in an extra large service reservoir.

In the fourth quality, namely, that of being adapted to graduate trains down inclines, the Westinghouse brake, as used on the New South Wales lines, had been most conclusively shown to be the very worst possible, both in theory and practice. It had been shown by extracts from Mr. Marshall's Society of Arts paper that it was altered to non-automatic on the heavy grades of the rocky mountains in America; and one of the Westinghouse representatives here had told him that all the triple valves used in

America had a four-way cock. This cock enabled the train-pipe to be connected direct to the brake cylinder and cut out the triple valve altogether.

The argument that the Westinghouse brake was used every day on mountain inclines in the hands of skilful drivers only proved, that all being in perfect order and the man in charge being skilful and clear headed, the train would come down safely; but it was acknowledged by the agents and the drivers that all their care and skill was necessary to work effectively and with judgment.

It had, however, now been proved beyond the shadow of a doubt, that a train might be fitted so that the Westinghouse brake on the tender and one carriage, with the engine hand-brake, might control it on a heavy down grade by using great care, and yet in the same train, with much more break-power available on others of the carriages, a series of contingencies might lead to a driver so using up his store of air that the train might dash to destruction; and it therefore appeared to him that if the Westinghouse brake was to be retained on the passenger trains of this colony for the mountain lines, the members of this association must, by this time, have made up their minds that it was imperative that a second train-pipe and guage should at once be added to it. The fact that a driver could reduce his brake-pressure, but must take it off altogether and put it on afresh, was fatal to it; and the fact that he only knew by the effect on his train, and not by his gauges, what was taking place was another dark spot on its qualifications.

Under both the Hanscom and the Vacuum the graduation up or down was in the driver's hands, and in the Hanscom system there was the further advantage that having two gauges he knew exactly what was going on. With the valve he had introduced himself, it could be made as suddenly as required. Now what he had said might look very much like finding fault with the Westinghouse brake, but he would ask did it not arise from the fact that it had been devised for a service on comparatively level running, and had since been carried on to inclines and heavy gradients by

the wealth, influence and power of those who were interested in its use. He was thankful that the railways of this country were not run by wealthy capitalists or Jay Gould monopolists, and he believed the Government would give the public the opportunity of having the very best brake that could be found, or they would apply improvements to the one they had got, if it could be shown to be advantageous.

As regarded the quantity of air required for working the several brakes, he found, from some calculations made by Mr. Kiernan, and read before the Manchester Association of Engineers, 26th February, this year, that a Westinghouse cylinder 8 in. diameter and 6 in. stroke and 60 lb. pressure, required 100 cubic in. air at atmospheric pressure; whereas, an 18 in. Vacuum cylinder and 6 in. stroke, with 10 lb. effective pressure, requires only 678 cubic in. at atmospheric pressure, so that about 50 per cent. more air was required to put the Westinghouse brake on. But in the Hanscom we ran with air pressure on both sides of our brake piston; we let it out of one side and put it on the other, getting your power with the minimum expenditure of air.

With regard to the air required to charge and release the brake on a train of ten carriages, with 400 ft. piping, on both the Vacuum and Westinghouse, Mr. Kiernan's figures gave—

To charge—Westinghouse, 190·932 cubic inches; Vacuum, 61·812.
To apply brakes full—Westinghouse, 20·031; Vacuum, 19·633.

The statements made by the President as to what took place when he and Mr. Pollock attended the trials made on a running train, and also Professor Warren's experiences of the trials at Adelaide and Melbourne, so bore out what he advanced in his paper on the non-suitability of the Westinghouse brake for working inclines, that although Mr. Campbell and Mr. Granlund had made a good stand for their company by quoting Board of Trade returns, and by showing how skillfully their delicate instruments might be handled after long practice, there had still not been a really tenable defence of the Westinghouse brake made at all, and, on its merits for mountain service, judgment must go against it

by default. It was, therefore, unnecessary to go into the clever features of double hose pipes, metallic hose pipes, the new triple-valve (with about twenty more parts), and other refinements of undoubted skill and merit which were connected with its operation, but which were quite foreign to the question of simple efficacy in braking a train down, say, Lapstone Hill. On the question of cost raised by Mr. Shellshear, when he had said he thought that the Hanscom brake would cost 50 per cent. more than the Westinghouse, he made the equipment of one carriage into a table as follows, not including bolts or screws :—

Westinghouse.	Pieces.	Hanscom.	Pieces.
Cylinder and covers	3	... ...	2
Piston and follower leather	6	... ...	3
Crosshead and springs	4	... ...	2
Release valve	5	... ...	—
Triple valve	15	... ...	—
Reservoir	1	... ...	—
Inch cocks	2	... ...	—
Half-inch cock	1	... ...	—
Train pipe	1	... ...	2
		Automatic valve	4
	—		—
	38		13

The price of one set for a van in London was put down by the Westinghouse Company at £20, and £22 for a Bogie carriage. He did not know what the extra cost of the new triple valve was, but where those things were made a Hanscom outfit could easily be produced for £10 per set, unless his thirty years of workshop practice much deceived him.

In conclusion, he considered he had proved that the Hanscom brake had all the qualities required for working our inclines, and running our freight and passenger trains, with the maximum of safety and efficacy and the minimum of cost, and liability to derangement; and after an almost unanimous expression of opinion in its favour, he felt recompensed for bringing Mr. Hanscom's simple and clever invention under our notice.

The President said that now the debate was closed, he thought every member of the Association would join him in according Mr. Selfe a hearty vote of thanks for his paper.

A vote of thanks was unanimously passed to Mr. Selfe, and a similar compliment was paid to the President for his communication regarding the trials with the Westinghouse brake carried out under his supervision.

The discussion on the paper occupied the evenings of 8th and 15th September.