

Discussion.

The President. The PRESIDENT moved a vote of thanks to the Author for his Paper.

Mr. List. Mr. G. H. LIST remarked that, having been closely connected, in the absence of its author, with the elaborate Paper on Indian Railway-Signalling read at the Institution about a year ago, he was interested to see that there was not very much difference between signalling practice in England and in India, and that in India the right lines had been adopted. The practice there was very similar to the practice of the Great Western Railway, and he presumed that other English railways were worked on the same lines. The English signal-engineer had much more responsibility thrown upon him than the Indian signal-engineer: he usually had on his shoulders the whole of the telegraph work, a branch with which the Indian signal-engineer had nothing to do. In India the Government had control of all telegraphs, the railways only renting them and supplying their own signallers. The signal-engineer had to make, erect, and maintain any electrical apparatus in connection with interlocking, but not telegraphs or telephones. He noticed that that old friend the distant signal was just as much to the fore in England as in India; and he thought it would always be so until it was superseded by audible signals, which he quite agreed were the best, especially in fogs. They would be very useful in India, where, though there was no trouble with fogs, away from the coast, as a rule, there were dust storms, which were almost worse. A driver could do nothing in the face of a bad dust-storm. He had known a train to be pulled up dead by the fact that the driver did not know where he was, and dare not look out of his cab. In such a case an audible signal in the cab would have been of very great benefit. The audible signal, however, had not been adopted yet, owing to its cost. In India there were no electric repeaters—or, at least, there were none on the line with which he had been connected, the North Western Railway of India; he could not speak definitely as to the other large systems. In Calcutta, Bombay, and other important terminal stations, there might be electrical repeaters in use. In one case he had tried mechanical repeaters, which answered admirably. Electricity, however, was so easy to adopt, and so cheap, that it was better to be perfect than to depend upon mechanical operations. The question of “section clear but junction blocked” was a difficulty also in India, where an endeavour had been made to overcome

it by the adoption of double arms on the distant signal. Track- Mr. List.
circuiting was not in use in India. He thought it would be an advantage if it were used a little more in England. For instance, track-circuits on the advance starters at Hawes would have prevented the terrible accident that occurred there, because the signalman would have been reminded that he had engines standing ahead of his box. The North Western Railway of India had had the same trouble in standardizing signal-glass as had been experienced on the Great Western Railway. The North Western was made up of three systems—the old Indus Valley, the old Punjab Northern, and the old Sind, Punjab and Delhi—which had the most extraordinary collection of signal-lights that it was possible to conceive. The first work that had to be done was to standardize them. There was great difficulty in getting satisfactory red and green glass, but finally samples were sealed in the store department, and all glass supplied had to agree with those samples. A light ruby was adopted for the red signal, and a peacock green, that was, green with a distinct tinge of blue in it, for the green signal. These were found to be very satisfactory, but a good deal of trouble was incurred before the standard was arrived at. He would like to know what colours the Great Western Railway used for subsidiary and point signals. The Author stated that red was used only on the running-signals, but he did not mention what colour was used on point-indicators and subsidiary signals. Also he wished to know whether there was any arrangement for adjusting the spectacles or the lenses of lamps. In India a lens could be adjusted horizontally, so that a driver rounding a curve could pick up the light sooner ; but there was no such thing as vertical adjustment. He asked that question because at one station on the Great Western Railway which was very familiar to him a certain home signal appeared to have the light half-blinded. It might be that there was a compensation in the bull's eye of the lamp which threw the light down, because it appeared that the driver could catch it only when he was very close to the signal. In India automatic wire-compensators were not used. A few were tried at first, but they used to stick when they were particularly wanted to act. In one case the Government inspector, who inspected a line annually—an officer corresponding with the Board-of-Trade inspector in England—was particularly anxious to see if certain wire-compensators acted. He was assured that they did. Unfortunately, however, somebody had painted the compensator, and when the wire was cut the signal did not go to danger ; accordingly all the compensators

Mr. List. were taken off. It was found quite practicable and sufficient, by the List-Morse system, which was adopted as the standard in India on State lines, to give a varying stroke to the signal-lever, without interfering with interlocking in any way; and the signals were distinctly visible as a rule to the pointsman or signaller, who could see what was happening and give the lever an extra notch. Compensation was not a serious difficulty in India, because the temperature did not vary rapidly from day to day. Sometimes it was very hot and sometimes very cold, but those conditions were steady for several months at a time, and it was not difficult for the platelayers to compensate the signals once or twice a year. He was rather surprised to find that the Great Western Railway adopted solid rodding, because he thought it must be much heavier than tubular rodding and therefore harder for the men to work. It had the advantage that if bent in an accident it was much more easily straightened, but at the same time it was much more easily bent in slight accidents. For instance, a man stepping on a long length of solid rodding might easily bend it. He had tried both tee-bar and angle-bar rodding and had found them very successful for fairly short lengths, but long lengths of rodding round curves gave trouble, and the standard rodding adopted in India was tubular.

Mr. Acfield. Mr. W. C. ACFIELD considered that the interest of the Paper was much enhanced by the fact that the Author was the signal-engineer of the largest railway in the United Kingdom. He was glad to see that the Great Western had adopted tappet-locking, which was invented as far back as 1870, and was universally used all over the world. It had stood the test of time and outlived all other kinds of interlocking. It was a curious fact, however, that, notwithstanding its adaptability, some of the larger railways in England were the very last to adopt the system. He much preferred the tappet system actuated by the catch-handle of the lever, which had certain advantages. Directly the signaller clasped the catch-handle he knew at once that the lever was locked; it prevented undue pressure from being put on the locking; and it also saved the pressure that might be put on the locking by the spring of the point-rod, which was necessary to hold the points in position. With regard to signals on gantries, it was certainly advisable on railways to do without gantries as much as possible, but it was very difficult to obtain sufficient space between the lines to put up separate signal-posts, particularly upon lines that were widened some years ago, when the additional space was not considered necessary. The Great Western Railway was fortunate in that respect, as the line had been laid out originally for the broad gauge, and more room between the lines had been provided by the

reduction of the gauge. In providing gantry-signals, however, he Mr. Acfield. considered that in many cases it was far preferable to make the post which carried the signal-arms hang down instead of standing up above the gantry, particularly where there was a succession of signal-gantries such as was found on some of the suburban lines around London. The engine-driver obtained a better distant view of the signals as he approached them, because they did not interfere with one another. Signal-engineers, as a body, were certainly in favour of reducing the number of distant signals to a minimum for junctions, but it should not be concluded from the Author's remarks that that was possible in all cases. For instance, on a railway where there was a heavy goods- and mineral-traffic, particularly on rising gradients, the absence of a second distant signal would result in a goods-train slacking up, thus causing delay as the train was approaching a junction. The Author described a device for interlocking distant signals with the block telegraph system in such a manner as to make it impossible for a signalman to give "line clear" to the station in the rear unless the distant signal was at danger. Mr. Acfield would like to know what effect the failure of the electric repeater, through which that was done, would have on the block instrument. It would appear to break down the block circuit altogether. Power systems, both electrical and mechanical, were undoubtedly more expensive to install and maintain, but in view of the improvements that had been made of late years, he thought it was fair to assume that the cost would be reduced before very long, and would be more within reach of railway-companies. An eminent traffic-superintendent was alleged to have stated that although power systems of signalling reduced the labour of the signalman, and also placed more levers within his reach, one signalman could not control more roads than by the mechanical system, as it was purely a matter of mental concentration. He would be glad to hear the Author's experience on that point, as there was more than one installation on the Great Western Railway. Fig. 17, Plate 5, showed a long section of railway divided into short sections by the introduction of automatic signals, and the Author spoke of them as electrically-worked signals. The signal-boxes would be probably more than a mile apart—perhaps 2 miles—and there must necessarily be trouble in getting fog-signalmen to the automatic distant signal, the third signal to the right. He would like to know how that difficulty was overcome. On the Midland Railway, which he had the honour to serve, the case was met by providing what was called a "fog-lever" in the signal-box of the advance section. By pulling over the fog-lever the short

Mr. Acfield. sections of track-circuits were linked up as one long section, and it was compulsory for the automatic signals to be lowered before the starting-signal in the rear could be lowered for a train to leave that section. With regard to cab-signalling, two or three different systems were being tried in England, and an American gentleman had told him recently that in that respect England was ahead of America. If England wished to keep that lead, he suggested that the railway-companies should form a committee of signalling experts to go into the matter and agree upon some system. If that were not done, the position would be much like that which existed some years ago with regard to continuous brakes and indicating apparatus. Engines of one company had to work over the lines of other companies, and he did not think it would be advisable or even possible for an engine to be equipped with more than one system of cab-signalling, as the space on the footplate was very limited. The essential feature of a cab-signalling arrangement was that, in the event of any part of the appliance failing, the danger-signal should be given, and the Great Western system, as described in the Paper, was the only one he had heard of that actually provided for that.

Mr. Ross. MR. ALEXANDER ROSS remarked that, with one or two exceptions, the systems of signalling described in the Paper might be considered as the practice in Great Britain and Ireland, and, in fact, in a large part of the Colonies. With a few exceptions, there was nothing in the Paper but what might be described also as Great Northern practice. Of the one or two divergencies, the first related to the distant signal. As the Author said, the distant signal was an indicating signal, and, as giving the first indication of what was ahead, was one of the most important signals, if not the most important signal, on the line. To diminish the importance of that signal by reducing it to one only was in his opinion a mistake, and would not fully comply with the rules laid down by the Board of Trade. When the signal was kept at danger for the diverging line, the signalman could not indicate a signal at danger to a driver approaching on the main running-line, and, therefore, the capacity of the signalman to regulate the main-line running when it might be important to do so was reduced. Even for an unimportant junction there should be more than one distant signal. Another matter was the signal within the engine. On the Great Northern Railway all sorts of methods had been tried—the ramp, the trigger, and magnets on the line itself, which last avoided impact, and in his opinion was the scientific method. He would like to know how many engines the Great Western had fitted up. If the system was being worked on a single line, that was all very well; but had the

Author fitted up the whole of the Great Western engines, and if Mr. Ross. so were they all working on that system? A system might answer for a small service on a branch line, but the great difficulty was to standardize it and make it universally applicable, not only on the Company's own engines but also on the engines of other main lines, which might run over that Company's lines. It would be necessary to bring about a large amount of standardization before there was any general use of a signal on the engine. The Author made a point of the co-ordination of telegraphs and telephones with the signalling. There was no objection to that supposing a man was well up in mechanical appliances and in electricity, but he thought it would be found that most companies, especially the large companies, placed signalling and telegraphs and telephones in the engineer's department, and there was therefore co-ordination in that respect. With regard to what might be termed the negative side of the Paper, what engineers desired was not so much information on what was done as enlightenment on the many problems facing the signal-engineer at the present time. The Author's automatic working was really of a sectional kind. Could he suggest universal automatic working that would finally dispense with all the posts and signals-wires in the country and provide automatic working on the engine? That was a very broad question, but Mr. Ross believed that system of signalling was coming, and he would like to hear the views of members upon it. A question that had been always in his own mind was the uniting of the lock and block appliances, a subject upon which he contributed a Note¹ at the Engineering Conference of 1899. In that Note he pointed out that the mechanical working and the locking were perfect, and the block working was also perfect in itself, but that they were two different entities, and what was required was to unite them so that one could not operate without the other. There was no mechanical or electrical difficulty in doing that, and if it were done there would be three signalmen controlling a train. A could not forward a train without the consent of B, nor B without the consent of C, and the chances of neglect or mental aberration leading to an accident were reduced to a minimum. He knew that several reasons were urged against it. It was said, for instance, that it would retard the traffic; but he was old enough to remember when that was said of block-working itself. Block-working, however, was not long in proving that it regulated the traffic, with the result that more trains were passed along the line

¹ "The Advantages or Disadvantages of Uniting the Lock and Block Signal Appliances of Railways."

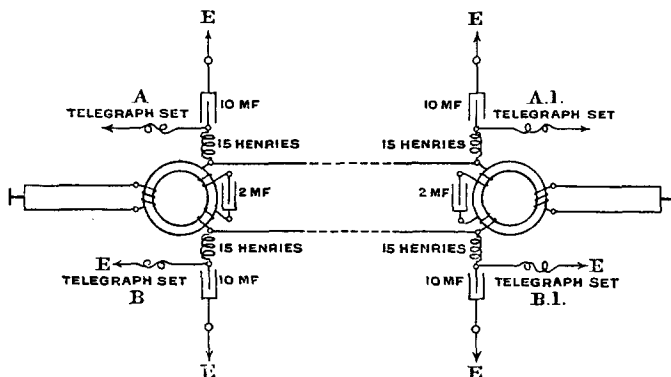
Mr. ROSS. in a given time than under the permissive system. Those and several other points of what he might call advance in signalling were matters upon which information was required, and he would be very pleased if members would give their opinions. Also rotation signalling had been explained to some extent, but not in a universal way. What was required now was advance in signalling and not satisfaction with the signalling of the present time, however perfect as practised.

Mr. SIMSON. Mr. DAVID SIMSON remarked that in the Argentine, with which he had long been connected, the railways could not go to the refinements mentioned in the Paper, although most of them had now adopted interlocking signalling in the terminal stations and some of the suburban stations. The distant signal had proved rather a stumbling-block so far, as it had been found that the Argentine signalman would often not be bothered to pull over the weight of a long wire; he tied a hitch in the wire, so that the levers in the interlocking worked loosely and the signal remained permanently "off." In order to get over that, on some lines the home signals were placed a considerable distance from each end of the stations, and were connected with the wire lock to the points. In Argentina there were frequent ground fogs, and on the Buenos Aires Western Railway, with which he was connected, large white disks were placed at an angle of about 45° to the track, which threw a white flash in the face of the driver, and told him effectually where he was. These disks were placed about where a distant signal would be placed. Sometimes the disks were painted with luminous paint, but ordinary white paint was sufficient. Hitherto the train-working had been done on the American system—by telegraph. The station-master handed to the driver the original telegram giving "line clear," and that was his credential for going on to the next station. On the principal lines, however, such as the Buenos Aires Great Southern, and the Central Argentine, the electric staff—the miniature staff—was now largely used, and was working very successfully. Signalling such as was described by the Author was practically non-existent, except at terminal stations near Buenos Aires and Rosario and important junctions. On some of the up-country lines there was still nothing but one signal on the platform worked by the porter.

Major O'Meara. Major W. A. J. O'MEARA remarked that, the Postmaster-General having acted as a contractor in Ireland, he had come, in that way, a little into contact with the question of railway-signalling. He was very interested to see that the Author had introduced a system of "occupation" instruments, because the Post Office had applied that principle to the control of swing-bridges, so that the

bridge could not be operated until the signalmen at the ends of the section allowed the automatic apparatus to come into play. With regard to the question of superimposing telegraphs on telephones, he felt that at the present time people who were interested in the existing systems of telegraph- and telephone-wires did not co-operate sufficiently in the use of those wires. The Post Office had been using superimposed circuits for a very long time, but he did not think superimposition had been developed quite to the extent that it might be. Within the last few days some of his officers had been working out a further development of superimposed circuits, and had found that the question of the balance of the two limbs of a circuit with certain arrangements was not so important as with some of the older systems of superimposition. In a circuit arranged with the different parts properly adjusted, it was possible

Fig. 20.



still to work with the two limbs of the telephone-line really out of balance. The arrangement was shown diagrammatically in *Fig. 20*. By means of this arrangement two hand-speed duplex circuits could be superimposed on a telephone-loop. Station A could communicate with Station A 1, and Station B could communicate with Station B 1, the two telegraph-circuits not interfering with each other. With reference to the use of copper wire instead of iron wire, he thought there was a wrong impression as to the commercial value of iron and copper wires. In first cost, he quite agreed, copper wires appeared to be more expensive than iron wires. Recently he had had to consider the question of the use of copper, bronze, and iron wire in relation to quite another matter—a matter which really would affect the future perhaps rather than the present—namely, the development of the telegraphic system in such a way that at no

Major
O'Meara.

distant date the wires might be available for telephonic purposes, enabling every village office to be a telephone call-office. He had prepared comparative estimates for a particular telegraph-circuit (an omnibus circuit with three offices), the total length of line being about 50 miles; with the result that the capital cost worked out thus: 200-lb. galvanized iron, £268; 40-lb. bronze, £300; and 100-lb. copper, £418. Yet, when the matter was considered from the point of view of annual cost, taking interest on capital at 3 per cent., and the saving of battery-power with copper wire as compared with other wire, the annual cost of the circuit on the basis of 10 years' life for the iron, 12 years for the bronze, and 16 years for the copper, with a 3 per cent. sinking-fund, worked out approximately thus: 200-lb. iron, £67; 40-lb. bronze, £70; and 100-lb. copper wire, £59. The result was in favour of copper wire.¹ He thought that was a matter of sufficient interest to be taken into consideration in connection with the question of copper versus iron.

¹ The details of the above estimates may be of interest and are therefore added.—W. A. J. O'M.

MINOR TELEGRAPH CIRCUITS.

Comparative statement showing the annual expenses in connection with the use of 200-lb. galvanized iron, 40-lb. bronze and 100-lb. copper wires, on a three-station circuit 50 miles in total length.

	200-lb. G.I. (Estimated Life 10 Years.)	40-lb. Bronze. (Estimated Life 12 Years.)	100-lb. Copper. (Estimated Life 16 Years.)
WIRE.	£ s. d.	£ s. d.	£ s. d.
Interest on capital at 3 per cent. . .	7 10 11	8 3 11	12 7 5
Maintenance (including supervision and establishment charges) . . . }	28 4 7	28 4 7	28 4 7
Renewal ² on sinking-fund basis at 3 per cent. }	21 4 10	16 3 9	14 12 5
	57 0 4	52 12 3	55 4 5
BATTERIES.			
Interest on capital at 3 per cent. . .	9 11	16 8	3 4
Maintenance (including renewal and supervision and establishment charges) }	9 10 8	16 2 6	3 3 7
	10 0 7	16 19 2	3 6 11
TOTAL ANNUAL EXPENSES (WIRE + BATTERIES).			
Wire	57 0 4	52 12 3	55 4 5
Batteries	10 0 7	16 19 2	3 6 11
	67 0 11	69 11 5	58 11 4

² These figures allow for the remainder value of the wire on recovery.

Mr. W. J. THORROWGOOD remarked that, while he found in the Paper many things that had been long familiar, there were yet many things that were new. Manually-worked signals had been raised to a high degree of excellence in England, but he thought the limit of the capacity of such signalling had been reached, and that it was now desirable, from the point of view of safety, on account of the stress on the signalmen, to go a step farther. He could not agree altogether with the Author in the view that the limit of the extension of power-signalling in England had been reached. The three cases mentioned by the Author were only moderately large signal-boxes, with thirty-one, forty-one, and eighty-three levers respectively. There were many larger boxes in this country, and if it was necessary to provide power-signalling for those boxes, why not for the larger installations throughout the country? With the extended use of electric traction for railways, and the consequent presence of current all along the railway, it would be found that the demand for increased facilities and more frequent trains would be met by automatic signalling, or preferably controlled automatic working. As to the cost of power-signalling, Mr. Siemens, about 4 or 5 years ago, offered to introduce all-electric power-signalling on railways at the same cost per lever or function as the cost of mechanical signalling. He did not know whether Mr. Siemens had altered his opinion since, or had withdrawn his offer; but whether it cost more or not, power-signalling was safer. One thing which tended to make the proportionate cost of power-working high was the small individual contracts that were given out. If a contract were given for the equipment of 114 miles of railway with automatic signalling and power-signalling at the stations, as had been done in America recently, he thought it would have a material effect in reducing the average cost of power-signalling throughout England. Amusement had been caused by the mention of the Argentine railways, because at some stations there were only one or two signals; but in England there were "halts"—which were in reality stations—with no signals at all. He thought such "halts" might be controlled by automatic signalling. With regard to cab-signalling, there was no question in the minds of signal-engineers that it was necessary. He had been struck by the simplicity and practicability of the system mentioned by the Author, and he hoped it would prove to be a success. He suggested it would inspire confidence if the Author would give the percentage of failures of the apparatus, calculated upon the total number of times the distant signal was given in the cab. He was glad to hear that England was ahead in cab-signalling, and he thought that, taking

Mr. Thorrowgood.

Mr. Thorrow-
good.

the signalling of all the railways in the United Kingdom and comparing it with the signalling of all the railways in America, it would be found that England compared very favourably with America. For instance, it was common knowledge that the block system was universal throughout this country, while the latest returns showed that in America there were 17,365 miles of automatic block signalling and 51,900 miles of non-automatic block signalling, and that represented about one-half of the total mileage of the railways of the United States. The other half was on the train-dispatch system, or no system at all. He thought the advance of signalling in America was more a question of terms. All-electric locking in America meant what was called in England point-detectors, check-locks, and indicators. Those things were used on the London and South Western Railway, and no doubt on many other railways. With regard to automatic signalling, the Sykes system was automatic signalling controlled by manual labour. It was rather interesting to know that it was an Englishman (Mr. W. R. Sykes) who originated the track-circuit in 1865, and, curiously enough, he put 1 volt between the rails. Mr. Thorrowgood said "curiously enough" because the principles of the track-circuit were not then fully established. A number of track-circuits were used on the London and South Western Railway over 25 miles of line, for automatic and controlled automatic signalling, and also at stations. Experiments were now being made with the object of overcoming the sanding trouble that made the track-circuit unworkable—in stations, for instance. In 1908 experiments were made with alternating currents for track-circuits at Richmond, polyphase motor relays being used. The energy was obtained from the 600-volt traction conductor and was reduced by a motor-transformer to 55 volts, and then again reduced to 4 volts on the line. Those 4 volts were taken to one end of the line and brought through one rail, then through two coils of a polyphase relay, and then back again by the rail to the starting-point. There was a second local circuit which was taken off the special transformer. The current was taken through the other two coils of the polyphase motor relay, and an impedance was introduced into the second circuit which gave the necessary difference in phase to enable the polyphase to work correctly. The rotor of the polyphase relay revolved about 70°, and made contact at the end of its travel. A train on the track short-circuited the first current, and the polyphase motor relay was de-energized and the contacts were broken. The experiments proved successful. The power taken was about three or four times as great as with ordinary battery track-circuit work,

but if the current could be taken from power-mains, the cost would not be excessive. A number of superimposed telephones were used on the London and South Western Railway—telephones superimposed on telegraph-circuits and telegraphs superimposed on telephone-circuits. A superimposed telephone was used between London and Southampton and between London and Salisbury with ease, and a good railway service was obtained, though he did not say it would be good enough for the Post Office. He had some time ago the pleasure of making, with Mr. Jacobs, of the Great Western Railway, a number of experiments on long-distance telephones, and the results were embodied in the instrument now used. With regard to the late Professor Ayrton's law as to the correct resistance for a single needle or for apparatus in omnibus circuits, he did not agree with the Author. He believed the railway telegraph-engineers of this country had well considered that point, and Professor Ayrton's law was not the only thing that had to be taken into account when deciding what should be the resistance of a coil in an instrument. Taking a circuit 80 miles long, the resistance through an iron wire would be about 1,280 ohms. If there were twelve instruments on that circuit, the correct resistance of each, according to Professor Ayrton's formula, would be 106 ohms. But if on the same circuit, 80 miles long, there were only two instruments, one at either end, then, applying Professor Ayrton's law, the correct resistance of each of those coils would be 640 ohms. Even taking the mean between 106 and 640, the solution of the question would be no nearer than it was at present. On working out Professor Ayrton's law it would be seen that the efficiency of the coils did not vary very much within wide limits on either side of the correct resistance given by the law. When settling the correct resistance for each coil it was necessary to consider the size of the coils, the ampere-turns, the gauge of the wire, and the number of alterations that would be brought about in practice. There would be, for instance, the number of different coils to be held in stock. It was impossible to have in stock a number of coils with 30 ohms, a number with 100 ohms and a number with 500. The only case in which a difference due to leakage could take place was in short-circuits, which meant that it was necessary to use a little more battery-power than would otherwise be used with the correct resistance in the coils. Short-circuits meant low voltage, and with low voltage the question of leakage did not come in at all. On the London and South Western Railway there were two standards of resistance, 300 and 200 ohms, which were found to answer the purpose very well. The coils were all made to give good signals

Mr. Thorrowgood.

Mr. Thorrowgood. when current of 15 milliamperes was passed through them, and he did not think there was much trouble with leakage of current due to high voltage.

Mr. Szlumper. Mr. A. W. SZLUMPER endorsed the remarks made by Mr. Ross and expressed the hope that signal-engineers would give the meeting the benefit of their experience in connection with the modern development of signalling. The Author did not anticipate that power-signalling would be adopted generally, except in special cases. Mr. Szlumper thought he would find he was wrong; he mentioned some of the advantages, but he omitted one important one, namely, that the Board of Trade permitted facing points to be worked at a distance of 300 yards from a box where power-signalling was installed. In a large installation that often meant the saving of one box and sometimes two, which was, of course, a very considerable economy. The Author spoke of three installations of all-electric signalling on the Great Western Railway, and it would be of interest to know on what system those installations were. Mr. Szlumper assumed it was successful, as it was contemplated installing it at such large centres as Paddington and Birmingham. Whether audible signalling was the most advanced development was a debatable point. It was accepted among experts, he thought, that the most modern development was automatic signalling, and that was a subject which the Author scarcely touched upon. Automatic signalling was a combination of power-signalling and track-working; in fact, a development of the Sykes lock and block. The mention of Mr. Sykes's name reminded Mr. Szlumper how much railway-engineers were indebted to Mr. Sykes for the many valuable inventions in signalling that he had introduced. Mr. Sykes anticipated track-working 40 years ago, but, like a good many inventors, he was born a couple of generations before his time. Automatic signalling had long since passed the experimental stage; in America there were hundreds of miles installed, and in England there was no small mileage. The London and South Western Railway Company, who, he believed, were the pioneers in introducing the system into England, had several installations, one on a 25-mile length of four-track main line. That length was track-circuited and there was an insulated joint at about every mile. At these points a signal-bridge spanned the line, carrying a distant and stop signal applying to each road, and those signals were controlled entirely by the movement of the train. When the train entered the track, the signal, which was normally in the "off" position, immediately went to danger, and when the train left the section the signal returned again to the "off" position. Within a stone's throw of the Institution there was

one of the finest automatic installations in the world, the Under-ground line, where he believed no less than thirty-eight trains per hour ran on one line. Shortly it was intended to increase that to forty, or even more; he believed they were only waiting to put more stock into service. Such a service would be absolutely impossible with any other system of signalling than the automatic. At Earl's Court, over a four-track road, he believed there were 1,186 trains per day, and the failures were very few and unimportant—about one in a million movements. Therefore he suggested that automatic signalling was the most recent development. One of the important advantages of automatic signalling was that it enormously increased the carrying-capacity of a line. With regard to power, it seemed to him that, seeing that in any installation of signalling the electric current must enter very largely, it was only reasonable to suppose that the proper power was electricity; in other words, an all-electric system. Audible signalling was, of course, not a new idea. There were several systems; possibly that installed on the Great Western was the best, but it seemed to be in more or less an experimental stage; otherwise, why confine the apparatus to the distant signal? Why not indicate the stop signals and do away with the outdoor signals altogether? With regard to the advantages, the Author mentioned that the distant signal was given to the driver at night as well as by day; but that advantage was quite easily obtained by the use of a Coligny-Welch lamp, which, in addition to giving the red and green lights, also showed a white arrow at night,¹ so that it was quite easy for the driver to distinguish a distant signal and even pick out one in a cluster of signals. The Author said that fogmen were not necessary, but that was another debatable point. Possibly on a small single shuttle line there would be no great objection, but in places like London, where fogs were very thick, he did not think any traffic-manager would willingly dispense with the services of fogmen. A great many of the distant signals were on the same post as stop signals, and it was an important part of the duty of a fogman to tell the driver the condition of the stop signal, and to enable him to do this the signals were repeated in the fogging pit or hut. If fogmen were done away with, the driver would be in difficulties. Another point was that fogmen were also platelayers, and in foggy weather platelayers could not be profitably employed in their ordinary work; in fact, the only work they could be suitably employed upon was fog-signalling, and inventors of

¹ Minutes of Proceedings Inst. C.E., vol. clxxx, p. 37.

Mr. Szlumper. fog-signalling apparatus should bear this in mind. In conclusion, he congratulated the Author on a very interesting description of the signalling used on the Great Western Railway.

Mr. Johnson. Mr. A. H. JOHNSON expressed his appreciation of the Author's excellent Paper. There was no attempt, of course, to cover the whole subject, because that would obviously entail the writing of a long treatise. He did not think it was properly appreciated that railway-signalling was at the very heart of railway-working, and any signal-engineer, to be worthy of the name, required a considerable knowledge of the principal departments of railway-working. It struck him that the signal-engineer was continually wrestling with "ghosts," so to speak, and it was a very difficult business. Not only had he to consider actualities, but things were always changing and he had continually to grapple with new conditions of traffic-working, which raised new dangers. He had to meet those dangers before they occurred, just as a general had to post his troops to meet assaults before the enemy made them. Without the power of imagination, the general was of no value; and the science of signalling required a similarly high quality in an officer. It was not sufficient for him to consider what had happened; he had to consider what might happen under the new circumstances. Signal-engineers in England were especially labouring under a very great disability. However well grounded the signal-engineer might be in his work, he was continually dominated by the operating department. Mr. Johnson wished to take the opportunity of appealing to Caesar, as it were, because the time was coming when something would have to be done. Signal-engineers were often told, when they pointed out things which experience and long thought had shown them, that those matters were the business of the operating department. If Great Britain was not to drop behind other countries in that important branch of railway work, the signal-engineer must be given a chance. The spirit of a business could not be dissociated from the business itself. If one department was to dictate to another department in its own speciality, it was equivalent to dissociating the spirit from the body of a man: it left a dead man. Great Britain was fast coming to a dead end on that subject, and other countries were getting ahead. Until recently Great Britain had taught the whole world in connection with railway matters, especially signalling, and it could still lead the world in signalling if signal-engineers were given a proper opportunity. The obsession of signalling by the operating department was really an importation from America, although in signalling practice Great Britain was far

ahead of America to-day. One heresy into which the Americans Mr. Johnson. dropped during the 12 years he was there was the use of one shunting-signal for a number of different routes. Any man practised in railway-signalling knew the danger of making one signal answer in that way. The signalman might forget to pull one pair of points and there was nothing to check him from pulling his signal-lever and sending a driver on to the main line in a fog when he intended to send him on to a siding. He had had the misfortune to see the spirit of that heresy imported into Great Britain, and he had been glad recently to hear Mr. Bloyd, President of the Society of Engineers, point to that bad practice as needing attention. Something had been said with regard to track-circuits on the Great Western Railway, and he noticed that on that line they had subdivided some long block sections. There were two ways of doing that. Some people had advocated making the sub-divisional signal a rear home signal, but he had always maintained that the signal should be worked as an advance signal, because if it were so worked, no new practice was involved: the rules and regulations applied to that advance signal, although it was so far away. The track-circuit principle was merely equivalent to a long fouling-bar; it did not accomplish any fanciful results. Mr. Szlumper had mentioned the fact that Mr. W. R. Sykes tried the track-circuit in the early days, and so did Mr. Edward Tyer. They were two grand old men in railway-telegraph and signal work. Mr. Sykes had told him that he tried the track-circuit at the Crystal Palace in the sixties, and it was very much the same as the system used to-day. Mr. Sykes used 1 volt and a low-resistance relay, and the only thing that stood in his way was that in those days they heaped the ballast nearly level with the top of the rail, and the lavatory arrangements not being as good as to-day, urine soaked through the gravel and practically short-circuited the rail. To-day track-circuits had not advanced beyond that system except in certain special installations. He thought a great many people looked upon automatic signalling as a panacea for all sorts of dangers, but as Mr. Szlumper had just pointed out, automatic signalling was a very old idea. When people spoke of automatic signalling they really meant, as a rule, self-acting signalling, and he maintained that self-acting signalling was not a burning question in England. On referring to the Report of the Committee appointed by the American Railway Association—a Report which was produced after 6 years of careful investigation in Europe and in America—it would be found that the Committee said that the English lock-and-block system (they called it the controlled manual system) was the best and safest block system known. They pointed out that

Mr. Johnson. the self-acting signalling was used as an expedient in America because stations were so much farther apart than in Great Britain. Some stations in America were many miles apart and they could not possibly adopt lock and block in that connection. There were two conditions under which "self-acting" block signals were brought within practical consideration, namely, long-distance signalling, and tramway traffic, or short train-intervals. On the District Railway they had been forced into their system of signalling by the short train-intervals, but that did not prove the system to be the best and safest. The old English manual block system, especially with its automatic features, was the best thing that could possibly be had, and nothing would beat it on a main line. The track-circuit system added to the lock and block was an improvement, and he had applied this combination on certain American railways 20 years ago; but it was after all only a modification of the lock-and-block system. With regard to cab-signalling, it was a high ideal, and a thing that must eventually come about in a country subject to fogs.

Mr. Timmis. Mr. E. W. TIMMIS, referring to the Author's suggestion of doing away with the distant signal for a train approaching a branch, remarked that there was no danger in doing that, though it might delay traffic, which was rather important. Supposing a driver to be approaching a junction on a foggy night and not able to see the signal until he was close upon it. He had to approach that signal at such a speed that he could pull up if the signal was at danger, whereas if there were a distant signal repeating that branch signal, that would not be necessary, and valuable time would be saved. As to keeping a distant signal permanently at "danger" that seemed rather a doubtful innovation. The function of a distant signal, as usually understood, was to give two indications, one "danger" and one "line clear." If the signal was capable of giving only one indication, why trouble about having a signal at all? Some other device might be suitable. It seemed a pity to take away the functions of a distant signal in that way. With regard to track-circuits, it was admitted by the Author that certain vehicles would not always operate the track-circuit, and that had been mentioned by another speaker. He would go further and say that it was possible to run a locomotive on to a piece of line which had been sanded in the ordinary course of events and to get no short-circuit. No doubt signal-engineers would be able to devise a means of overcoming that difficulty, because in his opinion track-circuiting was very important and had a great future before it. Certainly some remedy ought to be devised for that trouble.

Mr. C. B. BYLES ventured to think there was no one better Mr. Byles. qualified to write a Paper on Railway-Signalling than the Author, nor any railway in the world which was better signalled than the Great Western. By "better signalled" he meant not loaded with signals unnecessarily, but signalled in a consistent and appropriate fashion; and that, after all, was the thing which had to be aimed at. In regard to doing away with the splitting distant signal at a junction, he associated himself with the remarks which had fallen from the last speaker, and would only add that it seemed to him that to fix the distant signal at a junction at "danger" when the route was set for the inferior direction was to attempt an impossibility, because it was trying to make a signal, which actually could give only two signs, give a third sign. A signal nowadays could only show two things, "line clear" or "line blocked," and therefore any attempt to use it for the purpose of checking speed could not be successful. For that reason, apart from any practical difficulties, he did not think it was a wise arrangement. If it were desirable—as it seemed to be sometimes—that drivers should be warned of the necessity for reducing speed, the more logical course would appear to be to provide a separate signal altogether, whose sole function should be to indicate that necessity. He desired to suggest one other consideration arising out of the Paper. In discussing railway-signalling the elementary fact that signalling was provided for the purpose of ensuring safety to railway-traffic was sometimes lost sight of, and that was one of the difficulties the signal-engineer had always to face. He had to spend money, but he was unable to show, in return for that expenditure, anything but a hypothetical safety. A very remarkable thing during the last few years was the occurrence of two distinct epidemics of railway-accidents, having their rise in two separate causes. The first consisted of accidents arising from mistakes made by the drivers, and in that connection he mentioned the accidents at Salisbury, Grantham, Shrewsbury, and Slough. Within the last few months another epidemic of accidents had taken place, from neglect on the part of signalmen, and in that connection he mentioned Ormskirk, Hawes Junction, Pontypridd and Willesden Junction. Two facts emerged very clearly from those two series of accidents. The first was that all the accidents had occurred from the neglect of perfectly simple and straightforward rules. The second was that in every case, without exception, the man who caused the accident had been not, as might have been expected, a careless or intemperate man, but a tried servant of the Company, with many years' experience behind him, and in most cases an

Mr. Byles. unblemished character. Those circumstances, taken together, gave rise to very serious thought. Care was taken to lay down carefully prepared rules, but when those rules were broken persistently there must be some cause for it. It was quite easy to legislate, but the supreme test of any rule or law was its workability; and if it was found in practice that a rule was constantly being broken, not by careless men, but by careful, well-trained men, there was very strong presumption that something was wanting in the rule, or that circumstances made it difficult to carry out its provisions. Another point was that many of the rules which had to be carried out—and he referred particularly to the notorious rule No. 55—were working directly against the other forces which were in operation in railway work. Men were being taught to think, so to speak, in half-minutes, and yet they had imposed upon them the necessity of carrying out a rule which caused a great deal of delay. The moral was that, just as in the old days the traffic increased so much that the time-interval system had to give way to the block system, and the old hand-brakes had to give way to continuous brakes, so, as the pressure of operation became such that the present system of signalling was not adequate to meet the requirements, improved methods would have to be adopted to meet the new condition of affairs. To-day, as in the past, under ordinary conditions there was no mechanical harmony between the outdoor signals and the block instruments, and there was no compulsion on the driver to obey signals. He thought the lesson brought out very forcibly by the Author was that the time had come for making a step forward, and to begin with, as a small instalment, to make it impossible for signals to be lowered unless the track to which they applied was clear. For the benefit of those who were anxious to introduce power-signalling he might say that power-signalling and automatic signalling were all very well in their way, but they were not the things required at the present moment; and to advocate power-signalling, or any other elaboration of that sort, was to a certain extent to drag a red herring across the scent. There was a definite need at present for protecting the traffic by making the signals harmonize with the track, and that was the first need that had to be met. It seemed to him that by adopting gradually some of the expedients advocated in the Paper, a great deal might be done on British railways to bring them up to date in this respect, without any appreciable expenditure. It could be done so steadily and gradually that it would be found to be done before people were really aware of it. He would like to utter one warning. The British public stood a good deal of knocking

about, and did not mind being killed occasionally, but ultimately it woke up, and then there was usually a great outcry and very frequently some ill-digested legislation. Such a thing happened in 1889, when the terrible accident at Armagh resulted in the hurried passing of the Railways Regulation Act of that year. If the Railway Companies did not take steps to go steadily onwards, something of that sort would happen again, and restrictions would be placed upon them which would probably be found to be very onerous and much more elaborate than was really necessary. Therefore it seemed to him that the principle to go upon was to make steady progress in the smaller and less ostentatious direction of combining the block instruments and the track and the signals, and so gradually to perfect the present manual block system.

Mr. T. S. LASCELLES wished to associate himself with the remarks made by Mr. Ross about the lock-and-block system of signalling, a system about which very little was known among a considerable proportion of railway men; and as it would have gone far towards rendering extremely improbable the serious railway disasters that had occurred recently he might be allowed to make a few remarks on the subject. Signals were provided for the direction of the driver, to tell him when it was necessary to stop or permissible to proceed, and elaborate instruments were provided for communication between the signalmen as to whether the line was clear or not, and generally as to the running of trains; but on the majority of English railways no attempt was made to co-ordinate the indications of the block instruments with the outdoor signals. That was a very important point, because it did not matter how elaborate the signals were, or how perfect the telegraphic instruments, if the system could fail through the slightest error of one man, there must be a fault somewhere. The lock-and-block system of signalling was really very old, dating back to 1875. It was used on the South Eastern and Chatham, London and South Western, and Brighton railways, and on the suburban lines of the Great Eastern Railway, so that he did not think it could be said it was untried or open to very serious objection. The first object of the lock-and-block system was to prevent signals from being lowered unless the signalman at the next signal-cabin had given permission. That was accomplished by making the signalman at the next cabin unlock the signal for giving entrance to the section. The second provision was that the signal should without fail be restored to "danger" behind the train, so protecting it until a second unlock was required from the station in advance. One way of doing that was by means of a signal-reverser which automatically threw the arm to "danger." The next pro-

Mr. Byles.

Mr. Lascelles.

Mr. Lascelles. vision was that the train should not be signalled as having cleared the section, and a second train admitted, unless the first train had cleared. That was accomplished by what was known as a "rail-contact," an apparatus fixed on the line and depressed by the train. It released some portion of the apparatus and allowed the signalman to accept the second train. A great many objections were raised against that system of signalling, chiefly by those who advocated the absolute block system. The first objection was that it was liable to hamper traffic and that goods-traffic could not be got over the line so quickly. It was said to be sufficient, for the working of goods-trains, for the first train to be under the protection of the home signal, when the second train could be admitted into the section in the rear, and that could not be done under the lock-and-block system. A second train could not be admitted into the section in the rear, if it was carrying passengers, unless the requisite $\frac{1}{4}$ mile of clear line was before the home signal in advance; so that that argument only applied where two goods-trains or two trains not carrying passengers followed one another in succession, which did not happen very often on passenger-lines. Another argument often brought forward was that trains could not be worked under the so-called warning arrangement with lock-and-block signalling. The warning arrangement was a system of block working which was adopted at some places to expedite traffic. If the line was blocked at the station and it was necessary to allow a second train to enter the station for coupling-up purposes, the second train was admitted after the driver had been spoken to by the signalman and a green light or flag shown to the driver. With the lock-and-block working additional safeguards could be given to that rule, as well as allowing trains to be worked in that way. The Sykes system was in operation on the London, Brighton and South Coast Railway at several places, and it allowed that method of working. Two sets of block instruments were employed, so that signalling trains on the "right away" principle was kept distinct from the warning principle. An additional signal was provided at the entrance to the section, so that the driver obtained a special fixed signal under the warning rule. That was a very good plan, and he understood it gave great satisfaction on the Brighton Railway. When the serious railway disasters that had occurred for a number of years back were considered, it would be seen that many of these accidents could have been prevented by the simplest appliances known; and it seemed astonishing that it should be necessary to waste words on the value of such appliances. It seemed to him that to save a moment of time for a train was of

much less importance than killing a few people. With regard to track-circuits, it might not be generally known that the celebrated discoverer of the earth return-circuit, Professor Steinheil, of Munich, experimented with track-circuits, and it was by those experiments that he discovered the earth return-circuit, so that track-circuits were not new after all. Mr. Lascelles.

Lieut.-Col. H. A. YORKE was pleased to be able to associate himself with the remarks of Mr. Byles in regard to the signalling on the Great Western Railway being of a very high character. It was interesting to look back and see the character that railway bore 60 or 70 years ago. By chance a few days ago he was turning up some of the old Reports of the Board of Trade, to see how they did their work in those days, and he came across a Report from which it appeared that the Great Western Railway was the first line in England to adopt the present positive system of signalling, that was, the system which gave a positive indication for "danger" and for "clear." In those days the ordinary system was to give an indication for "danger," and when that indication was removed, and nothing was visible at all, the line was supposed to be clear. In 1841 the Great Western Railway installed a different system, simple, but fairly effective. On the same post there was a crossbar and a disk, the crossbar being at right angles to the disk. When the crossbar was visible to the driver and the disk was turned edgewise to him, it indicated that the line was blocked. When the disk was facing the driver and the crossbar was edgewise to him, the indication was "line clear." The Inspector-General of Railways in those days said: "These signals differ so essentially from those in use on other lines and appear so well calculated for the object in view, namely, the safety of the public, that I have thought it right to bring them to your especial notice." That was in a Report to the Board of Trade, dated the 1st June, 1841. It was satisfactory to find that the Great Western Railway was still giving a lead in some matters, such as those referred to by the Author in his very interesting Paper. It was the custom nowadays to describe English methods as old-fashioned, and some of the previous speakers had already referred to that point of view. He agreed with them that it was well to be sure that some of the modern developments and appliances, which were largely American in their origin, would give any better results. In that opinion he was confirmed by the Block Signal and Train-Control Board of the Inter-States Commission of New York. In their Third Annual Report, which had not yet reached this country, but of which he Lieut.-Col.
Yorke.

Lieut.-Col.
Yorke.

had received certain portions, the Commissioners said: "Nowhere in the world have appliances for safeguarding railway transportation been so highly developed as in America, notwithstanding which, nowhere in the world is there a greater proportionate number of accidents of the kind which such advance in the art should prevent." In spite of all the ingenious appliances that had been introduced in America, the railways there were not exempt from a very large number of serious accidents. With regard to the experience in this country, he thought it was only fair to remind the members that in the 10 years 1901-1910, there were three years practically without any train-accidents involving the death of a passenger. In 1901 not a single passenger was killed in a train-accident, and the same could be said of 1908; and in 1909 only one passenger was killed in a train-accident. He quite admitted there had been recently a series of accidents which had been accompanied by lamentable loss of life, and which he thought might be said to be inexcusable; but that rather tended to show, he thought, that the same Block Signal and Train-Control Board was right when it said elsewhere: "The ordinary manual block signalling system is not being worked at its highest efficiency." In England the railways used chiefly the manual block system of signalling, with a certain amount of track-circuiting and automatic signalling or self-operating signals. The Americans highly appreciated the manual block system of working and were using it very largely themselves, but they said they were not getting the full benefit from it because it was not being worked at its highest efficiency; and the Block Signal Board went on rather to infer that it was at any rate somewhat premature to spend money upon other costly and more complicated devices until the best value had been obtained from the manual block. That was very much the attitude which men in this country might adopt, and judging from what had been said, he thought that was the view held both by Mr. Byles and Mr. Johnson. Turning now to some of the points in the Paper, the Author referred to a device he had introduced for interlocking the distant signal in such a manner as to render it impossible for the signalman to give "line clear" to the station in the rear unless the distant signal was absolutely at "danger." That was a very useful and admirable device, but he would like to know whether it could not be extended also to the home signal as a useful addition. Within the last few weeks he had had to investigate an accident which might have been accompanied by very serious consequences. The signalman having received "train out of section" for the previous train, and having

at the same moment another train offered to him, gave "line clear" for the second train without taking the trouble to leave the block instrument for the moment and put his home signal at "danger." Very likely he intended to do so later on, but unfortunately he did not do so, and the second train, arriving in a few minutes and finding the signal off, naturally ran into the first train. The signalman could give no reason for having left the signal off. If something could be devised—and he did not see why it could not be done—that would make it absolutely essential that the signal should be in its proper position before the train was accepted, a point would be gained in the direction of safety. He wished to remind the members that there was not a single word in the Rule Book to say that a home signal was to be put to "danger" behind a train. The only rule that bore on the subject was to the effect that the normal position of all signals was to be at "danger," but the position might be called normal if it was at "danger" for three quarters of an hour out of an hour. There was no direct instruction that the signalman was to put the home signal at "danger" behind each train as soon as it passed. There was such an instruction with regard to the distant signal, but none with regard to the home and starting signals. Again, was it entirely impossible to devise a reliable and practicable signal-replacer or disengager? It seemed to him that it would go a long way towards rendering automatic signalling unnecessary if a signal went to "danger" as soon as the train passed it, without any outside human agency at all. If the same amount of thought were given to devising an apparatus of that sort as had been given to various other details of signalling, especially automatic signalling, it seemed to him hardly credible that a simple and reliable instrument could not be designed. He had seen many forms of disengagers, both mechanical and electrical, and when he asked why they were not used, he was always told they were unreliable; but he was bound to say he had never had it established that they were not reliable, or that a reliable instrument could not be designed. With regard to the outer home signals, he found himself in entire agreement with the Author on that subject. He thought the outer home signal was likely to prove an exceedingly useful addition to the equipment of a station under certain conditions, and he had himself on more than one occasion advocated such an addition in certain Reports. There was, however, one point about it. Why did the Author say that the outer home signal had always to be $\frac{1}{4}$ mile in the rear of the inner home signal? Why lay down a hard and fast rule? Surely the distance should depend on the

Lieut.-Col.
Yorke.

Lieut.-Col. Yorke. gradient, the speed, the brake-power, and various other matters. If $\frac{1}{4}$ mile was sufficient to secure safety in the case of a falling gradient, it was evidently too much in the case of a rising gradient or when the road was level. He thought the block telegraph rule was somewhat too rigid in that matter of laying down $\frac{1}{4}$ mile as being the exact distance to which the line must be clear before another train might be accepted. He ventured to think the distance should vary with local conditions. A signalman could not measure $\frac{1}{4}$ mile with his eye, and therefore he got into the habit of fixing some convenient point which he believed was $\frac{1}{4}$ mile from his box, and regarded that as the clearing-point. His suggestion was that every signal-box should have the clearing-point recognized. There would be no trouble in that, because there was already an unrecognized clearing-point. If every signal-box had the clearing-point recognized, and that clearing-point depended on the local conditions and the gradient, there would be a certain amount of elasticity and a certain amount of consistency in handling the traffic. On the Great Western Railway he believed they did fix clearing-points at most of the stations; but he did not know of any other railway that followed that practice. With regard to the warning arrangement, known as the "section clear, but junction or station blocked" signal, and recognized as one of the block signals of the country, he was inclined to ask whether that warning arrangement was really necessary. In making that remark he must be regarded purely as a private individual. The warning arrangement merely told the driver that he was to expect to be stopped at the next home signal; but no signal gave him any authority to travel farther than the next signal. The only permission any signal gave to a driver was to travel as far as the next signal and no farther, and no driver had any right to assume that he might go any farther; and if the signal he was approaching was at "danger" he received all the warning he should require from the distant signal, which must be at danger too. He thereby received all the warning that should be necessary, near the place at which he was to stop, and that was a far better warning than any given to him several miles away. The warning arrangement as at present used was a broken reed. He had had more than one inquiry in which the driver had been stopped at a box 3 or 4 miles in the rear of the point at which the collision occurred, and had been told that the next junction or station was blocked. He received his warning, yet he went on his way and calmly ignored it, ran past the home signal at the next station, and caused a collision. He could not have done worse if he had not been warned at all. It seemed to him that

the warning arrangement rather led to a feeling of false security. On p. 164 the Author made a suggestion as to track-circuiting a section of the line outside the home signal. He said: "Where this [the track-circuit] is outside the home signal, its function is to hold the block indicator for the block section in which the train is standing at 'train on line,' and to give the signalman a visual indication that the train is at the signal." That was all very well, but an indication to a signalman was not more than an indication; there was no certainty that he would see it. In going to the expense of track-circuiting, would it not be worth while to go a little farther and so link up the track with the block instrument that the signalman could not accept another train so long as the previous train was still standing outside the home signal? That, he thought, would be introducing a form of lock and block which some of the previous speakers had advocated, and with which he was fully in sympathy. As to audible cab-signalling, all that had been done on the Great Western Railway in that respect was exceedingly satisfactory. He had watched audible signalling for some years past; it seemed to be giving excellent results, and he agreed that it had the advantage of distinguishing the distant signal at night as well as by day, which was a point to which he attached a good deal of importance. For a long time he had advocated that until audible signals were installed the distant signal should be of different colour or have a different system of lights, so as to differentiate it at night from what was usually called the stop signal. In connection with telephones and telegraphs he could not help suggesting that the block telegraph instrument should be fitted with a recording tape, or some simple apparatus to record the block signals given and received by the signalman, in their proper sequence and with absolute accuracy. The present system of train-booking in the registers was very faulty. The signalman, being busy, had not time to do it except at intervals of perhaps 3 or 4 minutes, and he often made a whole series of entries more or less by guesswork. The disadvantage of that was, that not only did it mislead his superiors and the officers responsible for handling the traffic on the line, but he might also mislead himself. He might look at his book some time or other to see whether he had given or received a signal, and having entered a signal by error, he might make a serious blunder. Such a blunder was still more likely to occur in the case of a signal-box where train-booking boys were employed. He had had experience on two or three occasions of boys having made entries hopelessly wrong. Trains that had never reached the station at all had been shown as having passed that station and as

Lieut.-Col.
Yorke.

Lieut.-Col. Yorke. having been accepted by the box ahead. In one signal-box the same thing occurred on two separate occasions. If registering trains was of any value at all, it could only be of value when the records were absolutely accurate. He did not think the appliance need be very costly; simply a record for the purpose of settling any difference between the signalmen. It would be a check upon irregularities, and the advantages gained from accurate records of train-movements, and in the saving of the wages of booking-boys, would repay the cost of introducing it.

The Author. The AUTHOR, in reply, stated that the colours used by the Great Western Railway for subsidiary signals were white and green, white for the "on" position of the signal and green for the "off." The back lights were white for the "on" position and no light at all for the "off" position. The Author's practice as to the adjustment of signal-lenses was to so fix them, having regard to the line being straight or on a curve, as to give the best sight to a driver at the most important point. It was interesting to notice that Mr. List's experience with automatic compensators coincided with the Author's. As regarded the use of solid point-rodding, the chief advantage was that it was free from the liability of tubular rodding to become thin from inside rust without being noticed. It was also very convenient for cutting and welding. In reply to Mr. Acfield's question as to what effect the failure of the electric repeater would have upon the block instrument where the device described for interlocking distant signals with the block telegraph system was in use, it would prevent "line clear" from being returned to the rear until things were put right. This would appear to be the proper result of a failure. The possibility of controlling more lines from a power-worked signal-box than from a manually-worked signal-box seemed to depend entirely upon circumstances, but it was a fact that in a large box on the Great Western Railway where three men would ordinarily be required for working a manual plant, two sufficed for working an electrical plant. The answer to Mr. Acfield's question as to how fog-signalmen could be readily got to an automatic signalling-post was that when fogs occurred the automatic signalling-post was regarded in the same light as an ordinary intermediate signal-box switched out, and the line between the signal-boxes on either side of it was treated as an undivided section, so that fogmen at the automatic post were not required.

The Author regretted to find himself not in agreement with Mr. Ross's views as to reduction of the number of distant signals, as although on the Great Western Railway the reduction of distant signals on the principles explained in the Paper had been pretty

thoroughly carried out, no inconvenience had resulted. Mr. Ross The Author. had asked if universal automatic working that would eventually dispense with all fixed signals which would be superseded by signals on the engine, could be suggested. While not wishing to go so far as to say that such a scheme was absolutely impracticable, the Author certainly thought that the time was not ripe for the consideration of such a complete revolution in signalling methods. Audible signalling so far was considered to be only applicable to the purposes of the distant signal, which was a permissive signal and not a stop signal; and even were the ordinary stop signals to be replaced by signals upon the engine, it would still be necessary to provide some marks which would be in effect fixed signals at which engines would have to stop. The information given by Major O'Meara was very instructive, and it was very interesting to know his views with regard to the relative cost of iron and copper wires, and also to hear what the Post Office was doing in regard to superimposing one circuit upon another. In reply to Mr. Thorrowgood's request for the percentage of failures of the audible signalling apparatus on the Great Western Railway, it was sufficient, perhaps, to say that no failure had ever occurred in which a "clear" signal had been given when it should not have been given. Anent Mr. Thorrowgood's remarks as to Professor Ayerton's law, this was being worked to on the Great Western Railway with very satisfactory results, and no inconvenience with regard to standardization had been experienced. Mr. Thorrowgood was in error in mentioning eighty-three levers as being the number in the largest power-worked signal-box upon the Great Western Railway; the number should have been, as mentioned in the Paper, one hundred and eighty-three working-levers. In reply to Mr. Szlumper's question as to the system adopted in the all-electric installations of signalling upon the Great Western Railway, all three systems bore a family likeness, but there were differences as to detail. It might perhaps answer Mr. Szlumper's question to say that two had been put down by Messrs. Siemens Brothers and one by Messrs. McKenzie and Holland. It was interesting to note from Mr. Johnson's remarks that track-circuiting was experimented with so long ago at the Crystal Palace. The sanding of the rails mentioned by Mr. Timmis was undoubtedly a feature in track-circuiting to be reckoned with, but the Author hoped it would not prove an insuperable difficulty. Dealing with Mr. Lascelles's remarks, the chief reason why the Author did not consider the present form of lock and block superior to track-circuit control was that in order to properly protect a line by rail-treadles, which were

The Author. a feature of lock and block nowadays, so much complication ensued from so many points occurring at which the line could be fouled or cleared. Moreover, a feature of the lock and block, as at present applied, was that a releasing-key was required to provide against failures, and instances had occurred in which these keys had been improperly used, in some cases resulting in accident, the Author believed. It was very gratifying to find from Colonel Yorke's remarks that the Great Western Railway was in such good repute in regard to its signals so long ago as 1841. The Author found himself entirely in agreement with Colonel Yorke, as well as with Mr. Byles and Mr. Johnson, in regard to its being somewhat premature to spend money upon complicated devices until the best value had been obtained from the manual block, with possibly additions of track-circuit control, where such could be made an additional protection. The interlinking of the distant signal with the block telegraph device could be applied to the home signal as well as to the distant. Dealing with Colonel Yorke's question as to its being possible or otherwise to devise a reliable and practical signal disengager or replacer, the obtaining of a thoroughly reliable device of the kind was one which the Author had very much in view for the company he served. With regard to Colonel Yorke's question as to the distance of the outer home signal from the inner home signal being always $\frac{1}{4}$ mile, the Author saw no reason why this distance should not be varied to suit circumstances. The Great Western Company had already experimented with an automatic train-signal recorder of the kind suggested by Colonel Yorke.

Correspondence.

Mr. Bell. Mr. W. H. BELL remarked that the question of picking up current for signalling purposes was a point upon which further information would be acceptable. It had often been stated by railway-engineers that anything in the nature of a blow between the engine-contact and a ramp, especially at high speeds, would very soon cause the apparatus to fail. Had the Author experienced any difficulties from such a cause? It had always appeared to Mr. Bell that this was the most important link in the chain of any audible system of signalling which aspired to supersede the present visual system.