Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Thursday, October 16th, 1952

The President (Mr. T. S. LASCELLES) in the chair

Opening the proceedings the **President** said he was sure those present would wish him to express the deep regret they all felt at the calamitous accident that had occurred at Harrow and Wealdstone Station on October 8th and their sympathy with those who had suffered in it, as well as with their railway colleagues concerned in the matter. No member of the Institution had lost his life in the accident but many, including Mr. S. Williams, the immediate Past President, had been in the train which was run into and had had remarkable escapes, on which he congratulated them.

The accident was the second worst ever known on the railways of the United Kingdom, being exceeded only by the troop train disaster at Gretna in 1915. They had this in common, that a double-headed express was approaching on the adjoining line and dashed into the wreckage. Members would feel keenly over the tragedy, all their work being devoted to preventing such happenings from taking place.

After the minutes of the Annual General Meeting, held on April 2nd, 1952, had been read and confirmed, the **President** welcomed Mr. H. F. Dennison, Eastern Bengal Railway, Pakistan, present for the first time since arriving on leave.

The **President** said his next duty was the pleasant one of introducing their distinguished speaker, Mr. J. H. Verstegen, who retired not long ago after some forty years in the service of the Netherlands Railways, occupying at the last the position of Chief Signal Engineer, in succession to Mr. Van Aalderen who disappeared during the war and, he grieved to have to say, never was heard of again. Mr. Verstegen whose acquaintance some of them had made when the Institution visited the Netherlands in 1929, had been particularly connected with the introduction of automatic signalling, using power operated semaphores, in 1912 and later colour-light signalling. After the very troubled times of

the war, when so much apparatus was destroyed, he had the heavy task of restoring and rehabilitating the equipment and had taken the opportunity that offered to develop his own ideas on signal aspects, which had been applied with much success. He was going to explain them to the meeting that evening.

Mr. J. H. Verstegen said he knew he spoke for all his colleagues on the Netherlands Railways when he expressed his great sympathy with them all over the accident. They knew that in spite of all the care that was taken a dark day would come to them sometimes. On this occasion it was all the darker because there had unfortunately occurred what they always feared so much in an accident, a third train running into the wreckage.

He felt it a great honour, and a pleasure too, to be invited by the President to read a paper before the Institution, which included the signalling experts of the British Empire. An outstanding feature of it was that it was so much interested in the practice of foreign countries, an interest prominently represented by the President, whom he had known for many years.

Continuing, Mr. Verstegen explained the position the railways were in, following the war damage, and the preparations made to get new equipment from America, which had supplied the original automatic installations. Arrangements were made later to begin manufacturing such apparatus in the Netherlands, where mechanical equipment had been made for many years at the Alkmaar works. After reading the paper, given below, Mr. Verstegen showed a number of slides dealing with the points covered by it and a number of other items of interest.

Modern Signal Aspects on the Netherlands Railways

By J. H. VERSTEGEN (Member)

Diagrams—Inset Sheets Nos. 14-15

Introduction

In the autumn of 1944-45, when the Netherlands Railways were on strike on Allied orders, it became clear after the battle of Arnhem was lost, that a very bad time was to be expected.

That winter we realised that we had to expect a very badly damaged railway system and we set to work to try to organise

what was possible for building it up again speedily, as soon as the longed for liberation should become a fact.

This was the moment to plan *how* to do so and, as to my job, *how* I should figure out the future of the signalling.

Now the existing system was very satisfactory, although there were of course some features in it that could be improved.

One of the most important questions was : is it desirable to change over from arm signals to light signals ? With the speedy electrification before the war (with overhead wires) we had managed, although with some difficulties, to change and replace arm signals in such a way that the results gave a sufficient visibility notwithstanding the overhead wires and the masts. There were, however, cases in which this was very difficult, e.g. some home signals at junctions on and between stations. These are of the bracket type (a high and a low arm on separate small posts placed on a bracket).

In some exceptional cases light signals were used as mere translations of the night aspects of the arm signals.

A second important question was the speed indication in the signal aspects at junctions.

Although we had already before the war a maximum speed on the main electrified lines of 78 m.p.h. (125 km.p.h.), our system was still a two-speed indication system. The low bracket arm in the signal aspect indicates a speed of not more than 28 m.p.h. (45 km.p.h.) for the turnout, so all the speeds upward from 28 m.p.h. such as 37, 46½, 56, 65 and 78 must be indicated by the high arm. [In practice this is effected by a marker against the post, on which the (from 125 km.p.h.) reduced speed in figures in km.p.h. is indicated : 60, 75, 90 and 105, and covered by a local running instruction.]

Plans were made not only for repairing the old electrified system, but extending it with the utmost rapidity, aiming at a still higher speed than 80 m.p.h. All these speculations made a third speed indication (as we will see farther on) most desirable, in such a way that the highest signal should always indicate the maximum speed allowed for the line in question, the lowest always not more than 28 m.p.h. and the middle one a medium speed, between 40-60 m.p.h., indicated in figures on a marker.

There was also a third question that was very important. The Dutch solution for automatic signalled level-crossings without barriers was already in great favour. [White (now *green*) flashing

lights normally, *red* double-as-fast-flashing lights with a train approaching (and bells) and *orange* permanent lights in case of failure].

Installation of automatic signalling with light signals on all lines electrified and to be electrified could pay for itself if, together with the other savings, the level-crossings, the barriers of which were controlled by the same men as the manual block-signals, also could be automatically signalled.

After due consideration of these three and other questions, the conclusion was that changing over in principle to light signals was desirable, because of the overhead type of electrification, the greater ease of changing to three-speed indications near junctions and of extending the automatic signalling.

THREE-SPEED SIGNAL ASPECTS

General

In devising signal aspects for three speeds near junctions it would be very difficult, if not impossible, to do this with arm signals on the existing method on brackets : three posts, each with an arm on different heights on a bracket would be needed. Moreover, in the existing system, route as well as speed is indicated by placing the post with the low arm, as required for the turnout, to the right or to the left of the post with the high arm. If there are turnouts to the right and to the left at the same junction, there can be a post with a low arm on each side of the high one. There was nothing to be gained in devising such a system of arm signals in three heights.

But even in devising such a system with light signals the question arose : would it be of advantage to do this in the old manner : signals on posts on a bracket ? The light signals we had before the war near junctions were, as I said above, mere translations of the night aspects of the arm signals. In most countries this was originally the case, as is obvious. Another question is, is it reasonable when building up a new system, to take over the disadvantages inherent in the arm systems ? In a paper, which I read before the Transport Section of the Royal Institution of Netherlands Engineers in 1946, which has been published also in the Monthly Bulletin of the International Railway Congress Association for August, 1948, I gave a table of such light signals (translated arm signals), as used in some countries. I could only

say it was a confusing list and only comprehensible to an expert, taking his mind back in each case to the mechanical type of signals and the history of their development. Especially surprising was it to see everywhere " red " in a " proceed " combination, an accepted evil in combined semaphore aspects to which one had become accustomed, but unnecessary in light signal aspects and therefore not justified. [For this reason already in several countries, for cases where something special was being aimed at (for example for multiple-aspect indications), combined aspect indications for " proceed " had been developed without " red."]

Merely translating the arm signals into light signals gave us moreover some combinations of colours which were unnecessary, costly, and principally, in my opinion, somewhat confusing. Why should one, when *green* is enough, show $\frac{\text{green,}}{\text{green}}$ or when *yellow* is wanted, show $\frac{\text{green}}{\text{yellow}}$ or when *red* is wanted, show $\frac{\text{red}}{\text{yellow}}$ only because the arm signals happen to show these aspects ? These are the aspects in our arm signals where a block or home signal is combined with the distant of the next signal : the arm of the distant in the lower quadrant (yellow) beneath the block or home signal arm horizontal (red) in the normal position. Instead of translating these aspects into light signals it is a simplification to change over to the three-position signal in one height, as used in Great Britain.

Speed Signalling

In regard to the bracket signals, therefore, one of the first questions that arose was : is it necessary to indicate route as well as speed in the signal aspects of the home signal ? As a matter of fact, practice had already given the answer in many countries and in the Netherlands too. A typical instance is the following.

When necessary, our distant signals in rear of junctions are provided with an additional arm and arranged to display three aspects, so as to show whether " proceed " for the direct or for the diverging route is shown at the home signal. In course of time " direct " and " diverging " aspects of the distant signal came to have in practice so much the signification in the first place of " high " and " low " speed, that we started to use this

distant signal with three aspects also in cases where there was no question of a junction, only to be able to give the third indication " low speed " at the distant signal : this is " speed signalling " in *optima forma*. Amendments to the signal rules were therefore necessary, with the result that our signalling acquired a dual character.

It was not necessary to copy that in the new to establish a system with light signals. Everywhere in the world there is a trend to consider speed indications as more important than route indications.

So we decided with the new system to put speed indication first and ask for a route indication only where wanted.

FORM OF THE NEW SIGNAL ASPECTS

The basis for the design of the new signal aspects for the junction home signal was this : a three-speed system, speed indication primary to route indication, and to keep free from all thinking in terms of arm signals and their history, and start anew. Why take over unnecessarily the drawbacks of the arm signals, when all their advantages are to be had with light signals as well ? Of course, the result of this study had, apart from being thoroughly examined on its own merits, to be theoretically and practically compared, in all possible circumstances, with the existing system and especially by the direct users of both systems, the engine drivers. Because it is essential that a new system must in no way be possible of being confused with existing systems, since they will be used for years together. (The significance of the three signal colours *red, yellow* and *green* ought not of course have the slightest difference in the two). There was in my case, too, a very important advantage. The number of the existing light signals was so small that it was very easy to change them over, so that there would be from the beginning a very distinctive difference between the old and the new, arm signals and light signals.

Principles

I started from the following principles :—

1. The three speeds to be indicated by signal aspects arranged in three heights.
2. In every combination of lights in a signal only one of the three signal colours (*red, yellow* or *green*) shall appear at one time.

3. The height of the displayed signal colour, high, middle or low, indicates the speed allowed and in order to define its level, the other lights in the combined signal aspect are to have a neutral colour (lunar white), except when *red* is shown, the level of which is indifferent.

4. In every combined signal aspect there should not only be indicated the speed permitted at this signal, but also the speed to be expected at the next signal, unless that speed be higher than the speed permitted at the first. (This is the principle of the distant signal made general; the reverse is undesirable, in my opinion, because it is wrong from a psychological point of view to indicate in a restricted speed aspect that the next signal allows a higher speed).

5. In close relation to 4:

   (*a*) The " proceed " indication placed highest in a combined aspect always indicates the speed *at the signal itself.*

   (*b*) A second " proceed " indication given simultaneously with (*a*) but located lower, indicates the lower speed to be expected *at next signal.*

   (*c*) In case only one " proceed " indication is shown, this indicates the speed at the signal *itself* and that at *the*

limit is allowed, by error a train should run at the higher limit no derailment would occur at the points or curves of the switches.

In the present system, the requirement under (*a*) is fulfilled; requirements (*b*) and (*c*) are however combined, resulting as already said, in a less desirable situation, that the top indication, maximum speed, may be reduced by a board imposing a prescribed speed restriction, ranging, as we have seen, from 78 to 37 m.p.h. (125-60 km.p.h.)

To ask that " medium " speed be fixed as well as " high " and " low " would be beyond practical possibilities. To satisfy this demand would result in either imposing a lower speed than necessary at all diverging junctions where a higher " medium " speed may be allowed than the fixed one, or many diverging junctions would have to be rearranged for a higher " medium " speed, which is not a practical proposition. The exact solution, in theory at least, would appear to be as many heights for signals as there are stipulated speeds, and for every 15 km.p.h. from 45 to 125 km.p.h., would mean six! *A system, however, in which low and top speed are fixed and medium variable, will satisfy, in my opinion, all reasonable demands even in the distant future.*

Realisation

A system arranged on the foregoing principles calls for 10 aspects, namely :—

1. Stop.
2-4. Prepare to stop from high, medium or low speed.
5-7. Proceed with high, medium or low speed (next signal the same speed).
8-9. Proceed with high speed, prepare for next signal at medium or low speed.
10. Proceed with medium speed, prepare for next signal at low speed.

The translation of these significations into aspects gives :—

1. *Red* (only one light, red, is enough) :
   Absolute stop.
2. *Top yellow* (the two lower lights lunar white) :
   Proceed at maximum speed, prepare to stop (full braking distance for maximum speed).

3. *Middle yellow* (the high and the low lights white) :
   Proceed at medium speed, prepare to stop (braking distance for medium speed).
4. *Low yellow* (the two higher lights white) :
   Proceed at low speed, prepare to stop (braking distance for low speed).
5. *Top green* (the two lower lights white) :
   Proceed at maximum speed, next signal also for this speed.
6. *Middle green* (the high and the low lights white) :
   Proceed at medium speed, next signal at least also for medium speed.
7. *Low green* (the two higher lights white) :
   Proceed at low speed, next signal at least also for low speed.
8. *Top and middle green* (the low light white) :
   Proceed at maximum speed, prepare to pass next signal at medium speed.
9. *Top and low green* (the middle light white) :
   Proceed at maximum speed, prepare to pass next signal low speed.
10. *Middle and low green* (the high light white) :
    Proceed at medium speed, prepare to pass next signal low speed.

Had it been thought not (or not yet) necessary to have a system for three speeds, a system based on the same principles for two speeds would need six aspects, arranged in two heights :—

1. Stop (*red* only).
2-3. Prepare to stop from maximum or from low speed :
   yellow, white
   white, *yellow*
4-5. Proceed at maximum speed, next signal also for that speed, or proceed at low speed, next signal at least also for low speed :
   green, white
   white, *green*
6. Proceed at maximum speed, prepare to pass next signal at low speed :
   green
   green

On the other hand a four speed system based on the same principles would call for fifteen signal aspects, but a system for one speed (no junctions) needs only three :—

1. Stop (*red*)
2. Prepare to stop (*yellow*) (The normal one-height
3. Proceed (*green*) three-aspect signal)

For the sake of completeness, the number of aspects obtainable on these principles may be figured out in the following way. Suppose :—

x=the number of the aspects required on these principles in a system with any number of speeds (heights),

and x_h=the number of aspects in a system with h heights.

With any number of speeds one needs :

1. Red (in figures : 1) ;
2. Yellow in all heights (in figures : *h*) ;
3. Green in all heights (in figures : *h*) ;
4. The number of combinations of a higher green with a lower green [in figures : $(h-1)+(h-2)+(h-3)+\ldots\ \ldots\ \ldots\ +(h-h)$]

Therefore $x_h=1+2h+[0+1+2+3+\ldots\ \ldots\ \ldots\ +(h-1)]$

$=1+2h+\frac{1}{2}(h-1)\,h.$

From which we get :

for h=0 (no speed) : $x_0=1$ (*red* only)

h=1 (one speed) : $x_1=3$ (*red, yellow, green*)
(no junctions)

h=2 (two speeds) : $x_2=6$ (the aspects in two heights, as we have seen)

h=3 (three speeds): $x_3=10$ (the aspects in three heights, as we have seen)

h=4 : $x_4=15$

h=5 : $x_5=21$, etc. (1, 3, 6, 10, 15, 21, 28, 36, 45, etc.)

Conclusion

We have chosen for *one speed* : $x_1=3$ (*red, yellow, green*), the well-known three aspect signal for the open line, and for *three speeds* : $x_3=10$ (the aspects in three heights) for junctions.

Compared with the old arm signal system:—

(*a*) The for us new one (speed) height system : *red, yellow, green* can occasion no confusion or difficulty. It is a simplification in all cases where we had the combined

home and distant signal, consisting of two arms : a stop arm and beneath it the distant for the next stop signal. Instead of the two lights : $\frac{\text{red}}{\text{yellow}}$ $\frac{\text{green}}{\text{yellow}}$ $\frac{\text{green}}{\text{green}}$ we give now one light : red, yellow, green, not only a simplification, but even an improvement, and in some sense already a step towards speed signalling.

(*b*) The new three (speed) height system is so totally different from the old (except of course for the three signal colours and their signification), that confusion or difficulty by comparison is impossible. A big advantage is moreover, as I observed already, that the old system only exists in arm signals and the new one only in light signals, but apart from that, both speak for themselves. When dealing with one of them, one does not think about the other; because they are so wholly different there is no possibility of confusion. I would almost say that if one has to change a system of aspects, the more different it is from the old one (except for the signification of the three signal colours), so much the better, *but on one most important condition.* The new aspects must be so logical, must speak so much for themselves, must be so simple and so self-evident, their meaning coming (I would say, automatically) out of their very arrangement, that it becomes unnecessary to think about their signification.

Trials

This showed itself at once during the trials made with the new aspects. When they were so far advanced that the results could be shown, they were shown to all the classes of railwaymen that have to do with aspects, from the President down to the most simple employee. The result was what I expected. Nobody had the slightest doubt about, or objection against, the new aspects, or fear of confusion, or difficulties with the old ones, so that they did not object to using the new mixed with the old. This is a necessity and has been even more so than expected. This does not mean mixing them at one station, but that in introducing them on a certain section of line, one must end at a station

or start from one. Sometimes only a short section between two stations is involved, and so forth.

Nevertheless, the difference in aspects gave rise to no real difficulty whatever, the only one in this respect having been the well-known question of taking care that a light signal following an arm signal shall not dominate it.

THE NEW ASPECTS IN DETAIL

The ten aspects of the three speed (height) indication near a junction are shown in figs. 1-4 :—

Fig. 1. The stop indication, giving a *red* light only.

Fig. 2. The three caution indications, in three heights.

Fig. 3. The three proceed indications in three heights, when the next signal authorises at least the same speed.

Fig. 4. The three proceed indications when the next signal imposes a lower speed.

Where it is necessary to place signals at less than full braking distance (for the permitted speed) apart, the signal immediately in rear of *red* shows a *yellow flashing* light, giving 75 flashes a minute and the signal preceding that shows steady *yellow*. Thus *yellow* is always seen at a point at least full braking distance from the *red* which it announces. This is the same with the one speed (height) system along the line : *red, yellow, green*. If by insufficient braking distance more than three aspects are needed, *flashing yellow* (75 flashes a minute) as fourth indication is added'

Up to now I have been dealing with the so-called " high " signals, mounted on poles or on the traction standards. Inside the stations " low " or ground (dwarf) signals are used. These are as a rule one speed (height) signals for low speed (maximum 28 m.p.h.) worked just as the " high " signals for three aspects, and applied to train movements as well as to shunt movements, on the same principles as the " high " ones. *Yellow* means next signal *red* with sufficient braking distance for low speed ; if this is not the case, the signal shows *flashing yellow* (75 flashes a minute) and the preceding signal shows *yellow*.

When there are movements inside the station, which may be executed *at more than low speed*, the dwarf signal is extended to

cover more than one speed by a second unit mounted above the " low " one. This dwarf signal is thus a two speed (height) signal. The upper unit is for medium speed, the lower one for low speed. The accompanying illustrations show a three speed home signal at a station and a two speed dwarf signal in a station, the medium speed in this case being 45 m.p.h. (75 km.p.h.), marked on the signal background plate and covered by a local running instruction. (The aspects of the two speed dwarf signal are those as we have seen for $x_2=6$ with $h=2$; except for practical reasons we do not give with *low green* or *low yellow*, at the same time *white* above it : so green or yellow *alone* means *low speed* !)

When there are movements inside a station which may be executed *at more than medium speed*, " high " three speed (height) signals are used.

In this way the *four* possible arrangements used in the new system all follow the same principles :—

1. The *one speed* (*full* speed) *"high"* signals : *red, yellow, green* and in case of insufficient braking distance *flashing yellow* (75) between yellow and red (steady yellow thus always at full braking distance).
2. The *three speed "high"* signals, as described (the " high " unit for the same as the one speed " high " signal).
3. The *one speed* (*low* speed) " dwarf " signals (the low speed unit the same as the low one in the three speed " high " signal).
4. The *two speed* " dwarf " signals (the low and medium speed units the same as the low and medium ones in the three speed " high " signal).

Fifth Aspect

There remains one aspect not yet described : the *flashing yellow* with 180 flashes a minute for calling-on purposes : in short, for all cases wherein safety is not fully guaranteed, such as occupied track, not fully signalled territory, wrong line movements, etc., and for use as soon as a fifth signal aspect proves necessary, thus : *red, yellow* (180), *yellow* (75), *yellow, green.*

Searchlight Type of Signal

The type of signal we have chosen is the searchlight. One may consider this type of signal as perhaps being less reliable in operation than the type having no internal spectacle mechanism.

Our many years' experience of it, from long before the war, and practice in many other countries, such as America, have proved it practically not less reliable in working than other kinds of signals, while it offers in addition very considerable advantages.

APPLICATION OF THE NEW ASPECTS

Practical Examples

Fig. 5 (*a*) *and* 5 (*b*) *are examples of the application of the new aspects.*

In fig. 5 (*a*) the following are given :—

1. The train has to stop at the home signal (distant signal *high yellow*).
2. The train may run through the station at maximum speed (distant and home signals both *high green*).
3. The train has to stop on the through track with the distant *high and medium green* and the home *medium yellow* ; and
4. The train has to stop on the loop with the distant *high and low green* and the home *low yellow*.

Now it is to be observed that :—

(*a*) In case 3, it is also possible, depending on the distance between the home and the next signal (e.g. the starting signal) at a given station that the distant can show *high green* and the home *high yellow*.

(*b*) The signalling shown in case 3 in the diagram (distant *high and medium green* and home *medium yellow*) also can apply to the case of stopping on a loop for *medium* speed.

(*c*) If, when running through the station *medium* speed only is possible, when passing over a loop at *medium* speed, the distant has to show *high and medium green* and the home *medium green*.

(*d*) If there is a track in a station allowing of running through at *low* speed, the distant has to show *high and low green* and the home *low green*.

(*e*) At a junction between two stations the aspects of the distant and home signals for case 2 above (*high* speed), case (*c*) (*medium* speed) and case (*d*) (*low* speed) are met with.

The same can be said about cases 2-4 of fig. 5 (*b*).

Route Indication

Only at a junction between two stations where the same speed is allowed for two directions, and thus the same signal aspects are given for two routes, is the route indicated by additional lamps ($^{\circ}_{o}$ or $_{o}^{\circ}$).

Failures

Lamp failures always result in an incomplete or more restrictive aspect or in no aspect. The three height signal is only complete with three lights, the two height dwarf signal showing one light is more restrictive than with two.

Moreover, in every case where an incorrect or imperfectly shown aspect could lead to dangerous misinterpretation, a more restrictive aspect is caused to show automatically. Thus if *yellow* fails, the light becomes white and if *green* fails it becomes *yellow* with the result that three white lights will be shown, which is no signal at all, or an aspect in which *green* and *yellow* are shown at the same time, which is an imperfect or wrong aspect.

If the flashing at 75 in *yellow* fails, it will be replaced by flashing at 180 ; if this fails, it will be replaced by *red*.

For all these, there are special instructions, under which no incomplete or imperfect aspect can at the worst authorise a speed higher than that which it would do of if properly exhibited.

Speed and Braking Distance

Originally the question of authorising different speeds* by signal for passenger and freight trains was discussed.

However after due consideration the following rules were laid down :—

1. A signal aspect must show whether or not, and if so, at what speed the track in advance of the signal is allowed to be run over.
2. The available braking distances beyond the signals for these speeds are to be fixed.
3. Starting from the normal braking percentages for a train, the speed for such train is to be prescribed (braking table).
4. With abnormal (bad) braking capacity of a train, relatively less speed is to be allowed.

*At the end of the " Criticisms, etc." in the Bulletin of the Congress mentioned hereafter, these different speeds were referred to.

5. The three speeds allowed are defined as :—

High speed : a speed fixed for each line of more than 56 m.p.h. (90 km.p.h.).

Medium speed ; a prescribed speed between 37 and 56 m.p.h. (60-90 km.p.h.).

Low speed : not higher than 28 m.p.h. (45 km.p.h.).

If lower speeds were laid down for freight trains than for passenger trains, many wholly unnecessary speed restrictions would be the result (e.g. at junctions between two stations), unless certain freight trains were put on the same level as passenger trains in this respect.

Progress in speed improvement would not be furthered by fixing lower values and therefore we prefer this arrangement, so much the more as all trains are fitted with continuous brakes and an increase in braking power is anticipated.

Automatic Signalling

On the principal lines with manual block the length of the sections is 3 to 4 km. (about $1\frac{3}{4}$ to $2\frac{1}{2}$ miles). I am speaking of double track lines, as nearly the whole territory electrified and to be electrified is double track. All block signals are preceded by a distant, so by changing over to automatic signalling and placing the distant half-way in the old block and converting all signals to three aspect light signals, the number of blocks is doubled with the same number of signals. The block length becomes between 1,500 and 1,800 m. (4,921 and 5,906 ft.), more than sufficient for full braking distance for maximum speed, which is 1,000 m. (3,280 ft.) [for medium speed 500 m. (1,640 ft.), for low speed 250 m. (820 ft.)]

Nearly every three to four block sections there is a station with junction or a junction alone, so there we have three-height home and distant signals, the distant signal being at the same time a block signal. In this way there is nearly one three-height signal to 3 one-height signals. The small stations are included in the automatic signalling with track circuits and light signals in such a way that when a line is ready with the new signalling, it and the stations are modernised throughout except the big stations.

In this way at the end of 1952 there will be in service 250 km. (155 miles) of double track automatic signalling with 300 one-height high signals, 25 small stations wholly modernised and 15 bigger stations with the home and distant signals changed to

three-height light signals, with the starting signals automatic in certain cases. The ratio of 1 to 3 between the three-height and the one-height signals will improve to about 1 to 5 as soon as the larger stations become equipped with the new signalling arrangements.

" NX " Installations

The bigger stations, when they need new signalling, either from being badly damaged during the war and only provisionally repaired, or on account of the carrying out of new work, have signalling on these principles and controlled, if they are big enough, by an " NX " installation, if not, then by a simpler one.

In " NX " form we have s'Hertogenbosch, working since 1950 with great success (98 switches, 75 signals, 87 track circuits), and a double single track line between Utrecht C.S. and Blauwkapel, connecting at Blauwkapel with a crossing with junctions on the line Utrecht C.S.-Amersfoort with the line Utrecht Maliebaan-Hilversum, also with good results (20 switches, 22 signals, 70 track circuits). This has been at work for six months.

" NX " installations are being planned for, or are in course of erection at Arnhem (95 switches, 77 signals, 115 track circuits), Eindhoven (100 switches, 77 signals, 120 track circuits), and Leiden (38 switches, 41 signals, 53 track circuits).

General Conclusion

The results obtained with the new signalling are very good. Such difficulties as there are have nothing to do with the principles: e.g., in the beginning in " den Bosch " there were difficulties with the insulated joints of the track circuits. Better fibre has given better results. Recently there have been difficulties with the resonated impedance bonds from greater variation in frequency of the power supply than formerly, caused by changes in through-coupling of power supplies (even from Germany). The Netherlands Railways are making tests to find out how to make the bonds less susceptible to these variations.

As to the new signal aspects in three heights, as I said above, they give complete satisfaction. Before the account of these new aspects was published in the Bulletin of the Congress for August 1948, as I mentioned before, I had asked for criticism and was happy to receive criticisms and remarks from a number of

colleagues in different countries. These were published with my replies thereto in the September volume 1948 of the same Bulletin and I take with great pleasure the opportunity to thank in this paper once more very much the British colleagues who assisted in this international, and for me very useful and fruitful, written discussion : Messrs. Lascelles, Train, Tattersall, Woodbridge, Tyler, Boyle.

DISCUSSION

Mr. E. G. Brentnall, opening the discussion, congratulated the author on his excellent paper and said that the terrible conditions in the Netherlands at the time of the liberation called for a tremendous amount of courage not only in facing the heavy tasks ahead, but also in deciding how they should be carried out. He was sure that everybody would admire the great courage the author had brought to the task. To change the signalling principles was a very big decision to make, but he thought the author was very wise to change to multi-aspect colour-light signals, and in doing so to make them different from the existing semaphore aspects.

The question of speed signalling, as opposed to route signalling, had been given a great deal of consideration recently, particularly on the Continent, and Mr. Brentnall thought that for the full exploitation of speed signalling, continuous braking on all trains was essential ; but this had not yet been reached in Great Britain. The use of one colour at a time was a great advantage because it prevented ambiguity and considerably simplified matters generally. He enquired if the author had found any difficulty through signal aspects being confused with extraneous lights, such as highway lighting. This trouble had been experienced in Great Britain, and at times it had been necessary to have road lamps moved or shaded.

He also enquired if the two lunar white lights tended to diminish the other aspects, especially the green. The paper mentioned three speeds, high, medium and low for signals, and in the case of a branch line with a maximum speed of say, 50 km.p.h., Mr. Brentnall asked if signals with three speeds would be used or if only two speeds, for example, medium and low would

be sufficient. He also referred to main lines where speed restrictions were necessary owing to physical constructions such as bridges and curves, and where there were no junctions, and enquired if the medium speed signal would be used. He expressed great interest in the tests carried out with lights giving 75 and 180 flashes per minute. Since the application of the two types was very different, he said he would hesitate to use them because one indicated that the section was clear, whereas the other showed that it was probably occupied, and there seemed to be a possibility of ambiguity. The use of relay interlocking in Holland, the NX in particular, was very interesting. It had been argued sometimes by opponents of such installations that there were difficulties with these systems due to track circuit failures, and he asked the author if such difficulties had arisen to a greater extent on relay interlockings than in other power signalling installations.

Mr. J. F. H. Tyler said there was a characteristic that was very noticeable when comparing the signalling in Great Britain with that on the Continent. For intermediate signals they had three simple aspects, similar to practice in Great Britain, but when it came to the through stations, a different system of signalling seemed to be introduced. He did not know why that should be, but suggested that the difference might be geographical or perhaps because in Britain there were many towns through which trains had to run fast. British railways did have speed signalling in a sense, in that with multi-aspect signalling, at junctions the signal was approach controlled by track circuit where a turnout movement had to be made. This was, of course, supplemented by a junction indicator to give the direction, in somewhat similar way to the two lights for equal speed described by the author. Mr. Tyler asked if the author had encountered the problem of three-height signals applied in an area of intense traffic where it would be necessary to place a number of signals at fairly close intervals, according to the headway of traffic. If that were so, he thought that at the first signal, might be given the aspect, " proceed at maximum speed, pass the next signal at medium speed." At the next signal, it would presumably be the medium speed, " pass the next at low speed," until one got to the yellow and red. Supposing that had to be done with four aspects ; if the first warning had to be given at the first of those three signals, the next signal had to be passed at a medium speed and the train

had to stop at the third one. It seemed that if the braking characteristic were uniform, that is, so many miles per hour per second, the train would pass the middle signal at higher than medium speed. Mr. Tyler referred to the mixing of colour-light with semaphore signals, and the danger of reading through, and asked if the author had approach lighted by track circuit the colour-light signal ahead of a semaphore signal. He then referred to level crossings with no barrier, but with only flashing lights and asked if that arrangement had led to any increase in accidents, particularly to children.

Mr. B. F. Wagenrieder, referring to level crossings without barriers, enquired if any steps were taken to prevent the approach of a train in the event of a road vehicle having stalled on the level crossing.

Mr. J. P. Loosemore asked how many level crossings there were on the Netherlands Railways and in how many cases were they protected by automatic light signals? Where there were no light signals what arrangements were adopted? Were there any statistics showing the number of accidents at crossings?

The **Author** in reply to *Mr. Brentnall*, said no tendency of the lunar white lights to diminish the effect of the coloured ones had been experienced. Had it been so it would not have been serious. In an aspect containing lunar white—that was to say combined with yellow or green—the speed authorised by the signal in the rear could be maintained until reaching the signal displaying such aspect. It was only when the signal in rear instructed the driver to prepare to pass the next in advance at a lower one than the signal in rear itself authorised that it became desirable, in order to avoid any unnecessary reduction in speed, to be able to distinguish an aspect containing lunar white at a sufficient distance; that was to meet the case where, after the driver had passed the signal in rear, the aspect at the one in advance changed to something less restrictive and thus more favourable. This requirement was more than adequately met by this new system of aspects. There had indeed been some difficulties, here and there, from extraneous lights interfering with the signals, but such cases had been solved in discussion with the highway authorities.

With regard to the use of the high type of signal, there were the following cases to be distinguished:— (1) a junction for high (over 90 km.p.h.) and low (up to 45 km.p.h.) speed; (2) a junction for high and medium (60 to 90 km.ph.) speed; (3) a junction for

medium and low speed, or at some places a junction for all three speeds.

In case (1) the middle light, in case (2) the lower light, and in case (3) the top light, was not required to show either green or yellow, but whenever it was required to signal for more than one speed in a 3-speed system the three height– three unit—signal was needed.

As regards main lines, where speed restrictions were necessary owing to local physical conditions and there were no actual junctions, the ordinary normal one-height signal was used, supplemented by speed restriction boards where necessary. (The three-light signal was used only for junctions and then only if the junction was one for more than one speed. Along the ordinary plain line the one-light signal only was used.)

The 75 and 180 flashes per minute aspects were quite wide apart and never had there been any doubt on the part of a driver as to which aspect was being shown. In addition the 75 flashing yellow aspect was used as a special sign between steady yellow and red, giving a warning of insufficient braking distance, as a fourth running aspect. It was a step further to the still stronger warning of 180 flashing yellow, which indicated that the section of track in advance might be found to be occupied. That gave a fifth aspect.

With the " NX " power interlocking installations there were at first track circuit failures, due to breakdowns of fishplate insulations, but improvements to the latter had eliminated the trouble.

In reply to *Mr. Tyler*, the author explained that at small stations they could, as a rule, run through at full speed and the appropriate signal aspects would be displayed. At the large stations they did not ordinarily require a signal for such a movement. As regards braking distance between signals he must explain that there was some misapprehension on Mr. Tyler's part about the aspects. All the ten were not given at the one signal. Had that been the case they would have been obliged to use more than three colours in a 3-aspect searchlight unit and as yet they had not been called on to solve that difficulty, as there were always reserve places in the mechanisms in which to put the red, for example in the reserve place in the middle mechanism when four colours were required to be shown from the top one. Secondly, the several aspects were not meant all to follow one

another. The three-height signals were only used at junctions to convey, through the various aspects, the speeds applicable to the corresponding routes, there being the following possible combinations, high and medium speed, high and low, medium and low, or all three speeds.

If there were no junction involved they would not use the three-height signals but single-unit ones showing, in succession, green; yellow, red; or green, yellow, 75 flashing yellow, red; or green, yellow, 75 flashing yellow, 180 flashing yellow, red.

As yet they had not approach lighted the colour-light signal in rear or in advance of a semaphore signal but the author considered that a good suggestion.

Turning to level crossings, the author said that the use of flashing lights without barriers did not apply to large towns or cities. There they used barriers and recently had experimented with half-barriers and flashing lights also worked automatically. There had been no increase in the number of accidents. Quite the contrary. But it had to be remembered that in addition to the flashing lights there was a loud bell on each side of the crossing.

In reply to *Mr. Wagenrieder*, the author said that the stalling of a vehicle on a crossing had occurred but the question was not barriers or no barriers, but rather nothing at all or flashing lights, or half-barriers (either automatic or controlled from a signal box) with flashing lights. This was because they had thousands of crossings without barriers. They had had accidents due to barriers not being closed in time, or from road drivers running through barriers that were closed or being closed, and consequently, except where there was a heavy traffic in or near large centres, half-barriers with flashing lights, or flashing lights only, were preferred.

The **Author**, in reply to *Mr. Loosemore*, said there were about 7,000 crossings, of which 3,229 were public ones. Of the latter 602 had barriers, operated from nearby; 386 had them operated from distances up to, say 650 yd.; and there were 6 with half-barriers, worked from a distance. There were 95 crossings with flashing lights only and 81 which had actual gates. That left 2,059 without barriers or lights but equipped with the St. Andrew cross signs and red and white signboards. In important cases repeater warning boards were placed at about 160 yd. in rear of the crossing. Lifting barriers operated from a distance had red flashing lights, as did the most important of those worked from nearby.