Discussion.

The PRESIDENT, in moving a vote of thanks to the Authors for their valuable Papers, stated that his latest experience of signalling-arrangements had been derived 35 years ago, and, of course, long before any electrical appliances for actuating signals had been available. This had been on one of the South Wales railways, and he remembered it with interest, because the late Sir William Anderson—whose death was lamented by all, and who had, years afterwards, followed him next in seniority on the Council—had gone over the line with him, and had made out an estimate for the signalling, in which had been embodied a locking-apparatus of his own invention. He confessed that the description just read of the working of the installation on the Waterloo and City Railway had sounded to him something like a series of Chinese puzzles; but no doubt there were many gentlemen present who were fully informed on the subject and would take part in the discussion. He felt sure that the members would accord a hearty vote of thanks to the Authors. The President.

Mr. A. W. SZLUMPER, in acknowledging the vote of thanks, remarked that, as no Paper on signalling had been discussed at the Institution for about 15 years, he hoped there would be an interesting discussion. There were several points to which he wished to direct the attention of the members. The electric lock-and-block system, combining the block instruments with the outdoor signals, was now being largely adopted on English railways. There was, however, a doubtful element of strength in one link of that system, namely, the treadles. Supposing a train broke away, the driver knowing nothing about it and the signalman not looking out of his box for the tail-lights of the train—a supposition which, unfortunately, was very often realised—the front part of the train would release the lock-and-block instruments, leaving the rear portion fouling the section. Several appliances had been tried to overcome that difficulty. On the Liverpool Overhead Railway the mechanism was fixed to the last car, which actuated the treadle, and the desired object was thus attained; but that plan was not feasible on ordinary railways. It was impossible to fix any mechanism to the last car of, say, a goods train, because the composition of that train varied at almost every station. The only Mr. Szlumper.

Mr. Szlumper. alternative seemed to be the adoption of a track-circuit which had been introduced very largely in America, and worked very well. A track-circuit practically meant a continuous treadle. The Mansell wheel was, however, a difficulty in the way of its introduction in England. There were many hundred thousand Mansell wheels running, and it was found that this wheel would not cause a short-circuit, and short-circuiting a track- or rail-circuit had the same effect as depressing a treadle. With the ordinary wheel passing over a circuit, the presence of any pair of wheels on that section would cause a short-circuit and so effectually lock the signal-lever feeding that section, by keeping the electrical lock in the slot. On the Waterloo and City line there was no rail-circuit, but in the first place a break-away was almost impossible there, and in the second place there were treadles at almost every possible spot. Although "lock-and-block" might be provided, and it might be made quite impossible for the signalman to give a wrong signal, yet there was always the element of the human brain to be taken into account; and a driver sometimes passed a signal at danger. Many attempts had been made to overcome that, but he did not know of any arrangement at present that was effectual. No arrangement had been introduced which could automatically stop a train not fitted with continuous brakes, and goods trains being not so fitted, there was therefore at present no arrangement which would effectually prevent any driver from passing a signal at danger. The point had not been lost sight of on the Waterloo and City Railway, and, that being an electric railway, the difficulty had been overcome by the introduction of slippers for cutting off the current from the motor should they be passed when the signal was at danger, thus making it impossible for a driver to pass such a signal. Therefore he considered the signalling on the Waterloo and City Railway was as nearly perfect as it could be made. Perhaps it might be suggested that, the line being an electric railway, the signalling ought to be worked by electricity. A scheme had been prepared for doing so, but after mature consideration it had been decided to adopt the present system; and seeing that the line had been open for $2\frac{1}{2}$ years and had worked in the most satisfactory manner, he thought the railway company had come to a wise decision. There were several systems of signalling which he hoped would be touched upon in the discussion. There was an electrical system used largely in Germany, of which there were one or two installations in England; the hydraulic system also used on the Continent; and the pneumatic system, which had attracted considerable attention

of late. There were two systems of pneumatic signalling, one known as the high-pressure, or Westinghouse system, and the other as the low-pressure system. In the former the air was pumped to a pressure of about 80 lbs. or 90 lbs. per square inch. In the low-pressure system considerably less than half that pressure was used. In both cases cylinders fitted with pistons and valves were fitted to all the points and signals. The lever-frame consisted of miniature levers, considerably smaller than the ordinary mechanical lever, and it was a very easy matter to move these small levers. The chief difference between the high-pressure and the low-pressure systems was that in the high-pressure system the valves admitting the compressed air into the cylinders were actuated by an electric current, whilst in the low-pressure system electricity was not used. He had had the opportunity of seeing both systems installed in the Paris Exhibition, and had also seen the installation at Bethnal Green, which was a high-pressure system put in by the Great Eastern Railway Company two years ago, and was working very satisfactorily. But the question of the cost of those systems arose, and that was a very important question for railway managers. Another system coming into use, which he thought had a future before it, was the electro-mechanical system. The signals were worked by small electro-motors, and the points were worked mechanically, as at present. The frame was not more than half the size of the ordinary mechanical frame, because the signal-levers consisted of small brass slides, which were placed immediately above the point-levers. This system had been fitted at Glasgow for the Glasgow and South-Western Railway. With regard to signalling sidings he did not pretend for a moment to have given an exhaustive description of the systems in use, and no doubt there were several others as good as those he had described. The system shown in *Fig. 3* was one which had been largely used on the London and South Western Railway, and when Mr. Szlumper had accompanied Colonel Yorke over the first installation he had expressed himself as very pleased with it. Mr. Szlumper.

Mr. S. B. COTTRELL explained the working of a train from one station to another on the Liverpool Overhead Railway. As the stations were very near together, there were only four signals at each station—namely, two home and two starting-signals, the starter being practically the distant signal for the station in advance. Assuming a train to be leaving the one station, it passed the breaking contact underneath the starting-signal, proceeded, and passed the making contact at the point A (Fig. 6). The circuit passed through the semaphore arm of the starting- Mr. Cottrell.

Mr. Cottrell. signal, and pulled off the home signal at the station and the starter of another station in the rear, clearing the section from that station right up to the starter at the other, so that, having proceeded, the train was protected by the starting-signal. On the arm of every starting-signal was fitted a switch. These switches had been mercury switches originally, but he had now substituted a simple dead-weight switch, and unless the arm was at danger the circuit was not completed. Should a starting-signal fail to go to danger, the home and the starting-signals at the station in the rear would not be pulled off, forming an absolute block. That went on from station to station up to the terminal stations or the station where shunting-operations had to take place. At Herculaneum Dock station, where there was a carriage-shed, most of the signals were mechanical, some on the Sykes ordinary lock-and-block system, and some electrical. For example, the starter was mechanical, and the advance starter was electrical, being worked from the station in advance. That applied to all other stations where shunting-operations took place. Seaforth and Dingle stations were entirely mechanical, because so much shunting occurred that there was no object in having automatic signals. If a man was necessary to work points, he might just as well work the signal. Alexandra station was partly mechanical and partly electrical.

Mr. Robertson. Mr. F. E. ROBERTSON asked why the contact-breaker or contact-maker could not be fixed on a goods train. Such a train always had a brake in the rear of it, which could be fitted with the necessary apparatus as easily as a carriage on the Liverpool Overhead Railway. With regard to the inability of the Mansell wheel to short-circuit the contact, there was no difficulty in putting a wire from the boss of the wheel to the tire to give electric connection.

Mr. Szlumper. Mr. SZLUMPER observed it was only a question of expense. It would cost a large sum of money to wire several hundred thousand wheels.

Mr. Johnson. Mr. A. H. JOHNSON remarked that it would not be necessary to wire all the wheels. The engine had iron wheels, but on the guard's van the wheels would have to be wired, and that would not cost very much. The trouble with the Mansell wheel was due to its having a wooden centre, but there would be no difficulty in putting wires between the hub of the wheel and the tire. Of course it would have to be done in a mechanical way—probably strips of metal could be used. There would not be as much difficulty in getting "foreign" stock wired, as there had been in having

Mr. Johnson.

it fitted with suitable brakes, sometimes entailing two complete sets. In the United States, where the track-circuit was in use to a large extent, all signals were being worked automatically. Probably the automatic system was not suitable in this country, because there were so many interlocking switches, but the track-circuit might be applied to lock the levers. There was a great difference between the track-circuit and any other system; while one pair of wheels remained on the length of railway protected by that circuit it would hold the lock in the lever. That was an important point, because the drawback with all other appliances was, that, with a very long train, the forward part might be two or three sections ahead, and might have released many locks before the guard's van had passed. There was one installation of the pneumatic system of interlocking on the Great Eastern Railway, but that did not do the system justice. To appreciate the electro-pneumatic system it was necessary to see the working of a large yard, such as at Boston, St. Louis, Pittsburg, or Philadelphia. At those places there were stations as large as or larger than those in England; all the difficulties met with in this country had to be encountered there, and they had been working for years on the electro-pneumatic system. The English railwaymen in America had opposed it tooth and nail 16 or 17 years ago, but Mr. Westinghouse, being a strong man, had hit back, and to-day the Westinghouse system was undoubtedly a very good one, especially the electro-pneumatic system. He spoke of that system because it was the one he knew most about. The low-pressure system might eventually prove a good thing, but he knew very little about it in its present condition, although he had made an official inspection of the first plant put down by Mr. Dodgson at Buffalo, about eight years ago. In the electro-pneumatic system men were not seen throwing themselves energetically on the levers; the latter were all contained within a space of a few feet, and a man might be seen turning the handles over quite easily, although five or six trains might be coming out of the yard at once. In the signalling worked by means of electro-pneumatic power, the man who was manipulating the small levers had time to use his brain to safeguard the trains; there was always the human element to be taken into account, and that must remain whatever system of locking was used. The system was a great success in America, but this country was a long way behind the times. He did not care what system was introduced so long as some improvement was the outcome. English railwaymen were too conservative, and should bestir

Mr. Johnson. themselves. The principal improvements and the standardization in American signalling were largely due to the superior grade of engineers engaged on the work. The Sykes system was used to a considerable extent in America, in combination with the track-circuit.

Mr. Griffiths. Mr. W. J. GRIFFITHS remarked that he had installed the plant at Whitechapel, to which Mr. Szlumper had referred, on the Westinghouse electro-pneumatic system. But, as Mr. Johnson had remarked, it hardly did the system justice, because there was no scope in that yard for speed. Goods wagons were shunted and marshalled under conditions which were not the best, and the trains came in at very irregular intervals, consequently there could be no fixed working time-table. What was done one day was no gauge of what would be done on the next; one day the trains might be shunting back from the various sidings on to the up-road, but, another time, if that road was full, they would be shunting back on to the down-road; and that change of method had to be conveyed to the signalman by the shunter, either through the telephone from the farther end of the yard, or by walking to the cabin. That robbed the system of some of its despatch; nevertheless, since the plant had been installed in January, 1899, 15 per cent. more trains had been handled in the busiest 8 hours' shift than had ever been dealt with on the same siding-accommodation and with the system which had previously existed. He ventured to think that if that plant were installed on a running-station, where a fixed time-table was worked to, a much greater speed could be shown, because a man would know that, barring accidents, which nowadays were very infrequent, a certain train would run on a particular track each day in the week. If a train had to be shunted, side-tracked, or changed over, it would only be a matter of a second or two, and would be exceptional; whereas at Whitechapel such changes were rather the rule than the exception. One thing about the plant at Whitechapel was that there were facing points in the goods yard working at a distance of 245 yards from the signal-cabin. If a half-crown were placed in the tongues of the switches, the lever in the cabin would not work. It did not take any longer to work those points than to work points nearer to the cabin, it was only necessary to transmit the current from the locking-frame through the magnet which operated the point-motors and admit the compressed air into the cylinder. The locking of those points was closer, more rapid, and more certain than any other he had seen, although he had been engaged at Liverpool Street, and on

Mr. Griffiths.

various works elsewhere for about 12 years, and had seen a variety of methods of detecting. In some cases it was necessary for the man to be close to the points in order to see whether the train had cleared over, and was ready to be set back, but in the case of running traffic, it was an advantage to be able to operate the points with certainty at a greater distance than it could be done with a rod. Another advantage of this plant lay in the matter of the adjustment of the points. In the ordinary way a pair of points got out of adjustment more or less frequently, but there were about forty-two switches in the Whitechapel yard, and not an adjusting screw had been turned since January, 1899, because the cylinders which operated the points had a greater travel than the points themselves, by about 1 inch, and that gave about ½ inch at each end to take up a slight movement. If the movement exceeded that, the detector would instantly lock the lever in the frame. Mr. Szlumper had alluded to the cost of the system, though he noticed that Mr. Szlumper had not referred to the question of cost in his Papers. He admitted that the cost of any system requiring power-plant must necessarily be greater than that of a mechanical system; the materials and the fitting of the plant were much more expensive, and of a much more intricate character, and the first cost would certainly be higher. It varied very much according to the circumstances under which the installation was laid out. Sometimes it was found that a saving of 50 per cent. over the mechanical system could be effected in the levers, sometimes only 30 per cent., and sometimes the saving was as low as 15 per cent. At Whitechapel about 30 per cent. had been saved, but this was a very unfavourable case, because there were so few signals. Sometimes as many as six signals could be taken on one lever. Every time a pair of points was set, it was possible to work another signal off the same lever in the machine, and the selectors which accomplished this were in the locking-frame where they were protected from dirt and from the weather, and not outside, where they were liable to be damaged. There was a separate connection from each selector, contact to each signal or point, and the lever itself inside the case was the only portion which moved, with the exception of the switches or the locks. There was no movement between the signal-cabin and the points or the signals which had to be operated; there were no rods or wires in the track to trip men up, no rods to be compensated or adjusted; there were merely cables which could be bent round at any angle, and could be laid down and pulled up with the greatest convenience.

Mr. Griffiths. But the system was more expensive than mechanical signalling. It had advantages, however, in other directions. First, it was frequently possible to work from one cabin where under the present system two would be required; and secondly, it was possible to reduce the size of the locking-frame, and the signalman would have a less distance to walk up and down in his box, and could control a larger station than he would otherwise be able to do. The man was not worn out by physical labour, and after his 8 hours' shift was still in a condition to work, and was not inclined to be sleepy. It was found at Whitechapel that between the hours of 10 P.M. and 10 A.M., which was the busy time in the goods depot, the men hardly ceased work at all, but during the daytime they were able to sit down for a few minutes. It was a great help to a signalman to be able to do that, because it was impossible for him to think what he ought to do when he was rushing to and fro amongst the levers. Should a flaw be detected in the working, or any little mistake require remedying, he was more likely to detect it and remedy it than he would be when working the old kind of lever-frame. Again, the machine did not make the same noise. Any member who had stood in a cabin at such a station as King's Cross, Liverpool Street, or Waterloo, had probably noticed a considerable rattling. Sometimes the block instrument did not work very brightly or briskly, and sometimes the man did not hear the bell, whereas with the quiet working of the electro-pneumatic frame, the lever of which went over with only a click, the block instruments were given every opportunity for sounding their signals clearly. With regard to the question of wheels, in connection with track-circuits, Mr. Johnson had suggested wiring the wheels of the brake-vans. That would be satisfactory, provided a company would always undertake to run their own brake-van last; otherwise they would have to persuade the other companies to wire their wheels, and to wire also their horse-boxes, which he had known to be run behind the brake-van. So that if one company started to work the block system with track-circuits, and wired their wheels, it would be necessary for "foreign" stock travelling over their line to be wired also. He questioned, however, whether the danger of breakage of the bond from various causes, such as vibration, would not be considerable. With regard to the breaking away of trains on a railway equipped with automatic signals, a short time previously, on the Metropolitan Railway of Paris where the automatic electric system was in use, a train had either broken away or had run back. It was quite true that as long as the

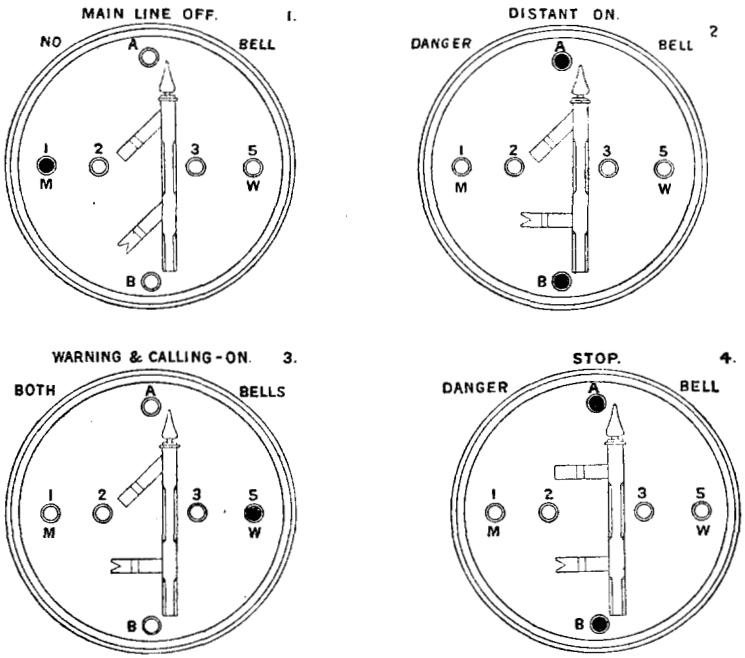
train stood on the treadles in a section, that section was blocked; but when a vehicle was running away on the wrong road it did not give any warning to the section in the rear. For instance, if a break-away took place on the Waterloo side, and the train ran back towards the City, there was nothing to warn a driver leaving the City that the runaway was coming rapidly in his direction. To such a cause the accident on the Paris Metropolitan Railway had been due; the vehicles having run back along the line instead of remaining stationary in the section. He did not think the striker on the Liverpool Overhead Railway would avoid that difficulty. If the vehicle was left standing it would be all right, but if it were running back he questioned if there would be time to stop the following train. Mr. Griffiths.

Mr. W. S. BOULT observed that one point which had struck him on reading the Paper and in listening to the discussion was the tacit assumption that the ideas of sixty years ago as to the best means of signalling to the driver of a passing train were still the best conceivable. He did not wish to decry the valuable work done by earnest workers on the subject; but he felt that the time had come when it was really incumbent upon railway engineers to consider whether some better plan could not be found than the use of three imperfect systems, each so imperfect that it had to be supplemented by two others. The present practice was familiar to all: on a fine day the signalling was done by a semaphore arm; as evening came on and the semaphore became indistinct, lamps behind spectacles were lighted and signalling by position gave place to signalling by colour; if a thick fog came on, both lamp and semaphore were useless, and a sort of Egyptian arrangement was relied on, thousands of men being called out and stationed along the line for the purpose of placing detonators upon the metals, to give practically danger signals only. The late Sir George Findlay had left it on record that during one fog the London and North Western Railway alone had had 3,752 men fogging for five days, until they had been practically worn out. About two-thirds of the number had been on duty at the same time. The present method of fog-signalling was exceedingly imperfect, and he might call the attention of the members to a remark of their late President, Sir Douglas Fox, that the matter "calls loudly for reform." Sir Douglas's predecessor in office, Sir William Preece, had characterised the system as "barbarous, dangerous and irregular." To pass on a train in a fog there were, first the bell-signals between the two cabins, and in many places the actuation of locking-apparatus; Mr. Boult.

Mr. Boult. then the signalman in advance pulled over his lever, pulling off the signal and generally operating another small signal for the benefit of the fogger; then the fogger kicked or pulled a couple of detonators off the line, and by that means the result was achieved that no signal was given; though even in fine weather a positive "line clear" signal was found to be necessary. It appeared to him that the proper place for giving a signal was where it was wanted to be read—namely, on, the engine; and by doing that one system of signalling would meet all necessities, both by day and by night and in all weathers. There would be nothing to get ready as the atmosphere changed or as darkness came on; everything would be always in working order and always done in the same way. There was also another source of confusion at roadside signals. As the traffic increased the number of such signals increased, and they became very confusing, particularly if there was a slight haze about. Many serious accidents had occurred in consequence of men mistaking the signals. A year or two ago four goods trains had been piled in one heap in consequence of one driver obeying a signal meant for another. A further advantage of signalling on the engine was that it would be impossible for the driver to run past a signal without noting it, as had happened at Slough recently. There should be an audible signal as well as a visible one, and that would call the attention of the fireman even if the engine-driver himself had temporarily lost his wits. As he had spoken so strongly of the advantage of having the signal on the engine, it was probably his duty to show how it could be done. *Figs. 1–4* showed the dial of the indicator of some apparatus designed by him, which was operated without any mechanical contact whatever between engine and road parts, all blows and wear and tear being thus avoided even at the highest speed. At the desired positions on the road, magnets were fixed so as to actuate "armature-relays" carried closely past them by the engine. The armature-relay consisted essentially of a small pivoted contact-making needle and iron collecting-bars between which the needle was mounted, so that magnetism emanating from the road-magnets was condensed or focussed upon it and caused it to turn to one side or the other, according to the polarity of the actuating road-magnet. The relay-needle could thus, at the will of the signalman, be made to close either of two "local circuits" on the engine, and thus to give either of two signals, to put on the brake, or do other work. The whole system had now been worked out so as to be available for slowing, stopping, calling-on,

starting, and road selecting, as shown in the diagrams. There was one semaphore for the distant and one for the home signal. There was also means of indicating numbers showing which road was made, instead of having a number of semaphores side by side. *Fig. 1* showed the main line clear, and at that stage no bell was ringing. *Fig. 2* showed the distant signal on. The driver would now begin to slow down ready to stop at the home signal. At a known distance short of the home signal, magnets would be placed which would throw the No. 5 spot red and ring two bells to call

Mr. Boult.



attention to the fact that the driver was close to the place where he would have to stop. Proceeding a few yards further—a number of revolutions which each driver would soon learn for his own engine—some more magnets were reached which put on the home signal, leaving one bell ringing. As soon as the driver could stop that bell he had passed over the danger magnets and was in a position to take his starting-signal. The signal given on the engine was not that which the driver was in the habit of seeing in front of him; it was really a record of the last signal he had passed, and as such was the order under which he was working.

Mr. Boult. In view of that fact, Colonel Yorke, the senior inspecting officer of the Board of Trade, had suggested that it would be better to abolish the use of semaphores in the indicator altogether, and to substitute some independent signal quite different from the road-side signal. He thought that was a suggestion which would meet with approval. His scheme was not an impracticable one, involving unreasonably large magnets or currents; it had been tried on the Great Northern Railway, at speeds up to 70 miles an hour, and had worked most satisfactorily. [Mr. Boult then showed full-sized apparatus, connected up with batteries, in operation.]

Mr. Allingham. Mr. G. C. ALLINGHAM observed, with reference to the track-circuit used in America, that it would be interesting to know whether bad insulation of the rails gave any trouble. It was true that this would only put the signals to danger, but it would be rather a nuisance to have the signals going to danger when not required. For instance, if the line became flooded it would short-circuit the rails and the signals would go to danger. If floods did not short-circuit the rails, he would be glad to know the reason.

Mr. Johnson. Mr. A. H. JOHNSON stated that the only trouble in America with the rail-circuits occurred with what was called metallic ballast, such as slag. The reason was that the electric pressure was confined to one volt, through a battery of small resistance, and the resistance of the track and relay-magnet was kept very low.

Mr. Cooper. Mr. R. ELLIOTT COOPER remarked that Mr. Boult's proposal with regard to signalling in the cab of an engine had been laid before a railway company of which he was the engineer, and that company had offered to place an engine at the disposal of the inventor or the syndicate who had taken up the invention, in order to test its practical utility. The railway was one of some length, on which signalling had not yet been commenced, and the company had been very willing to hear all that could be said as to practical means of improving the existing modes of signalling: but they had not got any further. New inventions, which might of themselves be very good, came rather late in the day in this country, and the difficulty was to induce railway companies to institute an entirely new system in the face of the heavy expenditure that had already been incurred. That remark applied equally to the American system of pneumatic signalling. There was no doubt whatever that if the construction of railways in this country were commencing, it would be a very great advantage to have the convenient little apparatus described, which required no physical power for its working, and which really did all that the mechanical appliances did; but it would be a very difficult thing

now to install the system on any large scale—it would practically mean the re-signalling of the whole of the lines of the country. That did not apply, of course, to many lines of special construction where engine-signalling could be carried out on account of their being detached from the general railway systems of the country; but the real difficulty was to get inventors to prove that in practical use their systems were of any value. The systems which had been described were really almost the same as the Sykes lock-and-block, which was in use on most of the modern lines. Although that system was perfect for the purpose of passenger traffic, particularly where the trains ran at short intervals, it was not always a convenient system where there was mixed traffic, or where the traffic was very largely goods and coal, requiring to be stopped and shunted at intermediate stations. On one line with which he was connected it very often happened that as many as three consecutive cabins had to be switched out on account of there being no use for them during certain portions of the night, and that meant that if there were three cabins 4 miles apart, there were 12 miles within which a train could not move on account of the signalling being worked on the absolute lock-and-block system. Many inventions had some disadvantages, and those he had mentioned were the practical disadvantages found in some otherwise excellent arrangements. Mr. Cooper.

Mr. F. W. WEBB said that, as at the present time the London and North Western Railway Company were introducing at Crewe a very extensive system of electrical points and signal-working, he had been much interested in seeing what had been done elsewhere, as described in the Papers. He would like to ask Mr. Cottrell if he was aware what system of signalling was being used on the Metropolitan Railway of Paris. He had happened to be there at the time of the accident near the Place de la Concord station, when one of the electric engines had failed to make the ascent, which was rather severe at that point, and, in setting back to make a fresh start, had liberated the signal in the rear; the result being that the train had been run into by the one following and a few people had been severely injured. He gathered that in the arrangement on the Liverpool Overhead Railway that was avoided, and that the train could be set back to a certain extent without liberating the signal in the rear. In connection with the work which was being done at Crewe, burrowing junctions were being made so as to separate the goods from the passenger lines, and he had been asked when that was being arranged to see whether the whole of the station could not be Mr. Webb.

Mr. Webb. worked electrically. He was very glad to say that 18 months ago one of the main line junctions had been started, with the consent of the Board of Trade, and had been worked electrically, signals, points, and everything else, with great success. They were now at work on perhaps one of the largest signalling boxes on the electrical system—a box which would contain about 300 levers, controlling the whole of the north end of Crewe station. He had had the privilege recently of showing Sir William Preece what was being done, and Sir William might be able to tell the members whether he thought the London and North Western Railway Company were working in the right direction. It was rather a big venture, but he was satisfied they would be able to carry it through. The station would be nearly 4 miles in length when it was finished, and a central power-station was being built that would do all the electric lock-and-block work, all the lighting, and possibly some of the heating. He hoped they had not made any mistake in what they were doing, and he would be very glad, when the work was somewhat further advanced, to show it to the members, and to listen to any criticisms they might have to make. He thought Crewe was only the first of a series of installations, and as soon as they were satisfied about it, and all the little details in connection with it, the Company would be able to turn out the machinery, which they were doing now fairly well, like making pins, and there would be no further trouble with the Board of Trade, who had to sanction what was being done, in working the points and signals.

Sir William Preece. Sir WILLIAM H. PREECE, K.C.B., Past President, remarked that working of railways by electricity had been the work of his life. The very first job he had undertaken, in the year 1853, had been the establishment of the block-system on the London and North Western Railway, and from that time, until he became associated with the Post Office, the whole of his work had been done on railways. It had been his good fortune and pleasure to be taken over the works at Crewe by Mr. Webb two or three weeks previously. The first thought that had come into his mind there had been—"How little people know what is being done in England." In leading articles in the *Times*, or any of the other daily papers, sometimes in the technical papers, it was stated over and over again, as it had been stated in the House of Commons last year, that in technical matters the English were entirely behind the Continent and America. There was never a greater mistake made. Nearly all the pioneer work in electricity had been done in this country. Its slow progress in this country

Sir William Preece.

was not because engineers were not capable of going ahead, but because the financiers who had to find the capital were afraid of electrical enterprises, and they were afraid of them because in the years 1878, 1879, 1880, and 1881 there had been a deplorable boom in electrical enterprise over which the Stock Exchange had lost millions, and they had not yet forgotten that loss. The result was that English engineers were twitted by the Press and others with being behind the age. But if anyone wanted to know what was being done in this country he should go to Liverpool and place himself under the charge of Mr. Cottrell, and there he would find the first railway in the world that had been worked successfully by electricity and controlled by electric signals in the way that Mr. Cottrell had described. And if anyone wanted to see a good solid, substantial, well-paying, well-managed railway, let him go to Crewe, and the "King of Crewe" would be only too glad to take him round and show him what was being done there. The charm of the work at Crewe was that it was an engineer's job. An engineer had taken up the electrical side of the question and had worked it out in a way that was thorough, complete, and successful. The points there were worked with precision and with a force that was not to be compared with the nervous energy of a human being in a box 200 yards or 300 yards away. There, underground and safe, was a little motor, which was put on by a gentle switch and brought the points over with a force which gave an idea of safety itself. The signals were practically the same as those Mr. Cottrell had described. As on the Liverpool Overhead Railway, the pull of the magnet took the signal off, and that, of course, was the correct principle. Then, if failure of any kind took place, there was no current, and the signal went to danger. He thought the country was on the eve of a tremendous boom in electrical traction. There were Bills coming before Parliament next session which, if passed, would cover the country with such a number of railways that people would be astonished. It was to be hoped that nine-tenths of the schemes would not pass. In any case it meant that, not only in London, but in the provinces, a wonderful advance was about to be made in electric traction. It had been led off at Crewe, where the signals and points had been worked electrically. He would not be surprised next year to find waiting for him at the end of the platform a neat little electric locomotive and a car ready to carry him to the works. There was one point connected with electrical working which he would like to bring to the attention of the Institution, although it had not yet

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been fully worked out. In the past year he had pointed out, in giving evidence before a committee, that in order to secure the absolute block-system it was necessary not only to put the signals at danger behind the train, but to make a section behind the train *dead*. In working a line by electric traction it was necessary to protect a train by a dead section, so that, if by any accident the train moved on to the next section, it must stop because there was no current to carry it on. That was a very simple thing to do, and it was being done. It had not been done on the Liverpool Overhead Railway for the simple reason that the trains were so near to each other that it was not required; the sections were so short that it was even impossible to consider their duplication. But there were lines, such as the Metropolitan system in London, where the sections between the stations would soon have to be broken up, so that the traffic might be doubled. If that were done in connection with the making of a section behind the train dead, he thought there would be greater security in the working of railway systems by electricity than there was at present. Mr. Webb had referred to the accident at Paris, caused by the train running backwards and putting things wrong. That could easily be remedied, and probably had been. It was one of those accidents which were always the result of the unexpected, and as engineers knew, in railway, telegraph, and electrical work the thing that was sure to occur was the unexpected. It was only when it arose that the difficulties and the dangers were learned, and in his experience in the application of electricity to various purposes he had never come across a difficulty that could not be surmounted. A great advantage which electricity would give in the working of railways, besides the additional security obtained by the working of the signals and points, was that of increased acceleration, increased mean speed, and the greater capacity it would give to railway managers for dealing with traffic. There was no doubt whatever that electric traction on the Metropolitan Railway system would increase the capacity for traffic by at least 35 per cent., and that was solely due to the fact that it would be possible to increase the acceleration from about 6 inches per second per second to at least $1\frac{1}{2}$ foot per second per second. If, in addition, electricity could be applied to the signals so that the sections might be duplicated between station and station, then he thought the railway service in the Metropolis would be what it ought to be, and not what it was now, a disgrace to everybody. There would be a pure atmosphere and rapid transit; there would be pleasure in travelling; and instead of wasting money in cabs

and other conveyances, people would be journeying to and fro in cool, clean carriages, with comfort to themselves and with great profit to the shareholders. Sir William Preece.

Mr. W. J. GRIFFITHS thought Mr. Elliott Cooper seemed rather afraid that the adoption of power-plant for working the points and signals would necessitate some departure from the existing type of gear. It was not so in the case of the electro-pneumatic system. It could be easily added to any existing system or any pattern of signal, without addition or alteration, with the exception of the air-motor. Mr. Webb had asked what system of signalling was used on the Metropolitan Railway of Paris. He understood that it was the Hall system; but at the time of the accident it had been worked on the permissive principle, which was now being altered. No doubt, in altering from the permissive to the absolute block, care would be taken to obviate a recurrence of the accident referred to. Mr. Griffiths.

Mr. A. H. JOHNSON mentioned that the dead sections referred to by Sir William Preece were already in use in America. He himself had taken out a patent for a feature of the system about 8 years ago, and other patents had been taken out. Mr. Johnson.

Mr. A. W. SZLUMPER, in reply, remarked that there were very few questions or observations needing an answer. Mr. Elliott Cooper, in speaking of the lock-and-block system, had suggested that there was an objection to its adoption because when the traffic on a railway was light—as at night-time and on Sundays—intermediate sections could not be cut out; but this was incorrect; it was done on all railways where the lock-and-block was established. He believed that on the London, Chatham and Dover Railway sections were cut out over long distances, in one case about 20 miles, viz., from Faversham to Margate; and on the London and South Western Railway several boxes were switched out of sections on Sundays. When a signalman wished to switch out his signal-box, he first ascertained on the telephone whether there were any trains about, and if there were not, he lowered his signals, and by simply moving a switch switched out his box. When the time arrived to switch it in again, having first ascertained that there were no trains about, he put his signals to the danger position, and then switched in his box, which thereupon became a section-box again. Referring to Sir William Preece's suggestions, some of these were already embodied in the system of working on the Waterloo and City Railway; the provision of the electrical tunnel-lamps practically split the sections into two, and he thought the provision of the slipper-bars for cutting off the Mr. Szlumper.

Mr. Szlumper. electricity from the motors, should a train approach within a few yards of a signal when it stood at "danger," practically constituted a dead section behind the train in advance. A question had been raised as to the cost of the signalling in comparison with pneumatic signalling. The cost of the mechanical portion was small, the chief expense being for the electrical safeguards and the lock-and-block; but in signalling by pneumatic or any other power there would still have to be the lock-and-block and other safeguards, just as in mechanical signalling.

Mr. Cottrell. Mr. S. B. COTTRELL, in reply, did not think such an accident as that on the Paris Metropolitan Railway was likely to happen on the Liverpool Overhead Railway. A train passed the breaking contact in the direction in which the train was travelling, and, assuming that a runaway train came back, it would break the circuit and simply put the signal to danger. With regard to the making contact, if the train came back the reverse way it would not bring the armature up to the magnet, and therefore no harm would be done. He had rigged up some dead sections on the Overhead Railway as an experiment, and there was, as Sir William Preece had said, no difficulty about the matter. It was a simple question of switches and cables; but, as Sir William had rightly said, the sections on that railway were very short, and the line being an open-air one, the necessity was not as great as it would be in an underground railway. The chief difficulty, as would probably be found on the Metropolitan Railway also, was that of dirty contacts. The whole of the signal failures on the Liverpool Overhead Railway were practically due to dirt; but if the men, when they came on duty in the morning, cleaned the contacts, everything worked very freely indeed. Sir William Preece had made some interesting remarks on the question of acceleration, and perhaps it would interest him to know that at the present time Mr. Cottrell was building a train to attain an acceleration of 30 miles an hour in 30 seconds. That was an acceleration of something like $1\frac{3}{4}$ foot per second per second, and meant increasing the present schedule speed, which was $12\frac{1}{2}$ miles per hour, to 17 miles or 18 miles per hour.

The President. The PRESIDENT congratulated the Authors on the discussion which had arisen on their Papers. Sir William Preece was nothing if not optimistic in his own special line of work, and he trusted that in a few years many trains in London would be worked by electric traction, would be electrically signalled, lighted and warmed, and that passengers would thus travel expeditiously with all the comfort Sir William had predicted.