Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Wednesday, March 28th, 1956

The President (Mr. E. G. BRENTNALL) in the chair

The **President** said it gave him great pleasure to take the chair at a joint meeting with the Institution of Locomotive Engineers, and he extended a very hearty welcome to all members of that Institution. Their President, Mr. K. J. Cook, was unable to attend as he had recently undergone an operation, but he was making good progress and hoped to return to duty very shortly. He was very glad to welcome Mr. J. F. B. Vidal, the President-Elect, Mr. W. A. Agnew, who had been a Past President of the Institution of Locomotive Engineers for twenty-five years, and Mr. G. T. Hart, the Secretary.

Owing to circumstances beyond the control of the Institutions, the paper proposed originally could not be given, but Mr. O. S. Nock had prepared a paper at very short notice and had thereby enabled the meeting to take place as arranged. He was a member of both Institutions, and the subject he had chosen, namely, " Signalling from the Driver's Point of View," was of very great interest to all present.

## Signalling from the Driver's Point of View

By O. S. NOCK (Member)

### Introduction

The primary function of any system of signalling is to give information to the driver of a train. All the most modern technique—track circuiting, relay interlocking, C.T.C. and so on—aims at perfecting the means by which the indication is controlled. Yet sometimes the ultimate result as seen from the engine cab leaves much to be desired. In presenting this paper the author is keenly aware of a two-fold problem—that of presenting, on

the one hand, a clear and unmistakable indication to the driver, by either semaphore or colour-light signals, and, on the other, of studying and improving those features of locomotives that assist in observation of signals. The problem is approached by the present author with a foot in each camp, as it were. For many years he has been engaged in the design of signals of all kinds, for installation in many parts of the world ; in the course of this design work problems of mounting, adjustment, sighting and display have been constantly met. On the other hand an extensive experience on the footplate over all main, and many subsidiary lines in this country, and to a lesser extent in Ireland, and in France has presented a rather different aspect of signalling, an aspect in which the differing characteristics of steam, diesel and electric locomotives are encountered, and sometimes provide a distraction, and hindrance to the sighting of signals.

The difficulties as seen by an observer in the engine cab are presented in what is hoped to be an unbiased view. Although the author was, in the great majority of cases, riding in the cab as an observer of locomotive performance from the motive power point of view, it was only natural that close observation of the signals from start to finish was an interesting and important aspect of the running.

**The Footplate**

The most difficult problems of signal sighting occur with steam locomotives, though with electrics, and diesel-electrics there are rather surprisingly, points that arise to distract and obscure, particularly in bad weather ; although the gradual replacement of steam in this country is now foreshadowed, it will be some time before this original and historic form of railway motive power is finally displaced from the main lines of this country. In discussing the problem of signal sighting from the footplate the problem must naturally be taken in its most difficult form.

The look-out ahead from a steam locomotive was at one time practically clear of obstruction. The early drivers, descendants of that exceedingly tough race of men who drove the stage coaches of 150 years ago, looked ahead over the top of the small boilers. They had not even the protection of a weather board (fig. 1.) When certain well-meaning designers gave them cabs they protested that they were being closed in, and couldn't see! Even when cabs became the rule rather than the exception boilers were

still small enough for the driver to look ahead over the top, when standing in his normal position on the footplate. It was at about the turn of the century that conditions began to grow more difficult. Increasing traffic, and the demands for higher speed brought certain locomotive engineers to new considerations of boiler design, and the Belpaire firebox, with its square sides and flat top was introduced into many new locomotives. At once the look-out ahead was narrowed and constrained. The driver no longer had the spacious view over the top, and the modern problem of signal sighting had fairly begun.

With larger locomotives the boilers became longer, and of increased diameter, and although the cabs were increased in width to the lateral limit of the loading gauge the view ahead was limited. Today indeed the footplate of a large conventional type of steam locomotive is anything but an ideal stance for observation of signals (fig. 2). In contrast to the layout of large British and American locomotives it is of interest to recall certain attempts to beat the sighting problem. In America there were the picturesque "Mother Hubbards," with the driver's cab mounted halfway along the boiler, leaving the fireman by himself in an exposed and uncomfortable platform at the rear (fig. 3). It is rather surprising that so many locomotives of this type were built, and that they survived so long. If much experience on the footplate has taught nothing else it is said that the prime requisite for good running is a perfect understanding and complete teamwork between driver and fireman. This cannot have been easy to achieve on a "Mother Hubbard."

The Southern Pacific Railroad operates a number of very large articulated locomotives. They are designed for oil firing, and advantage of this has been taken to run cab first, with the tender in rear (fig. 4). By this means a look-out as good as that of a diesel, or an electric is obtained, though of course this would not be possible in a coal burner. In spite of the apparent advantages of this arrangement, and the fact that steam locomotives on many American railroads were oil-fired, the cab-first layout appears to have been confined to the Southern Pacific. It is said that this departure from convention was not popular on another count. The men felt they were *too* exposed, and uncomfortably near the front when bucking into snow drifts.

Even in the most favourable conditions the sighting of signals from a large modern locomotive needs special care on curving

FIG. 1 (*Top Photo*).

FIG. 2 (*Second Photo down*).

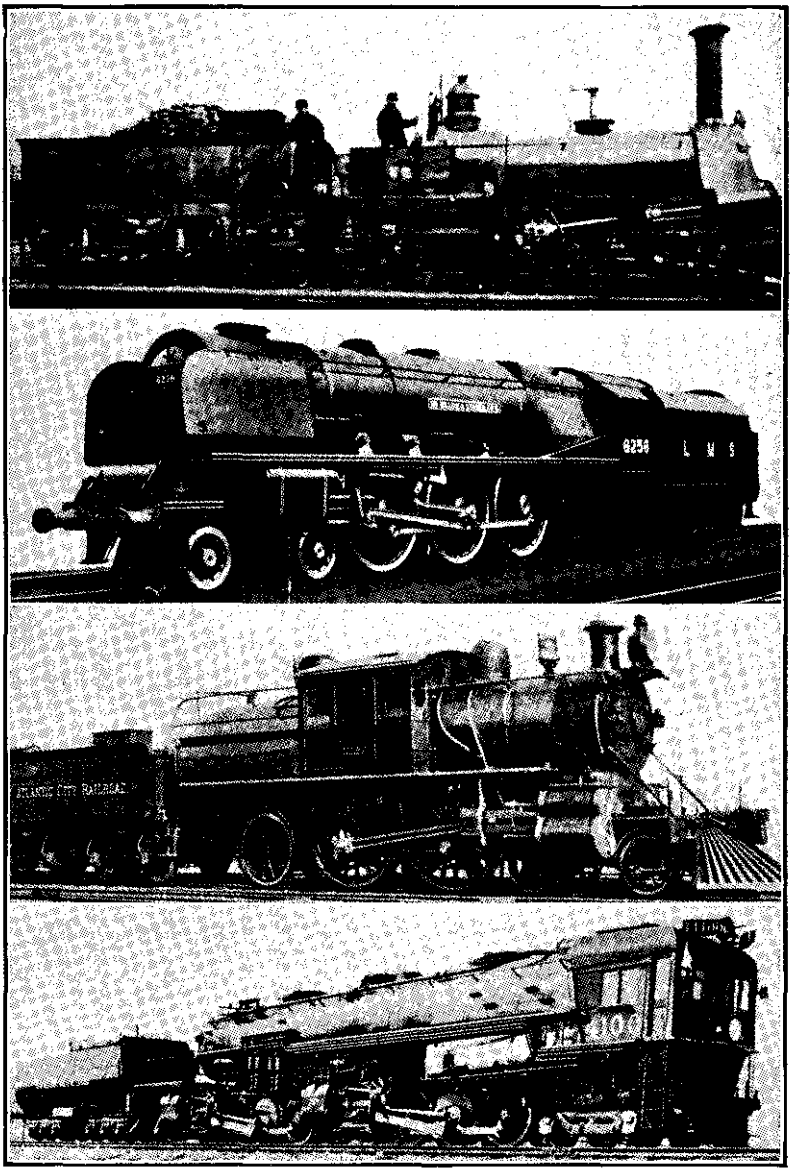


FIG. 3 (*Third Photo down*).

FIG. 4 (*Bottom Photo*).

stretches. It is here that the teamwork of driver and fireman becomes apparent, and however busy the fireman may be there are places along the route where he pauses in his other duties to sight a distant signal of which he gets a longer first view from his side of the cab than the driver does from his. Many firemen appear to know the road almost as well as their drivers. The author has travelled with certain top link drivers and firemen who call out to each other the aspect of every distant signal on the route : whichever of the pair sighted the signal called out, while the other, in acknowledgment, repeated the indication : " Right away Offord," " Right away Huntingdon," and so on.

**The Obscured View** (figs. 5 and 6)

The limitations of the modern look-out ahead will be further appreciated from the various photographs reproduced herewith ; but it is important to emphasise that all of these photographs were taken in conditions of clear visibility, when there is nothing except the physical contours of the locomotive obtruding upon the view.

On locomotives where the view from the cab window is narrow the driver can get a better view by looking outside the cab. At one time this would have been a hazardous procedure, involving risk of injury to eyes, especially at high speed ; on the other hand there were in earlier railway days many intrepid enginemen who thought nothing of leaning over the side for the whole of the journey, even in the most severe weather. On modern locomotives many of the latest types are fitted with a vertical strip of glass immediately ahead of the look-out window, and this simple but very effective device enables a man to look outside the cab in safety and relative comfort.

The window may be obscured from a variety of reasons. On some large engines the sounding of the whistle has the effect of temporarily clouding the glass on its outer side, and in the course of a run the glasses would become spattered with particles of dirt, and oil, thrown up, or down as the case may be. But by far the most troublesome cause of the look-out being obscured arises from exhaust steam beating down. This is no new problem, and an interesting attempt to overcome it was made more than 70 years ago on the Highland Railway where a special form of chimney was fitted to all locomotives. The chimney was, in fact, a double one, and the outer shell enclosed an annular space surrounding the true,

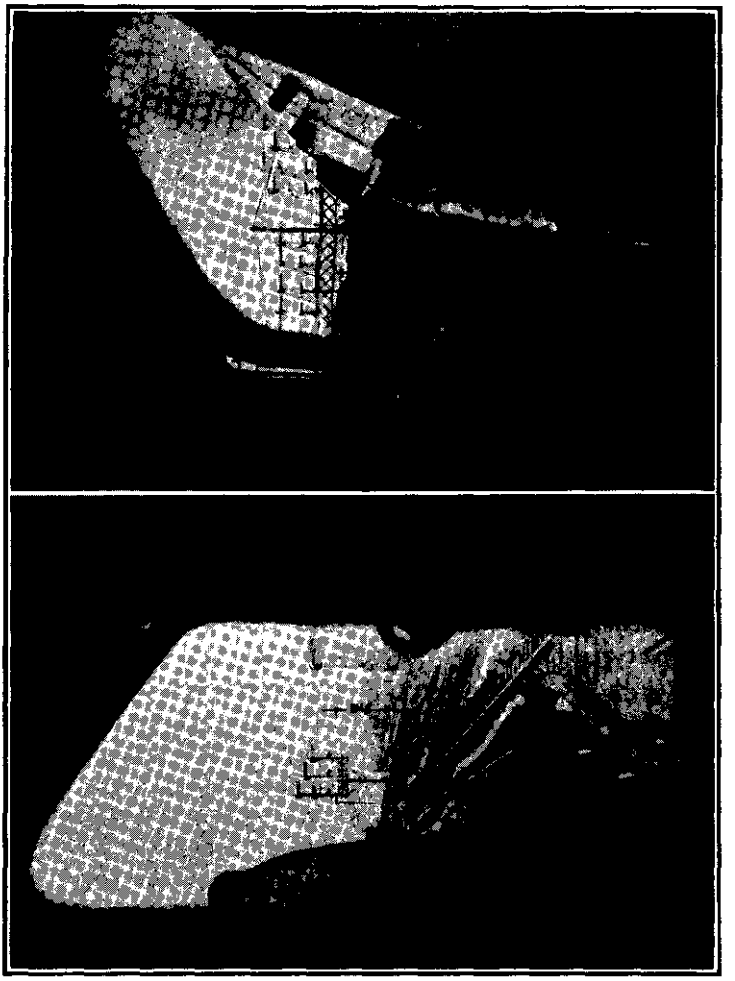


FIG 6.

FIG. 5.

inner chimney. The diagrammatic representation of this device is shown in fig. 7, and the theory underlying the arrangement can be appreciated by the direction of the air current induced through the series of louvres in the front portion of the chimney. The apparatus was designed to produce an upward current of air at the back of the chimney, which would lift the exhaust when the engine was steaming lightly, and carry it sufficiently high as to pass clear over the roof of the cab. It was thus hoped

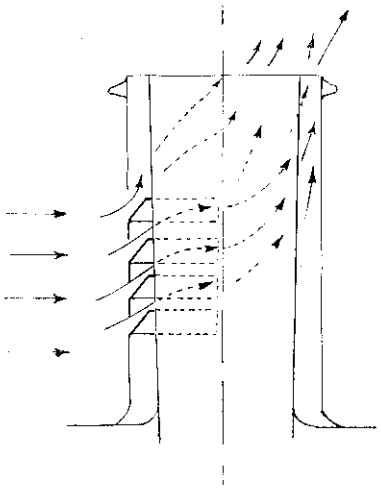


FIG. 7.

to avoid any obscuring of the view. So far as the author is aware the use of this device was confined to the Highland Railway. During the time that Mr. David Jones was Locomotive Superintendent upwards of 100 locomotives were so equipped; but his successor did not perpetuate this device. It is said that there was another reason for this device. Forest fires were being caused by hot cinders, and it was thought that by throwing the exhaust higher any solid particles would have cooled by the time they came down, and so do less damage.

The trouble of smoke beating down occurred again in more acute form with the introduction of locomotives having boilers of large diameter in conjunction with relatively small chimneys. (fig. 8). It also coincided with the introduction of improved valve vents, which resulted in locomotives running for long distances on a very soft blast and consequently little to raise the exhaust above the top of the chimney. Shortness of the chimney contributed in causing the exhaust to cling to the boiler barrel and at times to blanket the look-out ahead from the cab. Various devices were added to locomotives to obviate this difficulty, mainly in the way of providing deflecting screens alongside the smokebox. The actual form of these was, in the majority of cases, determined as the result of experiments with scale models in wind tunnels; the effect of the exhaust steam was simulated by blowing finely

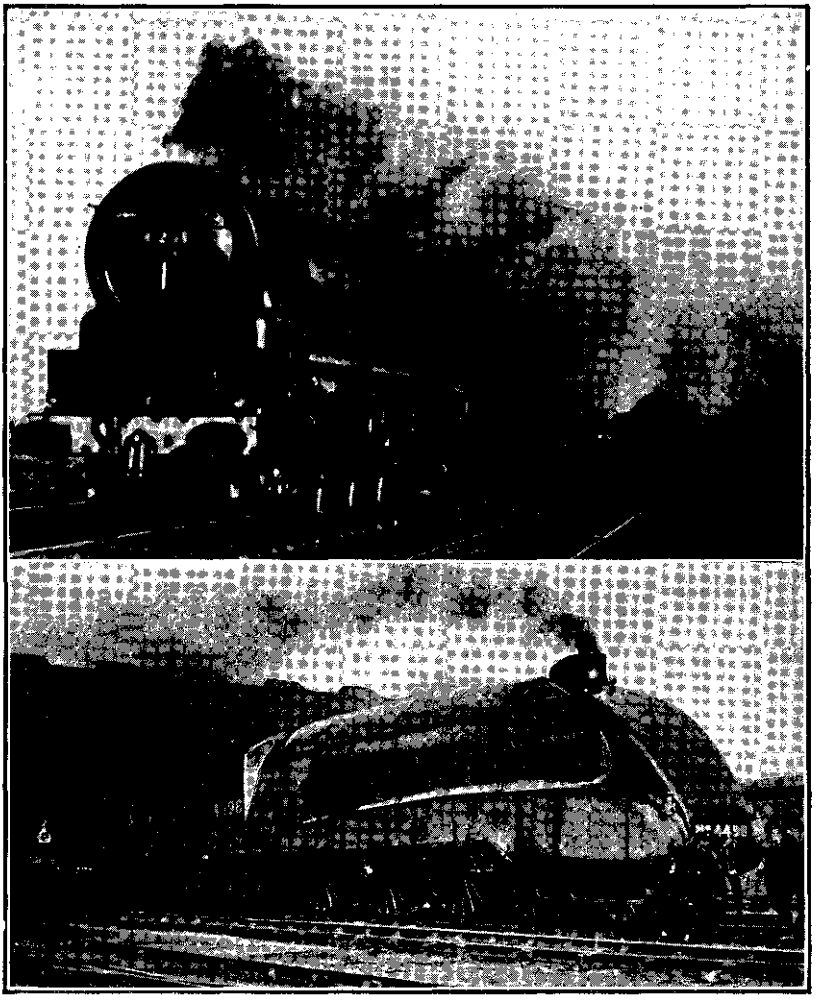


FIG. 8 (*Top Photo*). FIG. 9 (*Bottom Photo*).

powdered chalk upwards through the chimney of the model engine.

By far the most effective smoke deflecting device that has been noted by the author is the wedge-shaped semi-streamlined front of the Pacific engines introduced on to the London and North Eastern Railway by the late Sir Nigel Gresley in 1935 (fig. 9). This shape, while not streamlined in its truest sense, does act most

effectively as an aerodynamic screen, and many runs under extremely inclement and unpleasant weather conditions can be recalled in which the effect of it was to throw the exhaust steam well clear of the cab. A particularly important detail in this form of screening is the slight break in the line of the boiler immediately behind the chimney ; as originally designed the arrangement was not entirely satisfactory, but this small amendment appeared to make all the difference. The handicap of steam beating down needs no emphasis ; the author can recall occasions on locomotives that have not been fitted with deflector screens when the driver's view has been so obscured that steam has to be shut off on the approach to each distant signal in order to see them at all, and the effect on time-keeping in such conditions can well be imagined.

On locomotives with the modern deflecting plates, obscuring of the view to a limited extent occurs when there is a small amount of steam leaking from cylinders and glands. In cold weather in particular there is often a thin mist of steam rising, and this appears to cling to the side of the deflector plates. Although the deflector plates themselves are acting effectively in throwing exhaust steam from the chimney clear of the cab, they provide a point of obstruction of the view in this other way. At such times the only really clear view ahead is through the very narrow opening between the deflector plate and the smokebox of the locomotive. On a recent trip with a locomotive so fitted, on a very cold day, the thought arose that in such circumstances a better view ahead might be obtained by mounting the deflector plates further from the boiler at the bottom and flaring them towards the boiler at the top, thus giving a relatively wide opening of clear vision between the plate and the smokebox. In this connection it is worth noting that deflector plates on many continental locomotives seem to be placed much further out than is customary in this country.

Obscuring of the view by the exhausts from other trains is a hindrance that must be accepted as an accompaniment to everyday working ; surprisingly enough it is a hindrance that may not be entirely eliminated with the elimination of steam. The author recalls a recent case when running with a high speed express passenger train on a four track section on which his train was running on the third track from the left. On entering a long deep cutting it was seen that a train running on the furthest track on the left

was gradually being overhauled. The relative speeds were about 55 and 65 m.p.h. There was considerable obscuring of the way ahead due to the steam blowing from the slower train, and as the train was approached the view ahead was completely blanketed out. At one moment, steam on the fast train had to be shut off, not because the exhaust from its own engine was obscuring the view, but on account of the steam drifting from the other train. The driver was aware of a distant signal ahead—a semaphore—and shut off steam in case, when he did sight it, that signal might be in the caution position. When the fast train eventually drew level with the locomotive of the slower one, that locomotive was found to be a diesel electric ; the steam that had been obscuring the view came from the heating system of the train.

Falling snow, or blizzard conditions can seriously affect the visibility of the line as seen from the cab, especially if, in very severe conditions, ice begins to pack up against the cab glasses. But the aftermath of a blizzard has been known to leave the windward side of semaphore arms with a coating of frozen snow, so that these arms were camouflaged into a condition of obscurity against a snow covered landscape.

Fog can affect the observation of signals in a number of ways. In a thick white country mist, provided the scheduled speed is not too high it is normally possible to pick out the distant signals, with the added assurance that in the event of a " caution " the fogman will have a detonator on the line. In like conditions modern colour light signals illuminate the mist, and the signal itself is preceded by a shaft of coloured fog. In dense "smog " that forms in cities and their environs the observation of signals is usually very trying. With colour light signals the fog is slightly illuminated, but in the event of a caution signal there is nothing for it, but to reduce speed to a crawl and feel one's way forward to the next signal. The author has been on the footplate in conditions such as this, in weather so thick that colour light signals were not sighted until they were level with the smokebox of the engine, and when at the terminus station there was a man with a brazier standing to mark the position of the buffer stops ; although of course, the presence of a fogman is of considerable help to a driver in conditions of bad visibility, it is still the driver's responsibility to observe the actual signals.

In such conditions of visibility the intermittent warning type of audible cab signal, such as that installed on the Western Region,

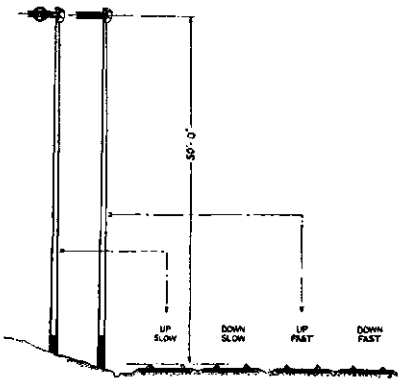
could be of little help once an adverse distant signal had been passed ; this system gives no indication of the aspects displayed by the home and starting signals. Little short of continuously controlled cab signalling would meet exceptional and rare cases such as this. Again even with continuous cab signalling, or any form of audible signalling, whether intermittent or continuous, the indications provided are an addition to, and not a substitute for the wayside signals.

**Presentation of the Signals**

(*a*) *Semaphores* (figs. 10 and 11)

In all considerations of signal sighting, and particularly with trains required to run at high speed it must be borne in mind that

FIG. 10.



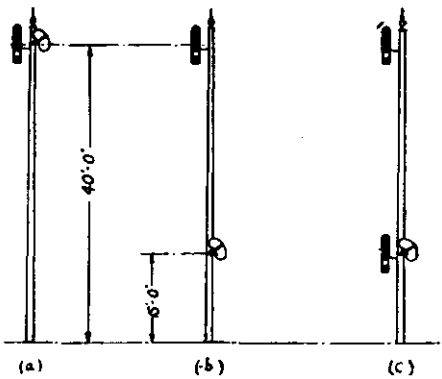




FIG. 11.

engine crews endeavour to get the earliest possible sighting of distant signals. Although full braking distance is available between the distant and the first stop signal, in the case of a "caution" drivers aim at having brakes on and the train well under control when the distant signal is passed. If this is done, a relatively light application of the brakes will suffice, and a harsh deceleration can be avoided. The importance of long sighting of distant signals was well appreciated in past years, and two railways in particular, the London and North Western, and the Great Northern set their semaphores on very tall masts so as to ensure a "sky background." The Great Northern combined with this the distinctive "somersault," or centre balanced type of arm, and had various arrangements of the lamps for night indications, sometimes with additional co-acting arms at a normal height above rail level. Even with such care taken to give good sighting there are times of the day when drivers find it difficult to get an early sight of the aspect showing from a semaphore signal; summer twilight before the oil lamps have begun to show distinctively, and all those locations where the sun, at certain times of the year, rises immediately behind signals are often troublesome. The author does not however wish to take sides in any remaining controversy there may be on the subject of lower-quadrant *versus* upper quadrant semaphores; both can give excellent indications, and on the many routes where both types are still encountered no driver has expressed to the author any strong preference one way or the other.

On several lines where manual block is still operated over the bulk of the mileage there has been a gradual changeover to colour lights for all isolated distant signal locations. This is a great improvement in itself, but careful attention has been given to individual cases, where long sighting of the signals is obstructed by the piers of bridges or other fixed structures, by the installation of repeaters, in the form of internally illuminated banner signals, at some distance before the actual distant signal location is reached.

Prior to the grouping of the railways in 1923 most of the old individual companies had long established standards for the position of the driver on the footplate; but on the formation of the "Big Four" groups the two largest found themselves faced with the following situation:—

| Railway | Large Constituent Companies | |
|---|---|---|
| | Using L.H. Drive | Using R.H. Drive |
| L.M.S.R. | 4 | 2* |
| L.N.E.R. | 2 | 4 |

*One in course of changing from R.H. to L.H.

Eventually both these companies, and also the Southern adopted left-hand drive as standard ; but very few existing locomotives have actually been altered, and for many years signal locations that had originally been sited for the driver's position hitherto standard have remained, to be used alike by enginemen handling the older right-hand drive locomotives, and by others working newer machines with left-hand drive. Similar circumstances have developed since nationalisation with the drafting of new left-hand drive engines to the Western Region, where hitherto right-hand drive was standard.

(*b*) *Colour Light Signals*

On straight lengths of line colour light signals have the great advantage of being sighted a long distance away, though on curves the direction in which the main beam is pointed must necessarily be a matter of compromise. In such cases the enginemen's expression " learning the road " has a particular significance, for the road knowledge of drivers and firemen extends to knowing the point at which colour light signals show up to the best advantage on curves. On right-hand curves, with large modern locomotives an experienced fireman makes it his job to get the first sight of a distant signal.

For some years now it has been the practice on the former L.M.S.R. to install the distant signals for the centre roads of a four-track system, as ground signals low down in the six-foot. In weather conditions causing smoke and steam to drive across the tracks this certainly makes them more readily visible than when mounted at driver's eye level, or higher, though such a practice would not appear suitable with right-hand drive engines. The latter were never very numerous on the former London, Midland and Scottish Railway, and today they are scarcely to be seen at all in fast main-line traffic on the L.M. Region.

(*c*) *Junction Signals* (fig. 12)

With semaphores, where fast running takes place the junction home signals must necessarily be of the " splitting " configuration, with differing heights of dolls to indicate the relative importance of the diverging routes. With colour light signals the use of a separate unit for each diverging route is undesirable, and the author would preface some comments on present day practice by recalling some footplate experiences of more than 20 years ago on a fast running main line equipped throughout with colour light signals. As originally installed splitting aspects were provided for all junction movements, including divergencies to branch and connecting lines, and for cross-over movements from main to relief, and relief to main lines ; consequently many of the signal locations had colour light signals of the searchlight type mounted with their lens units between 2-ft. 6-in. and 3-ft. 6in. apart. In some cases groups of three were mounted on the same mast. This particular stretch of line is exceptionally straight, and very long sighting of some of the signal locations was possible. The close proximity of the aspects gave rise, at extreme sighting range, to intermingling of the light beams, and where a green and red were displayed adjacent to one another the result was an indistinct white

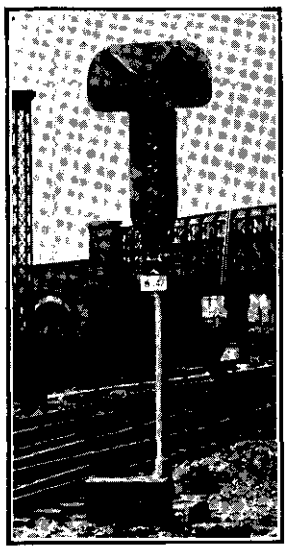


FIG. 12.

haze, due to the optical mixing of red and green light. On clear nights this gave a somewhat confused outlook from the engine cab, though the sighting was so long that the aspects were resolved at some little distance before the locomotive came to the signals. Conditions were not made any easier in the early days of that installation due to the fact that the majority of the locomotives running over that line had right-hand drive ; so far as the cab look-out is concerned the adoption of left-hand drive as standard has gradually reduced the number of right-hand drive engines running over that route, and those that are still engaged in express passenger train traffic are being converted from right to left-hand as they are going through the shops for general overhaul.

The instance quoted is perhaps exceptional, in view of the very long sighting of the signals that is obtained on that stretch. It is however, probably true to say that operating experience on that line hastened the development of the illuminated direction indicator, that obviated the need for " splitting " colour light signals and gave all the indication necessary to a driver by the use of only one colour light signal. The illuminated direction indicator, sometimes referred to as the " position light junction indicator " is now being adopted generally for the signalling of junctions and turn-outs other than those in the immediate approach to terminal stations, and large intermediate or junction stations ; in the latter cases it is necessary to give some visual indication of the route or platform into which a train is being sent, whereas at running locations it is rarely necessary to indicate more than three, or at the most, four alternative routes. After the initial experiments with this type of indicator, in which a red neon tube was used instead of the present strip of white lights, no indication at all from the direction indicator is given for the straight route ; a direction indication is only illuminated for routes involving a diversion from the main line. Although this modern form of route indicator is intended to indicate nothing more than direction, it is normal practice to display restricted aspects in the signals preceding it to give additional warning to the driver that a speed reduction is necessary for the turn-out. The accompanying illustrations show something of the development of route indicators for slow and fast running locations.

An alternative to the single colour light signal and direction indicator was put forward rather more than 20 years ago in

the system of speed signals of which an example was installed on the L.M.S. Railway at Mirfield. In this system the colour light aspects were displayed vertical instead of horizontally as in the system of splitting signals, and the position of the green, or the restricted proceed aspect provided an indication as to whether a train was taking the straight road or making a diverging movement. This installation has been in service for many years and the author has had an opportunity of observing it under various conditions. On the most recent, conditions of visibility for fast running were unfavourable. Fog hung over the whole country east of the Pennines to York and beyond. The visibility varied from 100 to 500 yards and while this was not serious enough to prevent the keeping of scheduled times on passenger trains of an intermediate express character, looking out for the distant signals called for the greatest vigilance when running at 45 to 55 m.p.h. In these rather depressing conditions Mirfield was approached, and the immediate impression was not of speed aspects, as distinct from geographical or other direction indications, but relief that the signals *were* colour lights and were so much more readily visible in this white mist.

**Signals as an Aid to Running**

The importance of long sighting of the distant signal has already been emphasised, and the various instances in which signals are likely to be obscured have already been discussed; but there are many cases one could note where, due to physical or other circumstances, the distant signals can be sighted from much shorter distance than is really desirable for running the traffic. On fast trains, drivers will run hard when they know for certain the state of the line ahead; but on the other hand, there is a definite reluctance to run where there are short sighted distant signals. This disadvantage is not confined to semaphore territory, and there are difficult locations where certain signals of a colour light configuration are not immediately in view when the first units are sighted. The Author has seen colour light splitting distant signals, of which only the right-hand one is seen at first, and the left-hand is obscured by the pier of a bridge; a driver approaching, and seeing the single yellow light might for a moment be misled into thinking he had a " caution," until the second unit of the group is seen round the pier of the bridge, maybe showing green for the left-hand fork at the junction ahead. This is a case

where road knowledge is a vital necessity if unnecessarily slow running is to be avoided. Sighting of distant signals is, of course, closely bound up with the speed of traffic and the available brake power on the trains ; and in a previous paper to a joint meeting of this Institution and the Institution of Locomotive Engineers the author analysed some of the factors that are concerned in the proper co-relation of brake power to signal spacing.

The tendency to accelerate all main line express passenger train services, together with the tendency to run trains of shorter coach formation does underline the importance of adequate sighting of the distant signal. With steam locomotives, the lighter the train, the less effective the brake force that can be applied to the whole. With relatively light trains, the weight of the locomotive is large in relation to that of the coaches, and as it is not the practice nowadays to brake the bogie and other carrying wheels the locomotive is braked to a less extent than the rest of the train. A diagram that was included in the author's previous paper on signalling in relation to brake power is worth including again, as it shows the difference in stopping distances recorded on the former Great Western Railway with a locomotive of the

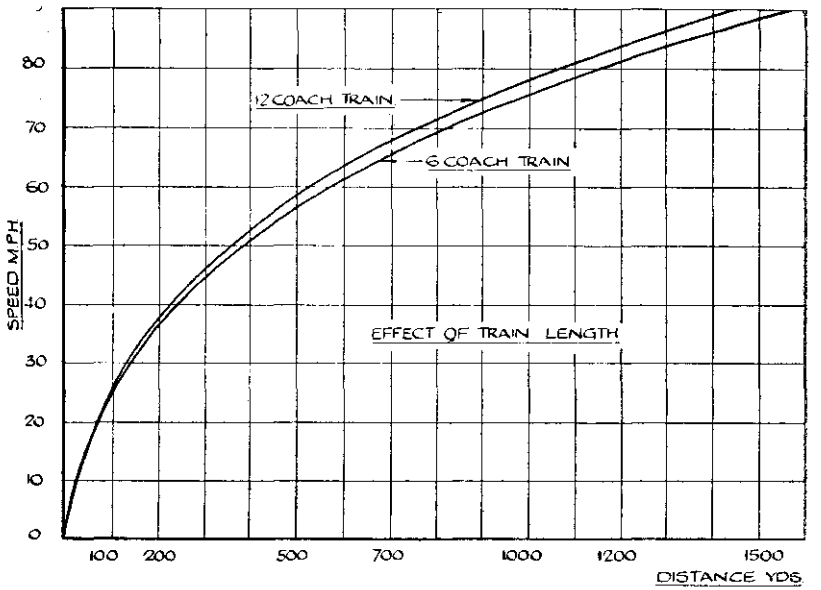



FIG. 13.

" Castle " class, weighing with its tender, 126 tons, and trains of 6 and 12 coaches respectively (fig. 13).

In the author's experience, stretches of continuous multi-aspect colour light signals with the signal location at approximately 1,000 yards apart are as near ideal as possible in the running of fast traffic. The use of the double-yellow indication gives an excellent preliminary warning, and on many occasions a train has been able to run at speeds of 55 to 60 m.p.h. very close behind a preceding train, due to the driver judging his speed so that each signal cleared from single-yellow to double-yellow at his near approach. At certain junction and large traffic centres where the alignment of the through roads permits of the continuance of a high rate of speed, it is not possible to space the signals at adequate intervals to provide for full braking distances. Connections to sidings, loops, platforms and suchlike occur more frequently, and then it is arranged for a series of restricted aspects to be shown in the event of a signal ahead displaying the red. Instead of the usual lead-up—" double-yellow," " single-yellow," and then " red," there may be two double-yellows in succession, and then two single-yellows, so as to preserve the normal distance from the first double-yellow to the red, and provide full braking distance for a train that would pass through the junction at a speed in excess of 80 m.p.h. The driver can therefore approach such a junction in full confidence, knowing that if any of the colour light signals is displaying red, he will have ample warning through this series of restricted aspects.

**Signal Delays**

One approaches the subject of signal delays, which are unhappily all too frequent in the running of traffic today, with some hesitancy, in full appreciation of the heavy occupation of the line and the difficulty, with present manual signalling apparatus, of a signalman being aware of exactly how near a train of the priority class may be. The author would for one moment, put what is purely an engineman's point of view. In many cases the immediate cause of delay can be clearly seen from the footplate, as when heavy express passenger trains working to fast schedules are checked or stopped in order to let slower and lighter trains cross their paths, or when shunting movements or light engines are the obvious cause of trouble. One appreciates that it is not possible for enginemen to see the railway operating

" picture " in the particular district as a whole, and for the benefit of that " whole " it might in certain special circumstances be best for a fast train to be delayed, since the holding up of a local movement might lead to serious congestion in the area. On the other hand, the running of fast services chiefly for the benefit of the business community has a publicity and a prestige value which railways, at the present time, are in considerable need, and the frequency of delay to such trains has, within the author's own experience, been a cause of discouragement, to say nothing else, to enginemen who are doing their best.

It is very difficult to find reasons to justify a case such as the following, which occured to an important business express booked at an average speed of over 65 m.p.h. for a run of approximately 100 miles. Due to temporary speed restrictions for engineering work some time had been lost in the early stages of the run ; but by hard work on the footplate the loss had been made up and the train was approaching an important intermediate centre on time. Immediately before the approach of that express a long and very slow goods train was allowed to take the main line, to pass right through the central area of this large railway keypoint, and to proceed for two miles further down the main line to a refuge loop ; its progress was very slow and the delay experienced by the fast train eventually amounted to no less than 17 minutes. What steps the signalman took to ascertain the position of the express one would not like to say, or whether any special instructions were given to him for the progressing of that goods train ; but the delay as seen through the eyes of those on the footplate was all the more inexplicable in that, on the route in question, the occupation of the line was relatively light at the time the delay occurred.

**Cab Signalling and A.T.C.**

This paper has, perhaps, served to emphasise unduly the hindrances to signal observation that are accepted as part of the ordinary day-to-day work on the footplate. But to the Author, who has spent so much of his working life designing signals, the difficulties that are sometimes experienced in sighting them naturally left a certain impression. In these circumstances the feeling of security provided on locomotives fitted with audible cab signalling, and automatic train control was no less marked. The widest experience in this respect has been obtained on the

lines of the former Great Western Railway, where the A.T.C. unit is frequently referred to by enginemen as " our little friend in the corner."

The use of the A.T.C. is bound up to a certain extent with questions of footplate psychology. It has been suggested that with audible warning apparatus in the cab the enginemen might tend to place such reliance with it, as to neglect the observance of the wayside signals. In the Author's experience, extending to more than 7,000 miles in the cabs of locomotives fitted with the W.R. type of apparatus, all the enginemen concerned seemed to make a practice of sighting the distant signals the moment they become visible ahead, and certainly not waiting to be "alerted," as it were by the sound of the audible signal, whatever indication it might be. In conditions of an obscured view the men had confidence in running at full speed till the ramp was reached, and the audible signal sounded, and of this one particular case may be specially mentioned. A stretch of line over which the speeds of express passenger trains rules at about 70 to 75 m.p.h. leads through a tunnel over a mile in length. There is a wayside station about a mile from one end, and the distant signal is located about 100 yards outside the tunnel. After the passage of trains the sight of that distant signal is often obscured by smoke in the tunnel, and yet full speed is maintained in such conditions, right up to the A.T.C. ramp, which is about 300 yards *inside* the tunnel.

**Conclusion**

In concluding, the Author must express his indebtedness to the British Transport Commission for the privilege of making many journeys on the footplate, and in particular to Mr. R. F. Harvey, Chief Operating and Motive Power Officer; to his colleagues in the Westinghouse Brake & Signal Co., and to the various photographers who have put at his disposal the pictures from which the lantern slides were made.

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DISCUSSION

**Mr. J. H. Fraser** in opening the discussion, said that the author had delivered a most valuable paper which placed great problems before the signal engineer and the locomotive designer.

He was in full agreement with the author's opinion on colour-light signals, which could be described as the signal of the future, with

particular reference to multi-aspects, as there was much to suggest that the advantage increased with the number of aspects. The author had said that in certain special cases it was necessary to repeat some of the warning aspects, for example, owing to shortening distance between signals, to repeat the double yellow and to repeat the single yellow. Although that had worked reasonably well, it was not a sound principle. In the static position, there was a signal at red, two signals at single yellow because the distance was short, and two signals at double yellow, and the driver had full warning and ample braking distance. Very often, however, it did not happen that way. A driver would be running at high speed and a train ahead would be running at equal speed, so they would receive one after another, the same indications. Under those conditions the driver might not know which of the two double yellows he was running to, and if he thought he was running to the outer one while he was in fact running to the inner one, he would not have the braking distance he thought he had. It was logical to give sufficient aspects to differentiate every condition. Automatic train control would be very valuable in conjunction with multi-aspect signalling. At the present time, railways were experiencing more and more competition from other means of transport, both road and air, and the one condition in which railways had a clear advantage was thick fog. Signalling systems should be designed with that in mind, and A.T.C. with multi-aspect signalling had great possibilities. If a driver knew that there were six aspects and that the A.T.C. gave an indication for a clear signal and some distinctive form of indication other than clear, trains could be run quite safely at high speeds in bad weather.

He was very interested in the author's remarks as to how some drivers and firemen exchanged words when they saw a signal clear, but on some engines one could not hear what was being said owing to the noise. While riding on the footplate of a locomotive in Switzerland, he noticed that whenever a clear signal was seen, both driver and fireman made a distinctive gesture with their right hand, which was a very good practice.

He had seen many French drivers wearing goggles and invited the author's opinion as to their value. It had never, apparently, been the custom to wear goggles on British railways.

**Mr. W. J. Sadler** referred to the high signals on the former London and North Western, and explained that the fundamental

reason for them was that the L.N.W. were among the last of the railway companies in Britain to adopt a reliable continuous brake. The chain brake then used had to be applied by the guard, the driver blew the whistle and the guard pulled the brakes. The same practice applied on the North London Railway, and there were signals at Dalston Junction 80-ft. high. Very high signals were a real problem in fog and they had to provide lower repeating arms to make sure that fog signalmen had a good indication of what the 80-ft. high arms were showing.

Reference was made in the paper to colour-light distant signals in the 6-ft. way, on the L.M. Region. These were prone to be affected or knocked down by wagon sheets which had become displaced on freight trains, and there was a case on record where a signal had been knocked over backwards and the wires between it and the signal box remained intact. The signalman noticed that trains were slowing down when approaching the box, but did not know the reason until a driver stopped and reported that the distant signal was missing. Mischievous children had often been known to throw brickbats at such signals and lenses had been broken on many occasions. The signals were particularly affected by dirt and ballast thrown up by trains, and it had been arranged for the ganger to clean the lenses of the signals as part of his maintenance duties.

With regard to splitting colour-light signals, it was very surprising that it had not been foreseen that a cluster of signals on a long straight length of line would tend to merge and cause confusion to drivers. There was the same problem with regard to isolated splitting distant signals. On some portions of the L.M.R., the Operating Department insisted on splitting distant signals for working heavy coal trains. It had been found that if the splitting indication was lost, there was a serious repercussion on traffic working, on account of long, slow coal trains crossing over a junction. The effect of running coal trains was very serious when crossing to slow lines, and they insisted on some form of splitting signal. The problem then arose as to what was the most desirable form of signal to provide. Retaining the splitting signal gave the problem that the author referred to on long, straight lines, that is, two signal aspects merging and causing confusion. This seemed to raise the whole question of the principle besides the design. He did not suggest that the optical system and physical construction of the signals were not designed with full consideration,

but there was the human aspect, the study of the reaction of human beings under certain circumstances. It was a question of method study and work study and it was very important to design equipment with reference to the psychological behaviour of the men who were going to work with it.

Concerning the experiences on the footplate with drivers and firemen who called out that the starting signal was clear or at caution, as mentioned by Mr. Fraser ; the motive power inspector was usually instructed by his superintendent that the driver sitting in his chair must have a satisfactory view of the signals, the principle that a driver could receive information from the fireman, was not acceptable and the driver must see the signals himself. For this reason, banner repeaters and different devices to improve the driver's view had been provided.

Another point with regard to colour-light signals, particularly isolated distants, was the effect of the shaft or glow or halo that came from it. In certain parts of the L.M.R., the driver, as he approached at night-time, could see in the sky a halo or glow from the signal, and he had heard the motive power inspector tell drivers that if they reckoned they could see a yellow light in the sky two or three miles away, to take their time. Approach lighting kept the signals out until the train reached a suitable distance to give the driver time to take the necessary action.

The hesitancy to adopt A.T.C. in the past had been due to a large extent to the motive power officials who were adverse to drivers being interfered with in their observance of signals.

**Mr. E. V. M. Powell** said there were two points in the paper, which had not been emphasised adequately. The first point concerned the background behind semaphore signals in daylight. In certain lights the red of a signal arm does not show up well against a dark green background and is almost invisible. The white band across the arm only serves to cut off the red end of the arm, and a distance gives no indication of the angle of the arm. This is particularly so in the case of lattice posts. Twenty-six years ago he tried to get this condition altered in Burma, where the system of signalling involved meeting a dead stop signal, the " outer," as the first signal of a station. He made several scale model signals, which were tried at scale distances against various backgrounds, and the most successful was one with a horizontal white stripe running the length of the arm. It was found by experiment that if the white stripe was more than

one quarter the width of the arm the latter completely disappeared when sighted against a sky or other white background, so powerful was the effect of the white. Against any dark background the white stripe showed up the angle of the arm most distinctly. He had, no doubt that a semaphore signal is most easily visible against a sky background, and the old L. & N.W.R. 80-ft. masts were placed so that the semaphore could be sighted against the sky, and were clearly visible at great distances.

The second point concerned night sighting. Some forceful protest ought to be made to civil authorities about street lights or signs having either blue-green or amber lights, which, in not a few cases, are a background to signals at night. It should be possible to replace those in the immediate background of railway signals by fluorescent tubes or other lamps, which could not be confused with signal lights, and even then they should be shielded from the direction from which signals are sighted. There has been some criticism of the practice of giving two consecutive double-yellow, or single-yellow indications where signals follow each other at less than minimum braking distance, but as this practically only occurs through big stations and junctions an additional flashing green light on the outermost distant signal might indicate when the road was clear right through to the advanced starter.

Mr. Powell agreed with the provision of splitting distants for diverging routes, but would make the green aspect of the diverging distant track-circuit-operated only when the train had got within 50 yards of it, to ensure that the driver had taken sufficient notice of it, and reduced speed for the turn-out. He did not advocate splitting distants for cross-overs from fast to slow roads, which are usually much sharper than normal running junctions, and require that trains should be brought under more severe control.

Comment had been made that drivers spend much time looking out of the side of the cab. A contributory reason for this is that in so many engines the driver cannot see through the cab window when sitting on his seat without straining his neck upwards. It is easier to look out of the side. Cab windows should be continued sufficiently low to enable a short driver to see the track just ahead of the engine without strain while sitting on his seat.

**Mr. R. C. Bond** said that, as a locomotive man, he wished to pay a tribute to the signal engineers for all they were doing and had been doing for many years to make the driver's job a little easier, and he was quite sure that any money spent on that work would be very well repaid. He had in mind the way in which signals on the main lines that he knew best, namely, the London Midland Region were, as far as possible placed over the road to which they referred. A lot of money must have been spent in putting up bracket signals in place of a straight post to give the driver that little extra help. The days when one had very high signals to the extreme left of a four-track line, frequently without co-acting arms, must have been very trying in foggy weather. A previous speaker's remarks about the 80-ft. signals at Dalston Junction had interested him very much. He was also interested to hear Mr. Fraser speak about the repetition of double yellows and single yellows. If difficult stretches of line were signalled in that way a great deal of the advantage of multi-aspect signalling might be lost because the driver might not know where he was expected to stop. He believed that at Mirfield there were already five signals with the fifth aspect of yellow above green, and from the footplate point of view this is exactly what is needed in difficult areas as the driver could travel in confidence, knowing precisely where he was meant to stop at the time he passed the outermost warning signal. The author had referred to the development of the junction indicator. In most conditions nothing was more clear to the man on the footplate than the position-light junction indicator, but there were circumstances where the splitting distant in multi-aspect colour light territory was still worth while. He had in mind places like Rugby No. 7 in the down direction, Rugby No. 1 in the up, and Camden No. 2, where the driver did want some indication before he got to the junction itself that the road was correctly set. He referred to signals normally showing a red aspect which, when cleared, displayed a green on the left or right of a yellow, thus clearly telling the driver how the road at the junction is set. Locomotive designers were very conscious of the need to give the driver the best possible view and detailed steps were taken in the making of cab mock-ups before going into production, but with large-boilered locomotives the view could not always be as good as perhaps in the old days. Regarding the photograph which the author had shown of the exhaust clinging to the top of the smokebox in front of the chimney. One

very often saw this with very short chimneys and he had ridden many miles on the particular class of locomotive shown in the photograph both before and after the smokebox deflector plates were fitted. There was no question that the plates were most effective in lifting the exhaust under all conditions sufficiently to prevent the view through the front cab windows being obscured. The same remedy had been effective with the Franco-Crosti locomotives. Ten of these locomotives were now running on the L.M. Region with the chimney half-way along the right-hand side of the boiler. As was to be expected, steam and smoke exhausting quite near the cab caused some inconvenience due to beating down over the windows. A smoke deflector plate placed alongside the chimney had once again provided a completely effective remedy.

There was one improvement he asked the signal engineers to consider; where there was an outer home signal between a splitting distant and the junction home signals, could the outer home also repeat the junction indication? Bourne End, on the L.M.R. main line, was an example of what he had in mind. It would help a great deal in those cases if the outer home signal gave the same message as that conveyed by the distant and junction home signals. He thought that there was often today an insufficient difference in height between the main line signal and that for the diverging route. An appreciable difference in height emphasised the fact of diversion, a point of importance to be borne in mind.

He hoped that joint meetings between the signal engineers and the locomotive engineers would be repeated as it was of great value to discuss everyday railway experience with colleagues in other departments.

**Mr. T. Austin** said that the author had made reference to the obscuring of signals and the difficulty of drivers in picking them up. In this connection he spoke of the practice on the Continent of using inclined indicator boards which seemed to be a very simple and effective way of indicating the approaching distance to a signal. The boards were inclined and striped, being numbered 300 metres, 200 metres and 100 metres and even to one riding in the train and not looking for them, they seemed to leap to one's notice. He thought that such a simple device might be used to advantage in Great Britain.

**Mr. J. P. Maitland** recalled that in 1910 he had paid a visit to the locomotive sheds at Luxemburg, and had found in the foreman there a person who was interested not only in locomotives but in signalling. That foreman had made a remark which had greatly impressed him, namely, that there were two aims to be obtained in signalling, the speed idea and the safety idea. Mr. Nock's paper had brought out those two ideas very ably, but there was still a great deal that needed to be done to reconcile them.

There was, of course, a great difference between considering the matter at a meeting such as the present one and dealing with the problem on the spot. He felt sure that the author would agree with him that any time spent on signal siting was well worth its cost. The determination of the mean between the two ideas which he had mentioned could only be realised by collaboration between the locomotive inspectors and the signal department on the spot and in each case, accepting as a basis the theory which the author had put forward in his paper.

There was one question on which he would like to have the author's views. He referred to restrictive approaches to splitting junction signals. There seemed to be a tendency to revert to the practice which had come in at the beginning of the present century and to give a caution aspect in the event of the subsidiary road being clear at the junction. That in itself was the cause of a great amount of reduction of speed. It had also been the cause of unnecessary coal consumption, and he indeed sympathised with their friends on the London Midland Region in insisting that some facility of that description was provided. There was another sidelight to that, namely, distant signals from branch lines at junctions which could not be worked. That again caused reductions of speed and a general hold-up of the traffic which to his mind was entirely unnecessary. He would like to have the author's views on the practice, which seemed to be on the increase, of providing one yellow aspect for the diverging lines at junctions. He thought that something could be done to make an improvement in that respect.

**Mr. F. B. Egginton,** commenting on Mr. Austin's proposal to use the Dutch " baak " as a warning to drivers of the proximity of a distant signal, pointed out that an example was installed at Mexborough as long ago as 1931. More recently, the Belgian system with vertical boards with black stripes 4, 3, 2, 1 at 400, 300, 200 and 100 metres on the approach side of a distant signal

was experimented with at Newark. Both suffered from the defect that they were not readily visible after dark owing to the absence of powerful engine headlights.

The desirability of splitting distants as asked for by a previous speaker is a question which has exercised thought for many years. In the early twenties a mishap took place due to the extinguishing of the light in the main line signal, leaving a single green light in the diverging signal. This was mistaken by a driver as a maximum speed signal with disastrous results. As a consequence, the Ministry of Transport formulated a requirement which still holds good, that splitting distants should not be provided unless there is some very good special reason for their justification. The single distant must be cleared for the maximum speed route only.

There were many places where the Operating Department insisted upon splitting distants due to local physical reasons, but generally they were avoided as far as possible.

The same considerations apply in colour light signalling, it being the normal practice to maintain at yellow the signal preceding a junction indicator signal set for a turnout movement, even though the latter displayed a less restrictive aspect.

Regarding the use of banner repeaters for distant signals to increase the braking distance, there was, of course, another method in use on the former L.N.E.R., that was to provide a colour light displaying Y/Y or G depending upon the position of the semaphore distant arm. The colour light was located sufficiently far out to give braking distance for the highest speed trains while the former distant signal was adequate for medium and low speed trains.

With the present day increase in general speeds the tendency is to get rid of the old semaphore distant and leave the colour light, but displaying Y or G only, to act as the normal distant for all types of trains.

**Mr. T. Austin**, referring to the suggestion that the Baak signals would be useless in Great Britain at night, said that during the war when there were no lights, white stripes were painted round trees and lamp posts. He thought that it would be most unlikely not to pick up the Baak signals at night. Reflective paints were available in which glass beads were embedded; the signals were easy to clean and he felt that the efforts to make these signals effective in Great Britain had been feeble.

**Mr. D. R. Carling** asked what was the author's opinion as to the value of flashing lights for signal indications ? These had been used for many years in Scandinavia and he believed their use was increasing elsewhere in Europe. Flashing lights could be used alone or in conjunction with steady lights to give additional signal indications when multiple indications were required. They might be particularly helpful where there was confusion due to background lighting as in some urban situations.

**Mr. O. S. Nock** in reply, said that he had listened to the discussion with great interest. It brought out clearly the slightly different approach to signal layout that is perhaps inevitable from the signal and locomotive departments on a railway. Whereas signal engineers in general were striving to produce a clear, logical, and consistent system of signal aspects, tending to simplify wherever they could, the locomotive department were anxious to have the most comprehensive indication of the state of the road ahead at every point. Signal engineers felt that at times things were getting too complicated, and that arrangements designed for some special layout were apt to confuse drivers when they met something different somewhere else. Locomotive men felt that to drivers who know their road—and road knowledge is an essential feature in the running of all classes of traffic—the question of complication does not arise ; they know what the various configurations mean, and their strongest plea is that they should be able to see the signals.

In the discussion, one found locomotive men asking for more indications in the approach to a diverging junction. Mr. Bond asked for something more than a single semaphore or its equivalent at the outer home, while Mr. Maitland spoke of the difficulties arising where only one distant signal is provided in the approach to a diverging junction, and where fixed distants are used where a branch line is approaching a converging junction with a major route. The Author would not venture an opinion as to the ultimate solution in cases of that kind, as the problem has been discussed at great length in the past in the proceedings of the Institution of Railway Signal Engineers, on the railways, and among contractors' staff. He appreciated both points of view.

He had been interested to hear both Mr. Fraser and Mr. Bond asking for what amounted to more aspects—a 5th and possibly even a 6th. While the question of complication would undoubtedly arise, additional aspects would avoid the illogical sequence

arising from the present extension of restrictive aspects, where one might have, as at Darlington, two double yellows in succession, and then two single yellows.

The question of the sighting of signals figured largely in the discussion, and he felt that this was a major point. Mr. Sadler had criticised the use of very tall signals on the former L.N.W.R. and while it is probably true that the origin of the very tall signals came in the days of the Clark and Webb Chain brake, the L.N.W.R. was completely equipped with the automatic vacuum brake by the " nineties " of last century, and one feels that if brake troubles were the sole reason for the tall signals, some attempt would have been made to do something different in the 30 odd years that remained between them and the grouping of the railways in 1923. On the other hand, there is no question that the tall signals were very much appreciated by the locomotive men of the L.N.W.R., as they were also on the Great Northern, particularly in the latter case when used in conjunction with the somersault type of signal.

Mr. Powell raised the very important question of the strong lighting, advertising, neon signs, and so forth that often form a most disconcerting background to railway signals at night. In certain cases it would certainly seem that some serious consultation with local authorities is desirable. In this connection the Author recalls that many years ago, when his firm was signalling a private railway adjacent to the River Thames, their clients were not allowed to use red or green lights in the signals as these aspects might cause confusion to shipping on the river and be mistaken for navigation lights. How much more important it is that street lighting, advertising, and so on, should not confuse and distract from the observation of signals on a railway.

With regard to the look-out ahead from the cab of locomotives the Author would pay tribute to the very careful and painstaking work that has been done since Nationalisation to improve the look-out ahead; the construction of full-sized mock-ups of engine cab layouts, and discussions of these with drivers before locomotives have actually been built is undoubtedly a step in the right direction.

Mr. Carling had raised an interesting point about the possible use of flashing lights instead of a steady light. Such a light does, of course, provide a most arresting indication and many years ago one of the old pre-grouping companies had experimented with

flashing lights for illuminating distant signals at night. At that time red was the colour for the night indication of a distant signal in the warning position, and on the majority of railways there was no distinguishing mark for a driver to tell whether it was a distant or a stop signal he was approaching. He had to rely entirely on road knowledge. In pre-grouping days the Furness Railway used a flashing red for its distant signals. They were lighted by acetylene gas and the flashing indication was controlled in the same way as that of a navigational buoy.

It is certainly true that the distance from the distant signal to the home signal should be sufficient for any train to stop when running at permissible speed if the brake is applied at the distant signal; but drivers try to avoid an emergency application, or even a full application wherever possible, and in this connection the sighting distance is most important when running high speed trains.

**Mr. E. G. Brentnall** moved a very cordial vote of thanks to Mr. Nock for his excellent paper, which was carried with acclamation.

**Mr. Vidal** (President-Elect, Institution of Locomotive Engineers), thanked the Council for arranging such a useful and enjoyable joint meeting. He thanked Mr. Brentnall for his chairmanship, and Mr. Nock for presenting such a valuable paper of mutual interest to both Institutions.