Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Wednesday, February 6th, 1963

The President (Mr. R. A. GREEN) in the chair

The Minutes of the Technical Meeting held on January 9th, 1963, were read and approved.

The President introduced and welcomed to the meeting Messrs. G. A. Brierley (Associate Member), B. W. Shepherd (Graduate) and R. H. Stone (Student).

The President then requested Mr. J. F. H. Tyler to read his Paper entitled "Signalling Developments on the Southern Region".

Signalling Developments on the Southern Region

By J. F. H. TYLER, B.Sc.(ENG.) (Member)*

Introduction

The Southern Railway and later the Southern Region has always been regarded as small by comparison with its contemporaries, but prior to the 1st January this year, it covered a larger area than was generally realised.

Until the recent Regional boundary changes, it stretched from Broadstairs to Padstow, a distance of 300 miles, or as far as from London to the Scottish border.

In 1959 in this area the total population was 8.7 million, having increased since 1931 by 22.3%, which compares with a 13.5% increase for the whole of England and Wales. Of this total, 3.4 million lived in the Greater London area, 1.7 million in the outlying suburbs and 1.9 million in or near the large coastal towns in Kent, Sussex and Hampshire. The balance of 1.7 million lived in the larger area further west which is mainly rural and agricultural The present day population figures are certainly greater, but whether there has been a corresponding increase in the west is doubtful, and in any case, the potential rail traffic is small.

There are no dense industrial areas, although there are a few coalfields in Kent, and freight traffic is low by comparison with passenger traffic, which is exceptionally high.

In 1961, the British Transport Commission statistical accounts showed the Southern Region ranking fourth with 2001 route miles open for passenger traffic, and first with a loaded passenger train mileage of 61.3 million.

The bulk of this traffic lies in the London commuter area which may be said to be east of a line drawn from Reading through Basingstoke to Portsmouth.

In this area, the greater part of which is electrified, electric multiple-unit stock in 1961 ran 42.6 million loaded passenger train miles, or 74% of the national total.

* Chief Signal & Telecommunications Engineer, British Railways, Southern Region

Passenger journeys for the whole Region were 408.5 million, or 40.5% of the national total.

Freight traffic, although obviously small, is rather more significant than might be supposed. The freight train mileage of 8.05 million is only 5.75% of the British Railways total. It is significant because it must be timetabled to suit the passenger traffic.

Boat trains are another difficulty, particularly in the holiday season when a total of 50 in a single day is not uncommon. Regular down boat trains are scheduled, but others, up and down, must be allowed for by spare paths reserved in the timetable for that purpose.

Traffic Growth

The country south of the Thames has been a much favoured residential area for over a century and the constituent companies of the Southern Railway were formed largely to serve the need for quicker travel from London to the suburbs and to the coast.

The Southern Railway, on its formation, had not only to cater for the growing population, which necessitated electrification, but also with the desire of the white-collar worker to live further and further from his place of business.

This involved more and more electrification, until after a few years the Southern Railway had the largest suburban system in the world. But soon the service which had to be provided was not a suburban one in the conventional sense. Main lines to Brighton, Eastbourne and Portsmouth had to be electrified and fast, semi-fast and stopping services had to be provided and integrated with the inner suburban services, and the process has continued with the electrification of the Kent Coast lines in recent years. Time and time again experience has shown that in the area between London and the South and South-East coast electrification attracts traffic.

The growth of passenger rail traffic in the period 1924-1938 is shown in Fig. 1, and Appendix A gives particulars of the number of trains and passengers dealt

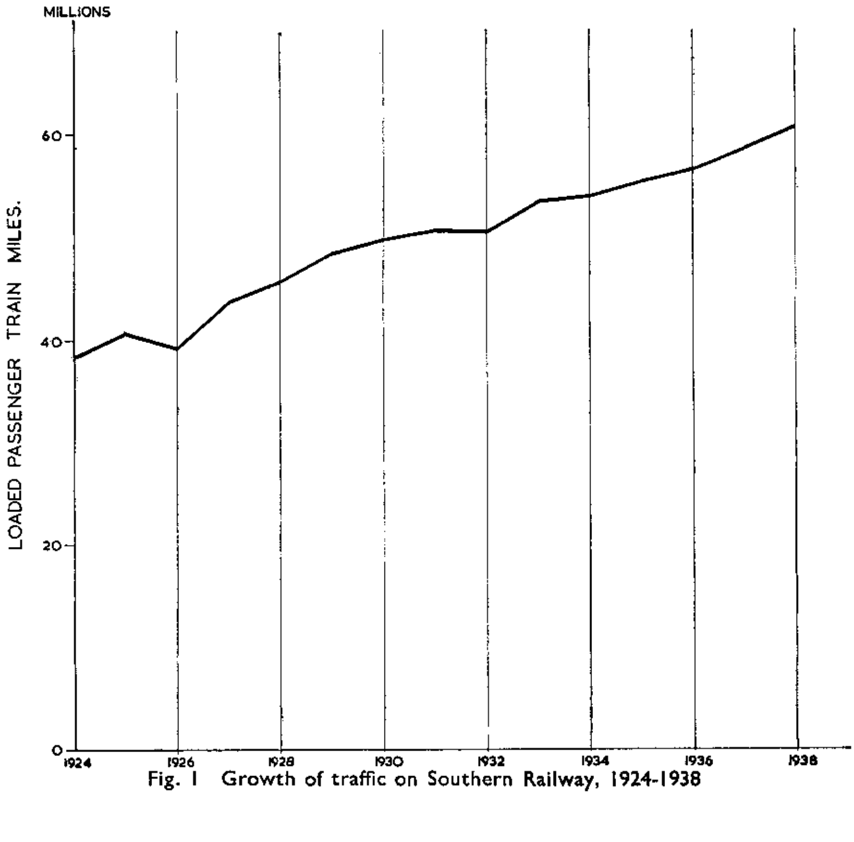


Fig. 1 Growth of traffic on Southern Railway, 1924-1938

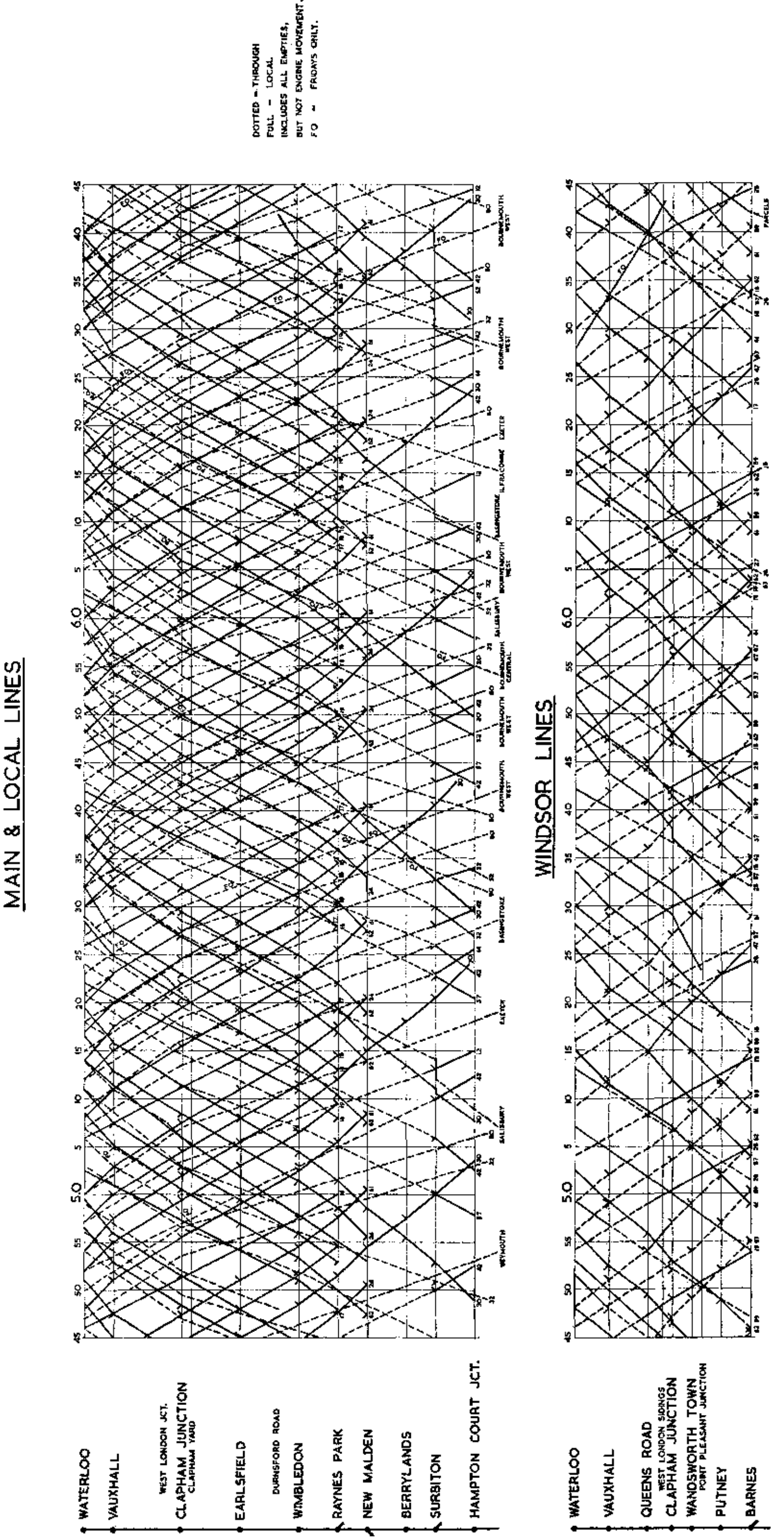


Fig. 2 Train graph of evening peak service at Waterloo

with daily at each of the Southern's London Termini in 1959.

These quite staggering figures have obviously had a profound effect on the signalling, and it is not surprising to find that multiple-aspect colourlight signalling had to be provided at each of the London Termini at an early stage.,

Some idea of the operating and signalling problems to be met at the London Termini is indicated in Fig. 2, which is a train graph for Waterloo between 4.45 p.m. and 6.45 p.m. on a typical week day.

Signalling Development prior to the Railway Companies' Amalgamation

Up to the time of the amalgamation in 1923 of the constituent companies it was only the London and South Western Railway which had introduced much power signalling.

In 1920 at Victoria, on the Chatham side, the South Eastern and Chatham Railway had installed 3-position upper quadrant semaphore signalling operated from two General Railway Signal Company's slide lever power frames, with dynamic indication, having 174 and 42 levers respectively at the "A" and "B" signalboxes. The equipment was manufactured in the U.S.A. but as the original consignment was in a ship sunk by enemy action installation was considerably delayed. The original locking frame at "A" box is still in service in the old signalbox under the guise of Victoria Eastern, but now operates multiple-aspect signals.

The London Brighton and South Coast Railway had no power signalling in the fullest sense, but on the Brighton side at Victoria it had installed the Sykes electro-mechanical system in 1908 at Victoria North, South and Shunting signalboxes, and at Grosvenor Bridge, Battersea Pier and Battersea Park signalboxes.

The London and South Western Railway did much more than its contemporaries. In 1901 it installed a low pressure pneumatic power frame at Grateley, with automatic semaphore stop and distant signals, track circuit controlled, without overlaps and without block telegraph working between there and Andover (exclusive), a distance of 6 miles. The following year two signalboxes at Salisbury were brought into use, with power frames of the same pattern as Andover. In 1904 two similar signalboxes at Staines were brought into use. Not long after Woking (exclusive) to Basingstoke (23 miles) including 11 signalboxes, was converted to the same system, with automatic and semi-automatic signals, and then 5 signalboxes in the Clapham Junction area were converted.

The Woking to Basingstoke installation, and that at Salisbury, are still in work and give little trouble, although they are long overdue for replacement.

Two hump yards at Feltham were brought into service in 1922, with electrically operated points controlled from panels with push buttons, and are still in service.

The Waterloo and City Railway, the second electric tube railway in London, was opened in 1898, and became part of the L. & S.W.R. system in 1907. The signalling at each of the stations was mechanical, but in the under river sections signals were of the Sykes electrically operated type. The signals were controlled by a "last-vehicle" fouling bar/treadle combination, track circuits not then being in general use. This railway was unique in the possession of a contact device which, if the train over-ran the signal, cut off the traction current and applied the brake.

There was early experience in the problems posed by electrification. In 1909, the L.B. & S.C.R. had electrified the South London line between Victoria and London Bridge on the overhead system at 6,600 volts 25 cycles A.C., and prior to amalgamation the system had been extended to cover 24½ route miles.

In 1916, the L. & S.W.R. began to electrify the suburban lines at 650 volts D.C. on the third rail system, and by 1923 it had covered 57 route miles.

Signalling developments from 1925 to 1940

The growing traffic in and out of London led to electrification, and with it a need for greatly increased line capacity. The Signal Engineer, Mr. W. J. Thorrowgood, realised that 3-aspect signalling would not permit the short headway working necessary in the London area, and introduced a fourth aspect into the colourlight system which had been adopted.

As his Chief Assistant, he had Mr. W. Challis, previously of the Metropolitan Railway, under whose direction the work was to be planned and executed by the railway staff.

In 1926 a start was made with the introduction of 4-aspect colourlight signalling from Holborn to Elephant & Castle, and from then until 1940, 16 power signalling installations were brought into use in conjunction with 334 track miles of continuous colourlight signalling. During this period the Brighton, Eastbourne and Portsmouth lines were electrified (with consequential signalling alterations) outside the multiple-aspect signalling area. Brief particulars of the works brought into use during this period are given in Appendix B.

All power signalling during this period was in accordance with standards laid down, although each installation was a little different from the one before as a result of experience gained. In consequence, technical staff and installation staff knew exactly what was wanted, and why, and some quite remarkable records were made. For example, London Bridge was brought into service only nine months after authorisation. It was the magnitude of the mechanical locking at London Bridge which caused attention to be diverted to the practicability of achieving the same result electrically. North Kent East, which followed eighteen months later, was the first all-electric locking frame on the main lines, and every power frame on the Southern since has been the same.

A characteristic of every installation was, and still is, the "8-hour" possession for bringing it into service. On the Southern, the Sunday service is often almost as heavy as on weekdays, particularly on routes to the coast, and 8 hours is now, as then, the standard time for changing over and handing back to the Operating Department.

Mr. W. Challis was the moving spirit in this period. He had no one to help him in 1926, and had to train staff as he went along, from job to job. When he died in 1939, before retirement, the Signal Department was as experienced as any in the country in the technique of power signalling. The author is glad to pay this tribute to the memory of a man to whom we of the Southern owe so much.

Signalling developments from 1945 to 1958

During the war the Southern had somewhat more than its fair share of the consequences of enemy action and obviously no signalling works could be put in hand which were not part of the war effort.

In 1946 a restart was made by installing a new power signalbox at Portsmouth Harbour to replace the mechanical box destroyed by enemy action.

Then in 1950 the Central Section Colourlight Signalling scheme was inaugurated. The purpose of this project was to close the gap between Bricklayers Arms and Pouparts Junction and Coulsdon North.

Brief particulars of the works brought into use in this period are given in Appendix C. Fourteen power signalboxes were brought into use, involving 121 track miles of colourlight signalling.

Signalling developments from 1959 to 1962

When the British Railways Modernisation Plan was formulated, the Southern Region naturally chose for its part extension of the electrification, which could be relied upon to yield a satisfactory return on the outlay.

During the years 1959 to 1962, Stage I was completed in two phases. Phase I, involving electrification to Dover via Chatham, was completed in time for the 1959 summer service, and Phase II, which involved electrification to the same place, via Tonbridge, was completed for the 1962 summer service.

As a standard the Southern departed from its then almost traditional power frame and adopted the route setting panel. Also, for the first time, contractors were employed on installation work.

Almost certainly route setting panels would have been adopted in the course of progress anyway, but the decision not to carry out the installation work by Railway staff must have been a hard one to make. It was forced on the Signal Department by the need to bring Stage I into use as soon as practicable in order to get the return on the capital outlay, which was of the order of £10 million for signalling and telecommunications alone.

The author is happy to record that the increase in the number of journeys is even greater than expectations on Phase I, and a similar trend is already apparent on Phase II.

The decision was wisely taken on Phase I to accept what was offered by the contractors in regard to signalling panels and circuitry. By this means considerable experience was gained in a comparatively short time.

On Phase II, however, as a result of this experience, and the author's personal knowledge of what was being done elsewhere in this country and on the Continent, a more detailed specification was drawn up. It was realised that there was no time to standardise on circuitry, a subject which in any case was being handled by staff at the British Transport Commission, but the method of operation of the panel by the signalman was specified precisely after much thought and discussion. It was considered essential that operation should be as simple as practicable and uniform throughout, irrespective of the contractor.

The specification for panels included the following features:

(1) Push/push method of entrance-exit operation.

(2) Call-on signals to clear conditionally on platform track circuit occupation.

(3) Restricted overlaps to result in delayed clearance of signals automatically. (This feature is provided only where required by the Operating Department). In the event of the overlap clearing, the signal immediately to assume a clear aspect.

(4) Shunt-ahead signals to be provided with additional entrance push button. (The reason for this is that a shunt-ahead must carry locking as far as the signal ahead, and the existing exit push button is, therefore, used in combination with it).

(5) Overlaps to be "swung" as desired by signalman using the individual point keys.

(6) A "pumping" feature to be provided to enable the signalman to reset a route for the same direction immediately a train has passed a main signal and replaced it to red.

(7) The white route set-up indications to change to red on track occupation.

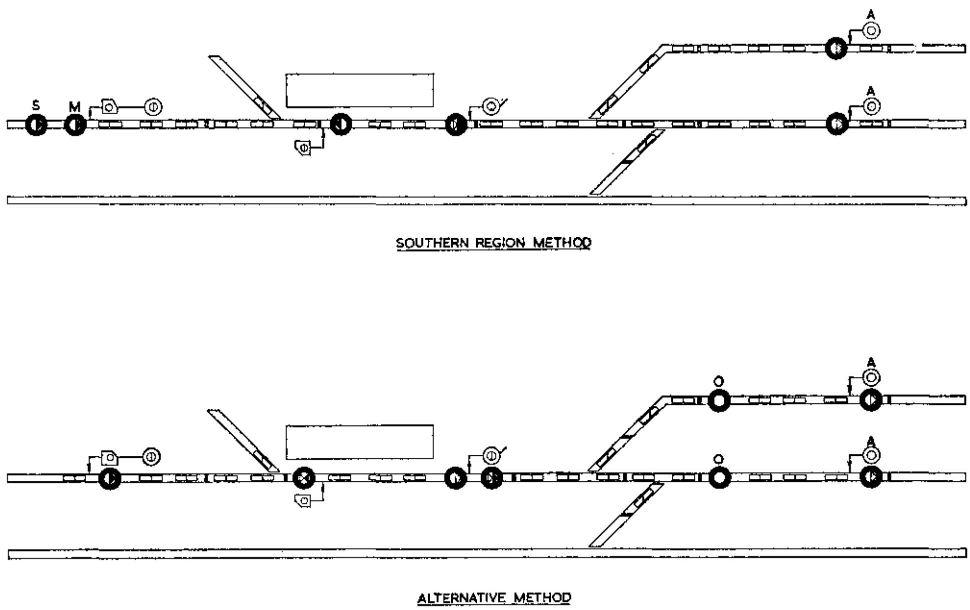
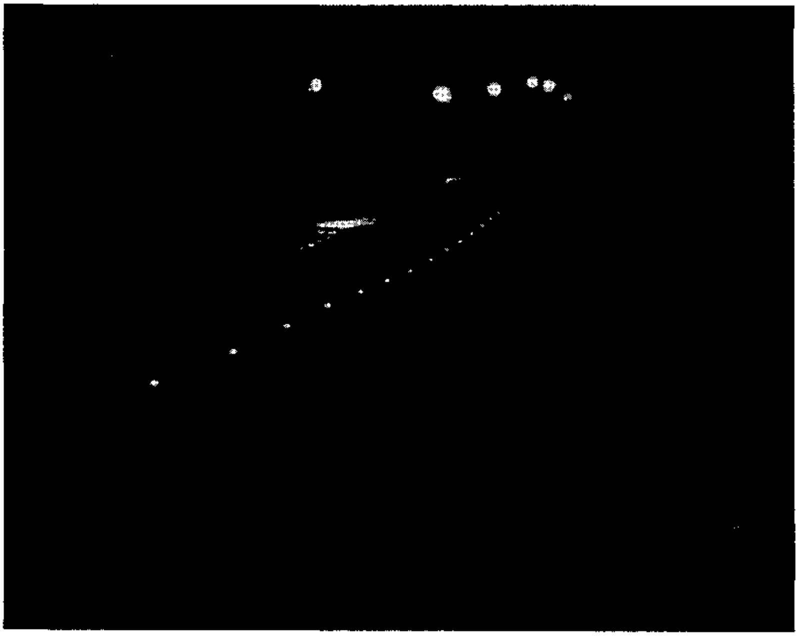
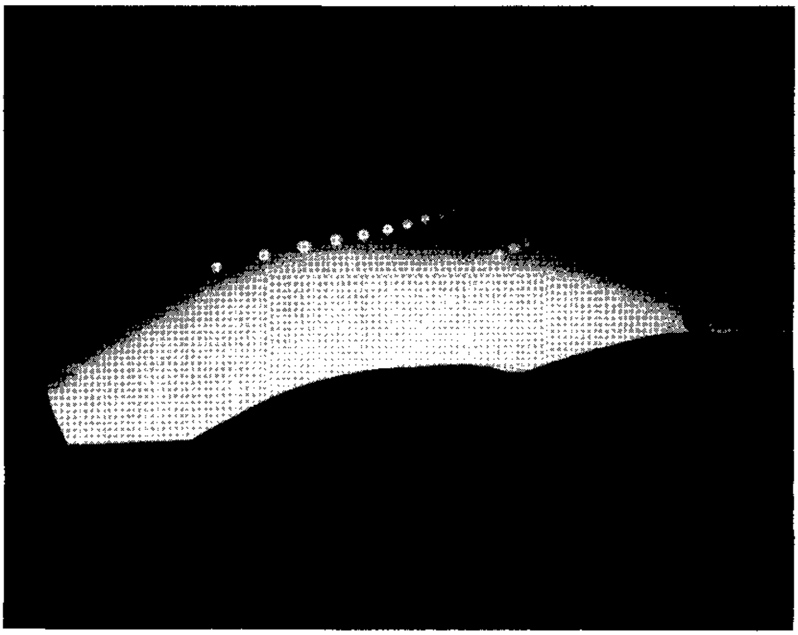


Fig. 3 Signalling panel operating methods





(8) The red signal indication to flash whilst a backlock is being time-released.

(9) The panel to be of such a height that the signalman may stand if he prefers.

Fig. 3 demonstrates the simplicity of the arrangement specified by comparison with an alternative arrangement in use elsewhere. I would commend our method to our Operating friends.

The arrangement used on Phase II is well liked by the signalmen, and has proved itself quite suitable for intensive traffic where it is necessary to "swing" overlaps in order to give the least restrictive signal aspect available to an approaching train.

Another feature adopted was the use throughout of P.C.P. protected, corrugated steel sheathed cable to equipment on the track. This cable is laid directly on the ballast at right angles to the track, and is held firmly by a suitable gland fitted to the apparatus. This obviated the use of small size troughing which can rarely be maintained neatly. The new method also permits much quicker installation. Fig. 4 shows a typical example.

In conjunction with this cable a track circuit disconnection box was used, thus enabling a 2-core cable to be connected to flexible single cables running to the rails, where the connection is made with a copper lug and steel drift pin. See Fig. 5.

In the relay room, cable and distribution fuse racks were designed to bolt to horizontal angles fitted to the walls. See Fig. 6.

Power supply switchgear was specified to be the same irrespective of contractor and this, too, was wall-mounted. Fig. 7 shows a typical layout. The recording voltmeter will be noted. As the power supply is taken from the traction substations, there is considerable fluctuation within certain limits, and a surge may cause a momentary "flick" sufficient to cause track relays to drop out and stick relays to release. The recording meter has been found to be most useful in tracing the cause of failures of this kind.

These were some of the features specified in order to ensure that each installation

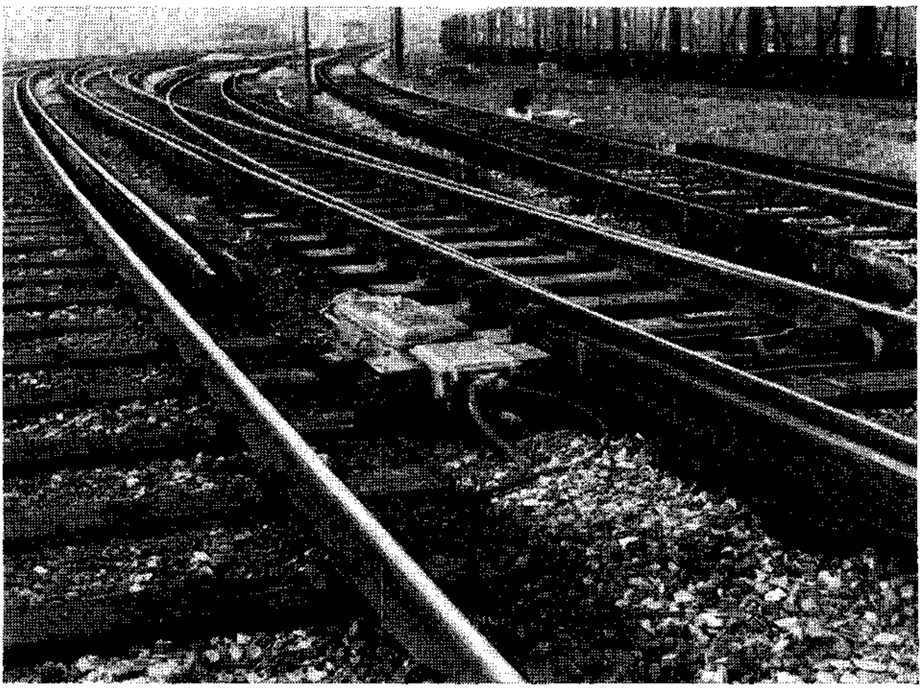


Fig. 4 Use of corrugated sheathed cable to apparatus

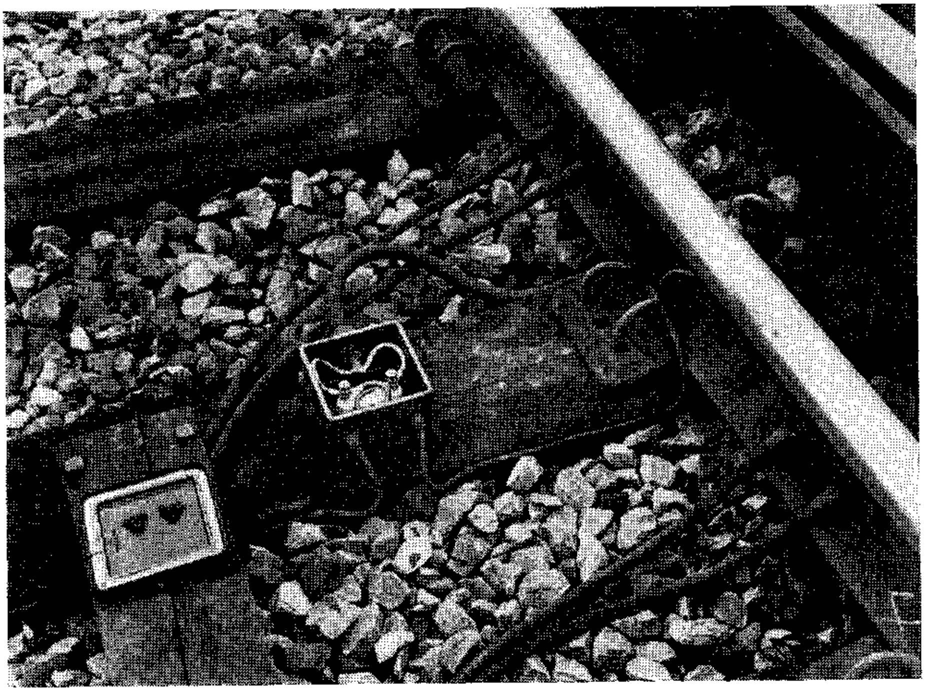


Fig. 5 Track circuit connections

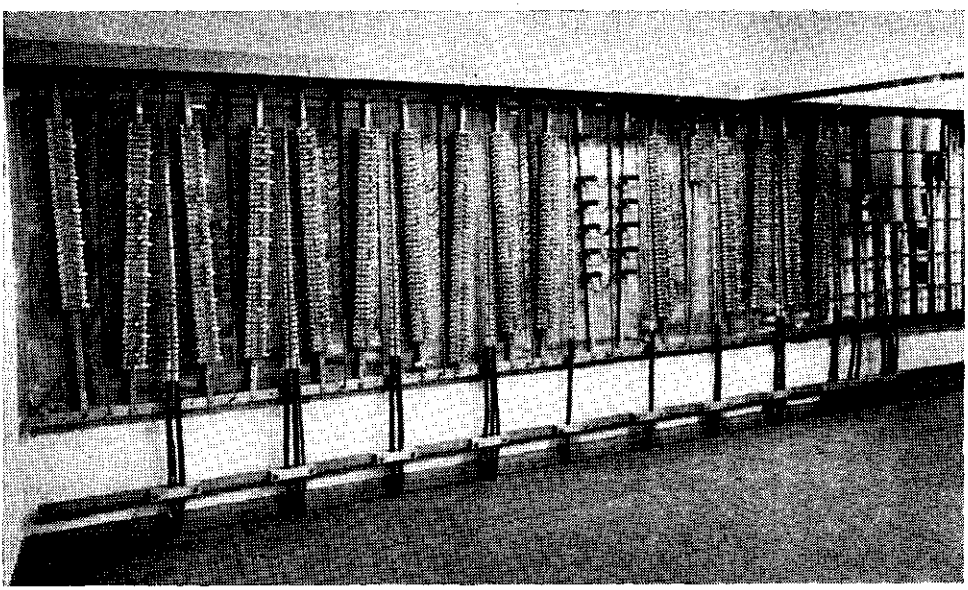


Fig. 6 Cable and distribution fuse racks

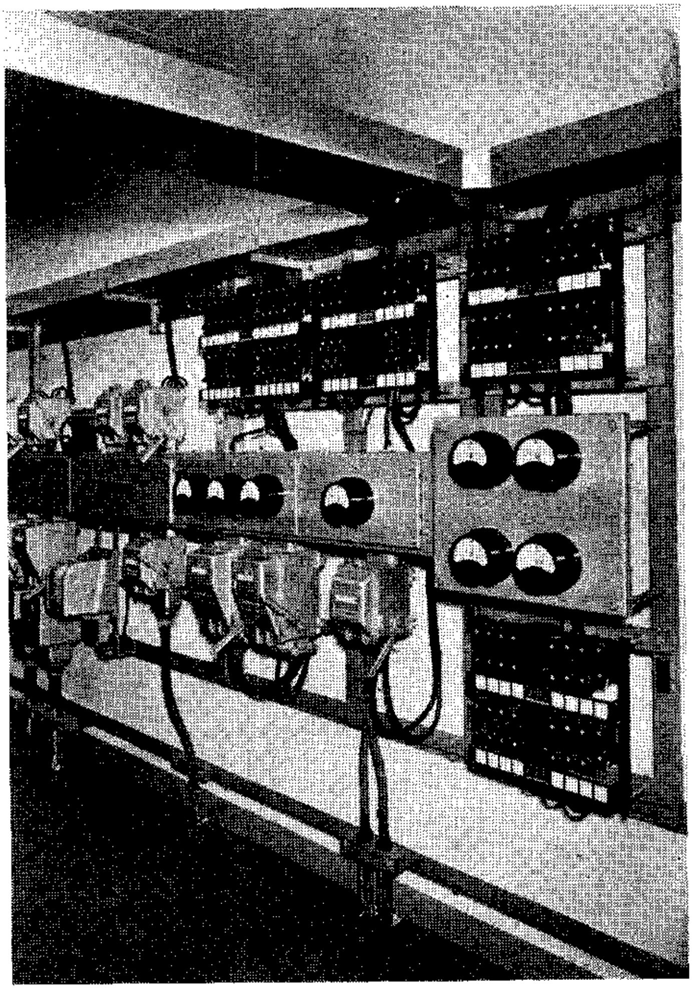


Fig. 7 Power supply switchgear

was as far as practicable the same, irrespective of the particular contractor.

The area embraced by Phase II is shown in Fig. 8. Continuous colourlight signalling extends over 212 track miles between Hither Green and Dover.

Between Hither Green and Sevenoaks, the headway required by the projected service was 2½ minutes for following stopping trains. Below Sevenoaks the headway had to be 3 minutes for non-stopping trains.

The signalling had to provide braking distances suitable for locomotive-hauled vacuum fitted stock travelling at 85 miles per hour, but the non-stop headway requirements had to be fulfilled with multiple-unit stock travelling at 60 miles per hour. In service, trains run much faster, which results in a useful margin.

Approaching the main stations the signal spacing was closed up to avoid through trains being checked whilst the train ahead slows down to enter the platform loop. It was opened up gradually on the leaving side to enable stopping trains to follow through trains as quickly as possible.

It was decided that the whole line should be controlled by 6 new signalboxes at Hither Green, Orpington, Sevenoaks, Tonbridge, Ashford and Folkestone East.

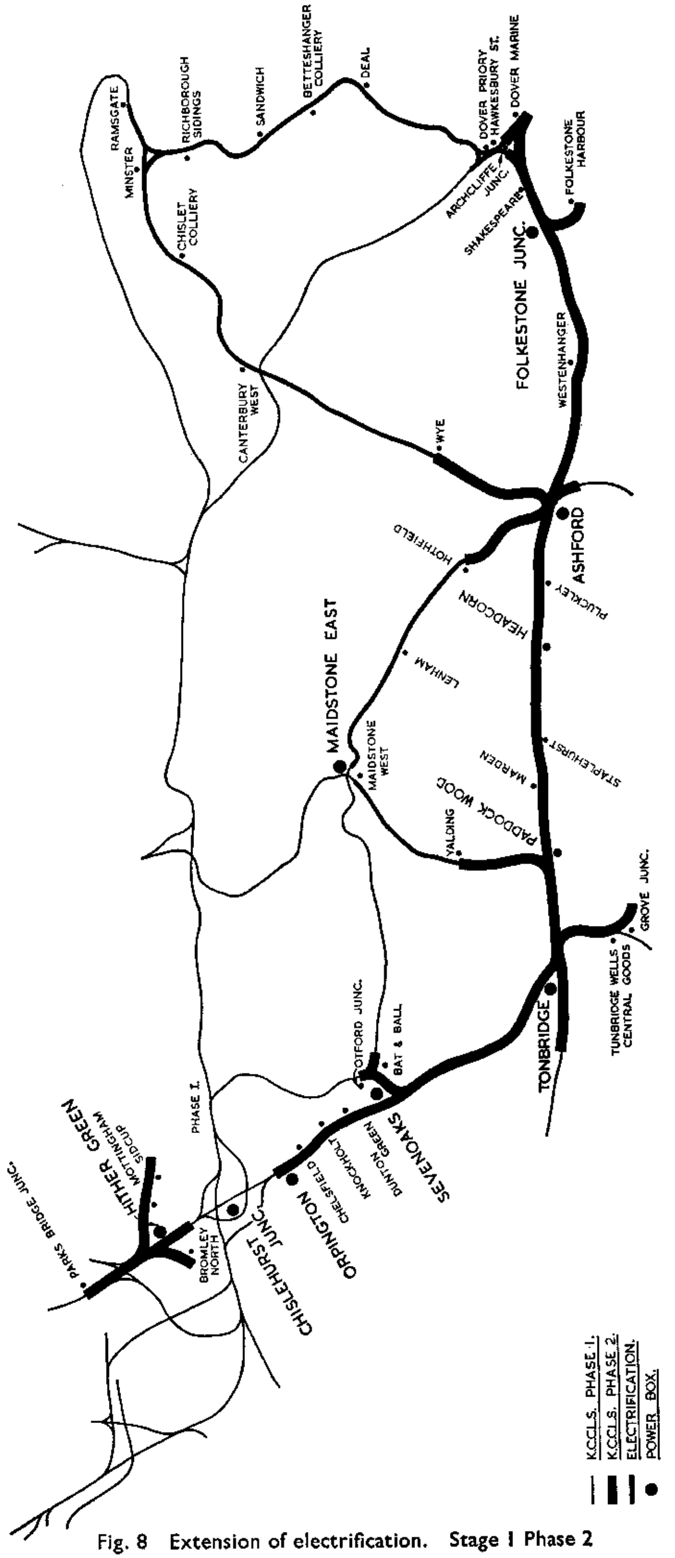


Fig. 8 Extension of electrification. Stage 1 Phase 2

Paddock Wood, which is a fair-sized junction station where the movements are mainly running movements, was to be controlled from Tonbridge, 5½ miles away. Having regard to the size of the layout at Paddock Wood it was decided that an emergency control panel should be provided at the relay room. The emergency panel would be used under the telephone direction of the Tonbridge signalman. At Headcorn, the up and down platform loops were to be controlled from Tonbridge (15¾ miles) and Ashford (11 miles) respectively. The existing mechanical signalbox was retained, but is shortly to be abolished as the sidings are now out of use.

The method of remote control to be used was the subject of much thought and discussion. Finally, it was decided that as the cost of using telecommunication cable and telephone type relays was not greatly in excess of the cost of a transistorised system using a single pair of wires, the former arrangement should be used on the grounds of simplicity and freedom from component failure.

This arrangement has worked very well, and there have been no failures of the remote control circuits.

The distance between Tonbridge and Ashford is 26¾ miles, with the possibility of up trains changing their order at Headcorn and at Paddock Wood. This problem exposed the limitations in large areas of control of the magazine type describer as used by the Southern for over 30 years. To change the method of train description to the modern digital type was out of the question in the time available. Transfer receivers were therefore added on the Tonbridge panel for Headcorn and Paddock Wood, and on the Ashford panel for Headcorn descriptions.

Another interesting feature is the automatic operation of points at Bromley North. The traffic at this terminus is such that it can be handled at a single platform, and arrangements have been made to enable the signalbox to be closed, except at peak periods and when siding movements take place, and the points and signals relative to the movement of trains in and out of the one platform to be automatic when the box is closed. Hither Green observes the automatic working by

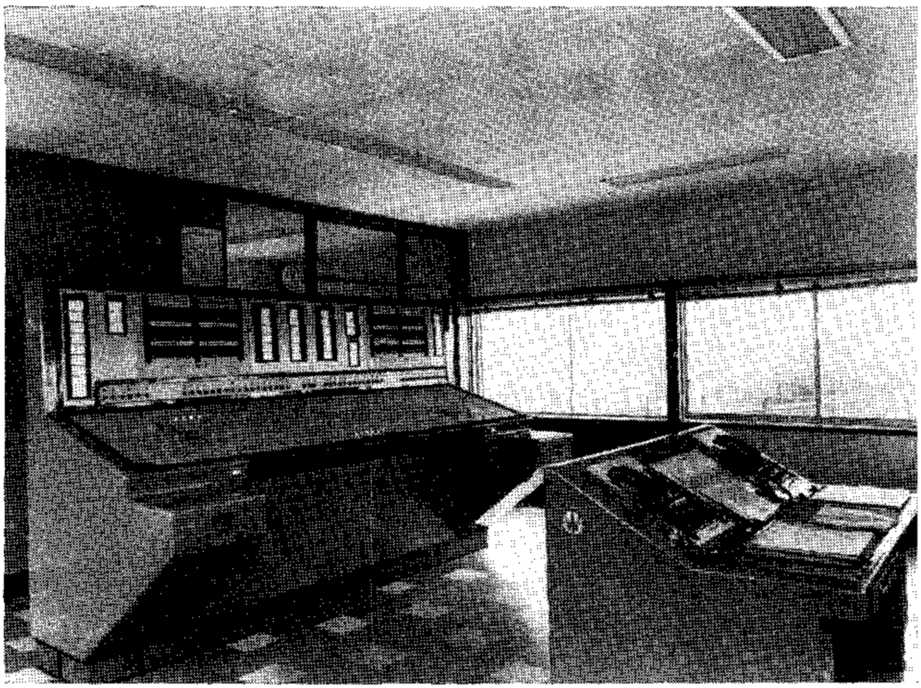


Fig. 9 Hither Green signalling panel and booking desk

means of indications on the panel at that signalbox.

The desk type of panel was chosen as being the most comfortable from a signalman's point of view, and the layout was reduced in size to a practical minimum, having regard to the indications which have to be displayed, so that minimum movement of the head is necessary to see the whole of the layout under his control.

The signalling panel at Hither Green is shown in Fig. 9.

The booking boy in a signalbox with an extended area of control is required to log the times of trains at several points during their passage through the area. This obviously requires the boy to know when the trains occupy particular track circuits. As he cannot see the panel he has been provided, on his desk, with a simplified diagram of the layout having on it such track circuit indications as he needs for this purpose (see Fig. 10). If a digital describer had been used, similar indications would also have been given, although perhaps then automatic printing would have replaced the booking boy.

Figs. 11, 12 and 13 show the signalling panels at Tonbridge, Ashford and Folkestone Junction (now Folkestone East) respectively.

The signalboxes are uniform in design, varying only in size, and Fig. 14 shows Hither Green which is typical.

Figs. 15 and 16 show respectively the relay room at Paddock Wood and the emergency signalling control panel which is provided there.

At Paddock Wood full geographical circuitry is employed. This assisted greatly in reducing the time of installation.

At Folkestone East also, full geographical circuitry has been used and Fig. 17 shows the rack units. Fig. 18 shows the overhead wiring which is neatly carried in open racking.

Experience has shown that for overhead wiring open racking is much to be preferred when installation is carried out to a tight schedule; and when geographical circuitry is adopted generally, using multicore cables between units, a very neat job is possible.

The type of signal cantilever and signal bridge are characteristic of Southern installations. They are of all-welded

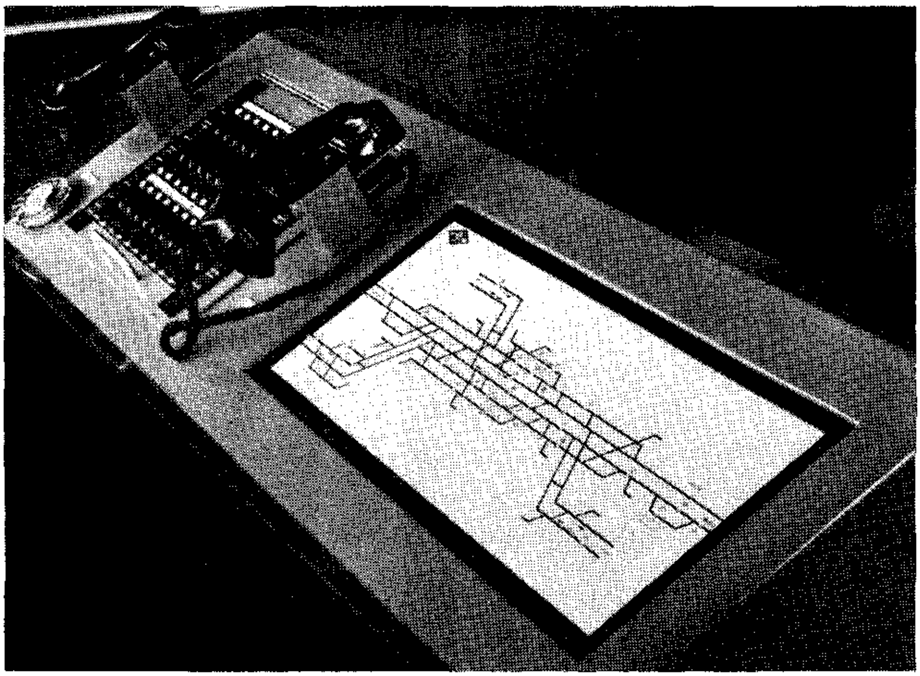


Fig. 10 Ashford booking desk (close up)

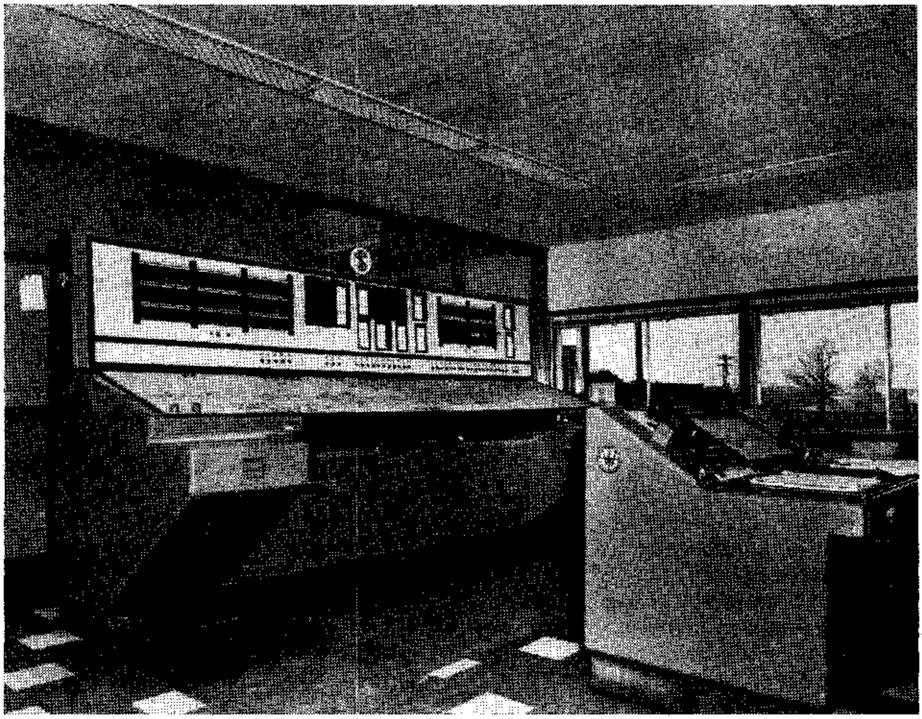


Fig. 11 Tonbridge signalling panel and booking desk

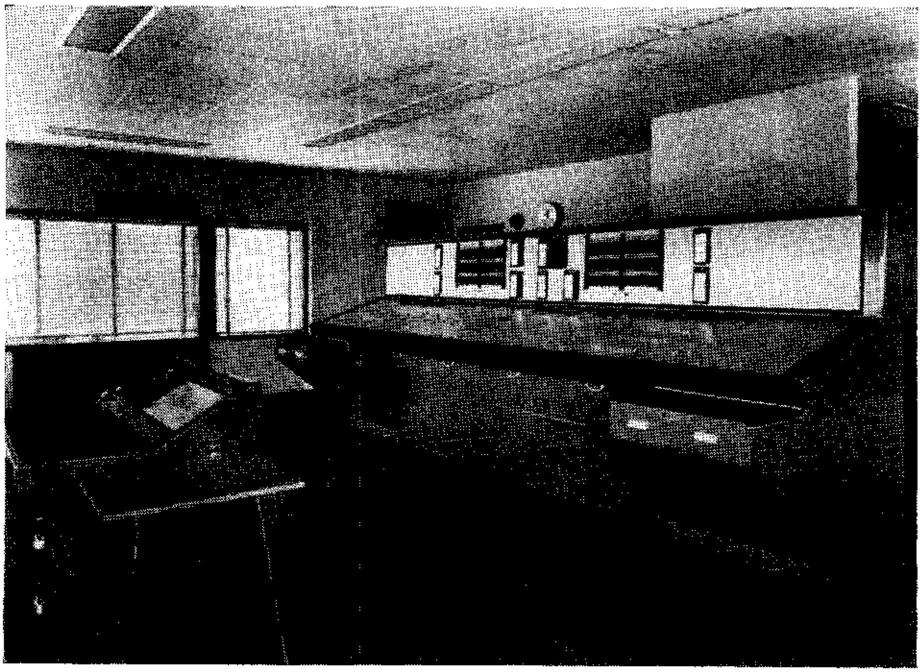


Fig. 12 Ashford signalling panel and booking desk

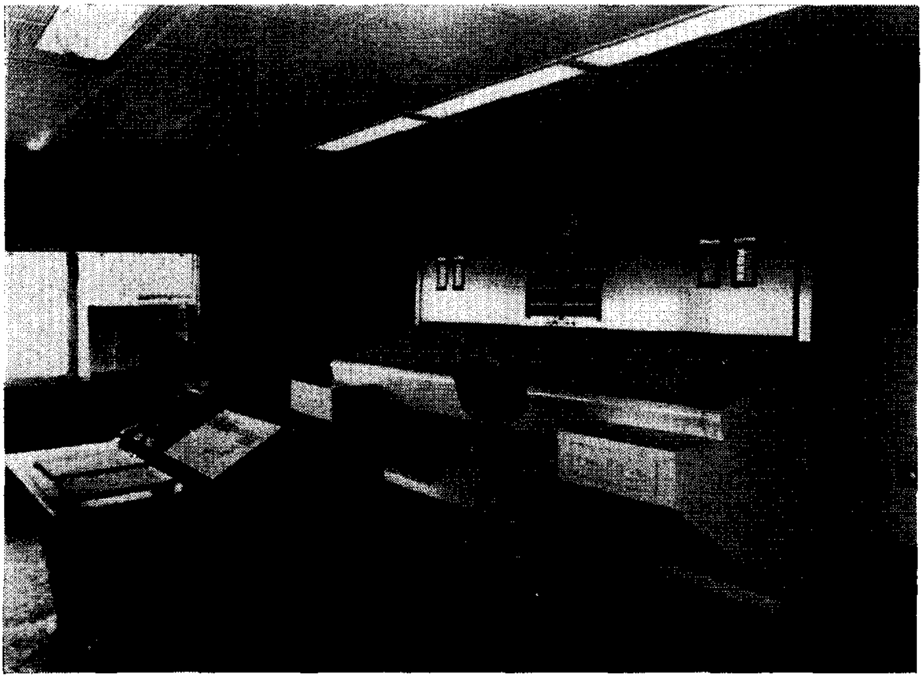


Fig. 13 Folkestone East signalling panel and booking desk

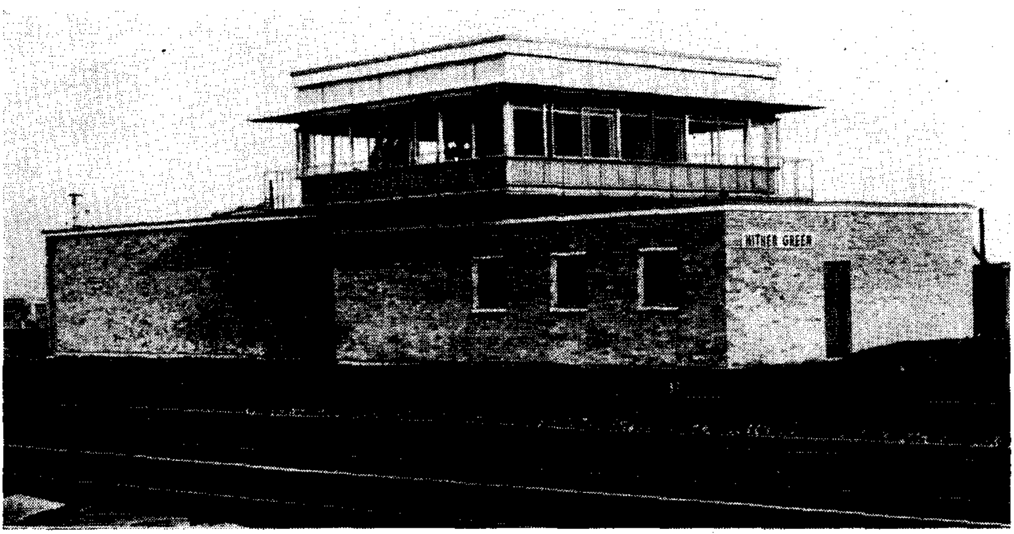


Fig. 14. Hither Green signalbox

Fig. 15 Paddock Wood. Relay Room

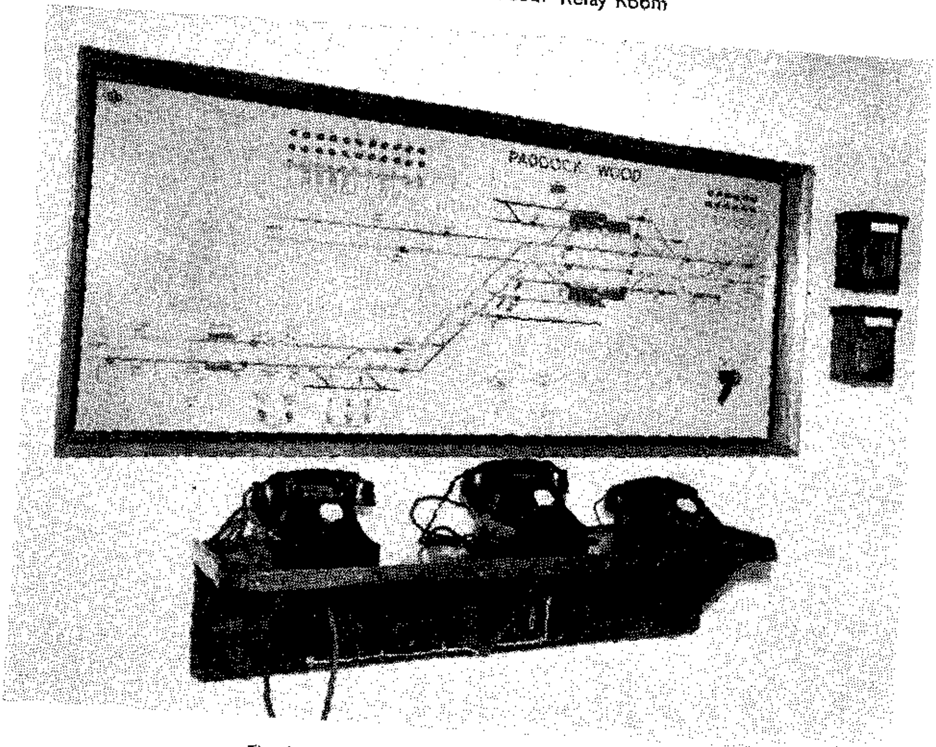


Fig. 16 Paddock Wood. Emergency Panel

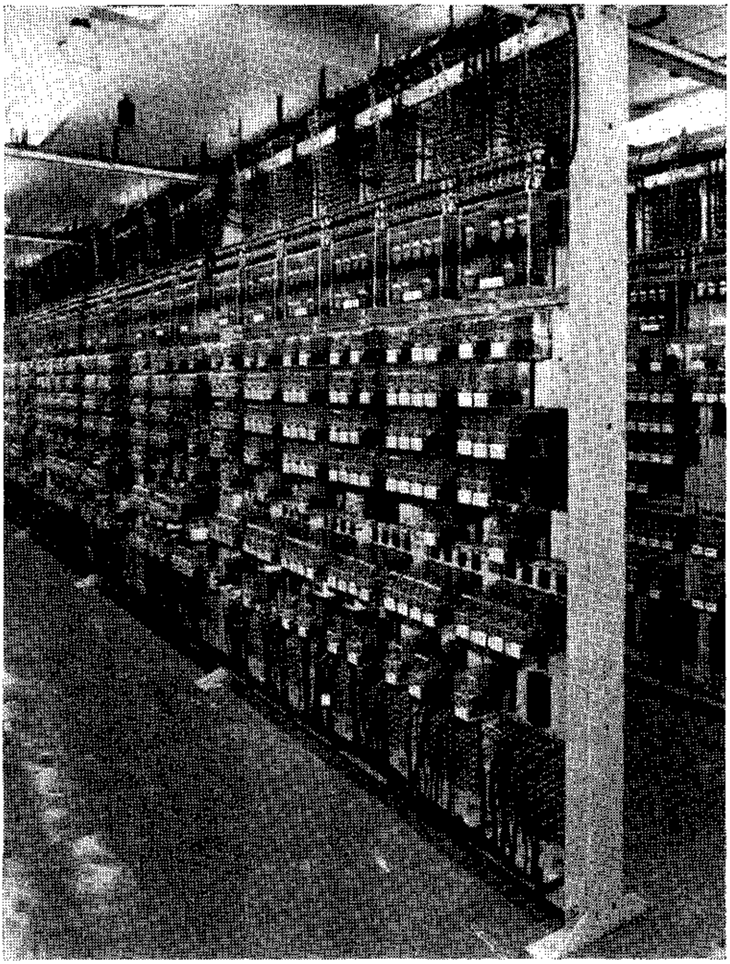


Fig. 17 Folkestone East. Geographical circuitry units

construction, with tapered horizontals. Fig. 19 shows a typical example.

The time available for installation being short, three signalling contractors were employed simultaneously. Messrs. Westinghouse Brake & Signal Company carried out the work in the area from Hither Green (inclusive) to Tonbridge (inclusive), Messrs. S.G.E. Signals Limited were responsible from there to Ashford (inclusive) and the remainder of the route to Dover was carried out by Messrs. Associated Electrical Industries—G.R.S. Ltd. It is estimated that contract work represented just over half the work done, the remainder, which included all the stage work, being carried out by Railway staff.

Particulars of the work involved in Phases I and II are given in Appendix D, and the cost and some statistics are shown in Appendix E.

One feature which has not been mentioned is the installation of stop signals in the Chislehurst (down), Polhill and Sevenoaks tunnels in order to maintain the signalling headway.

It was considered important that trains should not be stopped in the tunnel, except in an emergency. The signal at the entrance to the tunnel is therefore controlled by the track circuit applicable to

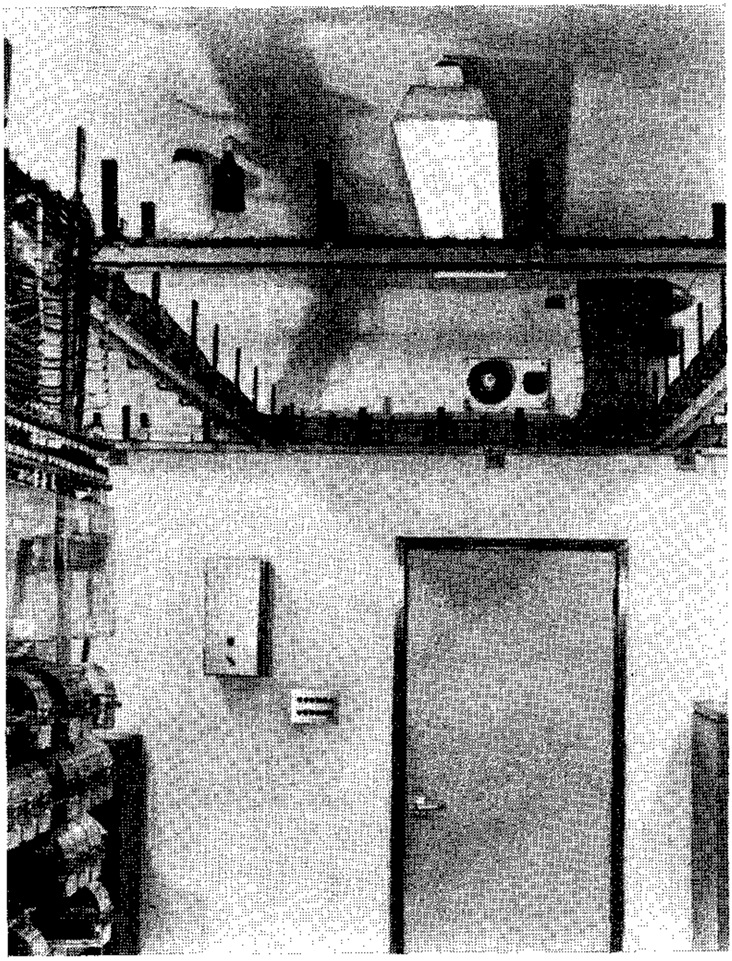


Fig. 18 Folkestone East. Overhead wiring in relay room

the tunnel signal unless the signal at the exit is "off".

It is of interest to note that from Charing Cross to Dover via Tonbridge, some 10% of the line is in tunnel.

Signalman's work load

It was felt that some measure of the work performed by a signalman at a busy box should be obtained for future use in determining the number required to operate a particular panel. It is necessary to know how many signalmen are to operate a signalling panel and the division of work before the route initiating circuits are designed. If no account is taken of this fact it is likely that in operating the panel one signalman, in setting up a route, may cancel a route initiation by his partner, with resultant confusion.

To get a basis of comparison, data was first collected at Waterloo, which is a non-route operating miniature lever frame, where practically every point lever is restored after use. It was found that on an average day, 5,871 point lever movements were made which, incidentally, was found to result in 10,068 point machine operations. It is estimated that the number of signal lever movements totalled 6,936, including replacement, so that the total number of lever movements per day is 12,807.

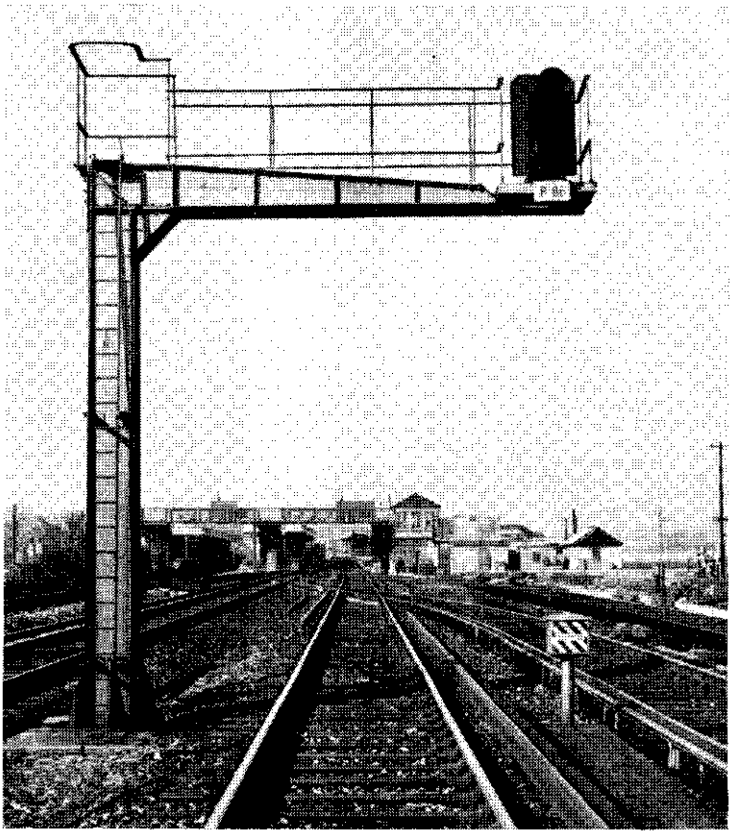


Fig. 19 Signal on cantilever structure

This load is borne by 4 signalmen, on early and middle turns, and 3 signalmen on the late turn when traffic is very light by comparison. From this it may be estimated with reasonable accuracy that on the early and middle shifts, each signalman pulls or replaces 1,440 levers, and does not appear to be overloaded, even at peak traffic periods. In fact, this is one of the characteristics usually noticed by visitors to the signalbox at those times.

Corresponding data was then obtained at Hither Green, which, in addition to controlling through traffic on 2 up and 2 down lines, also controls traffic into and out of the Continental Goods Depot on the up side and the marshalling yard, carriage sidings and diesel depot on the down side. The result is shown in Fig. 20.

Each route operated involves the depression of two buttons for setting up and the pulling of the entrance button for cancellation, i.e. three push button movements. The maximum load borne by any of the signalmen during the typical week shown on the graph is 850 routes, per shift, or 2,550 push button movements.

If Waterloo were route-operated on the same principle as Hither Green, the corresponding figure for the present area of control is estimated to be only 1,267 push button movements. In making this comparison, however, it should be noted that the area controlled by Hither Green involves 26 track miles whereas the corresponding figure for Waterloo is only $9\frac{1}{2}$ track miles.

At Waterloo, the signalmen have relatively little telephone work to do, but at Hither Green it is considerable owing to the shunting work, and the greater area of control. This factor has also been the

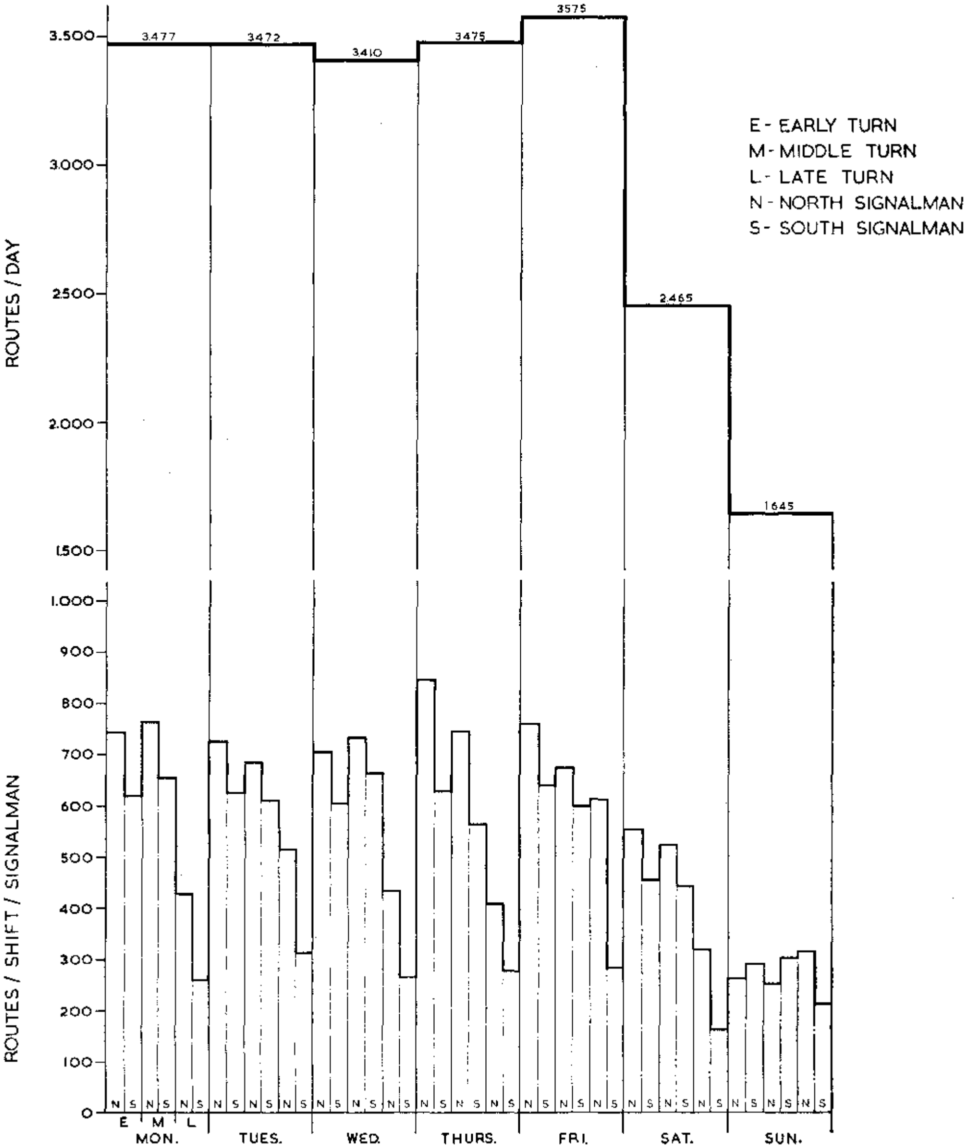


Fig. 20 Hither Green. Routes operated by signalman in a typical week

subject of investigation at Hither Green.

At that signalbox, there are two telephone concentrators, one for each signalman and two identical concentrators on the booking desk, one for each boy. Those on the panel are connected to signal post telephones, shunters telephones and the like, whilst those on the booking desk are connected to general circuits.

In a period of 18 days, the following numbers of calls were recorded :—

Signalling Panel north	*Signalling Panel south*
2,650	2,218
Booking desk north	*Booking desk south*
5,880	6,731

From observation, it may be assumed that the signalmen do not themselves speak to the caller on more than one third of the calls received at the booking desk, but they do answer all the calls received on the signalling panel. It may also be assumed that the calls are spread fairly evenly over each shift since, when through traffic ceases at night, there is considerable shunting.

This leads to the estimate that, on an average shift, the North and South signalmen each deal respectively with about 80 telephone calls.

Taking everything into account, and bearing in mind that the signalmen are kept fairly busy at Hither Green, the author concludes that the maximum work load for a signalman on a route setting panel is 900-1,000 routes per shift, depending on the amount of telephone work.

Some aspects of standardisation

The writer is a firm believer in the benefits to be gained from standardisation. The main reason why so many installations were brought into use in the period 1925-1940 was the severely practical standards which were adopted right from the start.

Many of these standards have been discarded in the light of modern developments, e.g. power lever frames for route

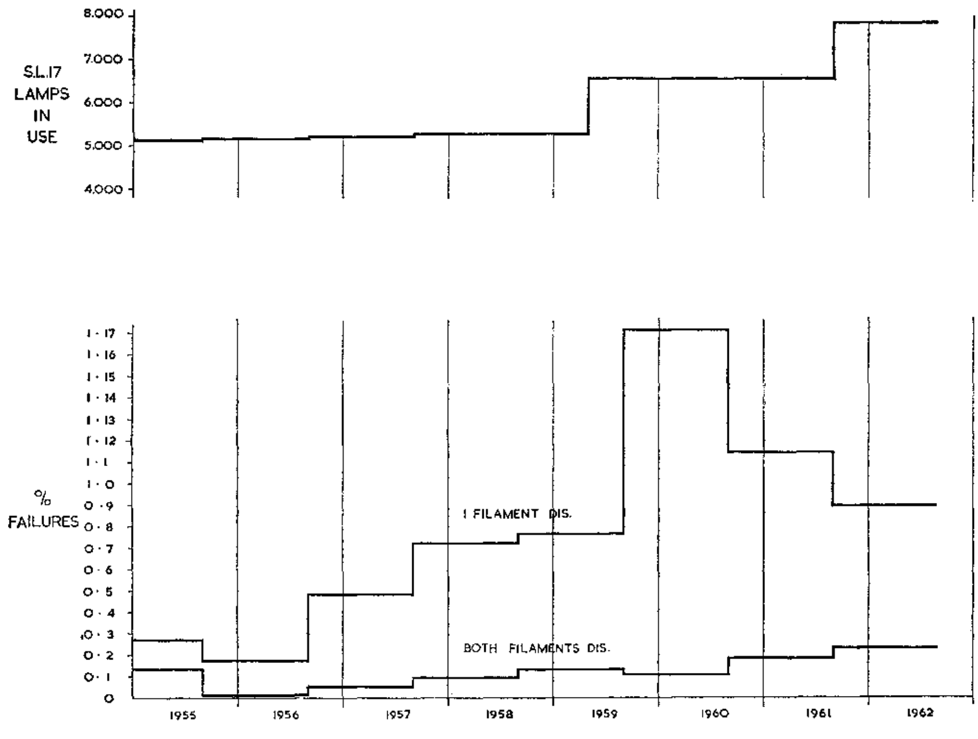


Fig. 21 SL.17 lamp failures

operating panels and miniature plug-in relays for shelf mounted relays, but it is difficult to resist the comment that some standards which have been adopted do little more than increase signalling costs.

One example is the adoption of the independent double filament lamp which, on the Southern, will replace the parallel burning filament SL.17 lamp which has been used since the earliest colourlight signals were installed in 1926. This lamp now exists on over 900 track miles of continuous colourlight signalling, but, admittedly, the beam candle-power of its auxiliary filament, burning alone, is not as good as the lamp which has been adopted, although it is nothing like so different as is popularly thought. The aspect displayed by the SL.17 lamp may be safely assumed to be adequate after 36 years without complaint. The standard lamp is, in addition, required to have proving circuits which will add some £50-£70 to the cost of each signal. Fig. 21 shows the failures of SL.17 lamps which have occurred on the Southern Region in recent years, and in this connection, it should be remembered that in the case of both filaments failing, the side light will still be present. It should also be noted that independent double filament lamps are used for isolated colourlight signals, such as distant and I.B. section signals.

Another example is the adoption of the 5-lamp junction indicator. The displayed aspect is certainly better than the 3-lamp type which the Southern has used for 26 years, again without complaint, but surely before a higher standard is adopted, it should be ascertained whether the existing standard is inadequate.

The writer makes use of these two examples to reinforce a plea that in such cases, if the cheapest, satisfactory piece of equipment cannot be adopted as a standard, and other circumstances do not demand a change, it should continue to be acceptable where it is in use in quantity.

Justification of signalling schemes

At the present time in every Region the management is insisting that a handsome return must follow the investment of new capital. This means, for instance, that signalling in connection with an electrification scheme which shows an adequate return is accepted, but if the signalling scheme has to stand alone because it is brought about by the need to renew, the same demand for a return is still made.

The difficulty in showing a return lies in the fact that mechanical signalling is much cheaper than power signalling. The difference between the like-for-like renewal in the simplest form (which is supposed to exclude the standard betterments) and the cost of the project is rightly held by the Accountants to be new capital for which a high rate of interest is demanded. Bearing in mind the increased maintenance and renewal charges for the new installation it needs little imagination to see that far from there being a return on the scheme there may well be an annual debit.

Sometimes it is possible to dispense with existing connections to such an extent that the maintenance and renewal charges saved by the Chief Civil Engineer will result in an overall annual saving, but such cases are rare, and, in the author's view, it is putting a premium on inefficiency.

What is needed is a policy. At present, semaphore signalling is accepted without question. All Operating Officers know the advantages to be gained from multiple-aspect signalling, but it is not yet accepted as the right and proper replacement for outworn mechanical signalling.

It seems to the author that the cost of signalling should be related to the amount of traffic to be handled during the life of the signalling. In a recent example worked out for a renewal scheme on the Southern Region it was found that if the cost were considered to be borne by the traffic passing through the installation area during its working life of 25 years, the operating cost in that area would be reduced by 2.67d. per train mile, which seems to put an entirely different complexion on the matter.

In the present climate it is doubtful whether certain of our Southern schemes of the past would have been authorised. For example, the Central Section Scheme did not materialise to cope with increased traffic, but to enable existing traffic to run better. It was a policy decision which has never been regretted, but on the strictly financial grounds which would apply to it today, could not be justified.

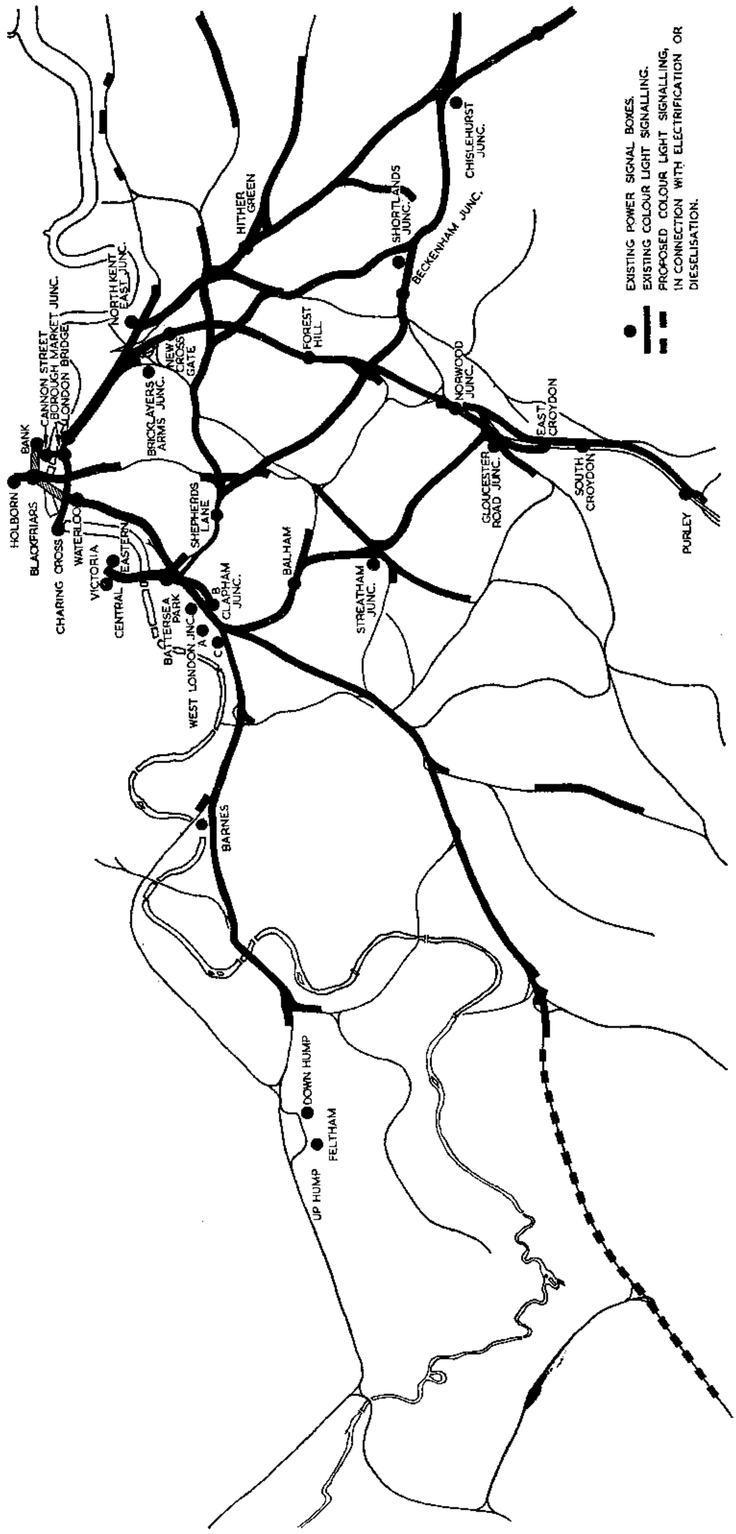


Fig. 22 Continuous colourlight signalling on Southern Region as at 31.12.62. London Area

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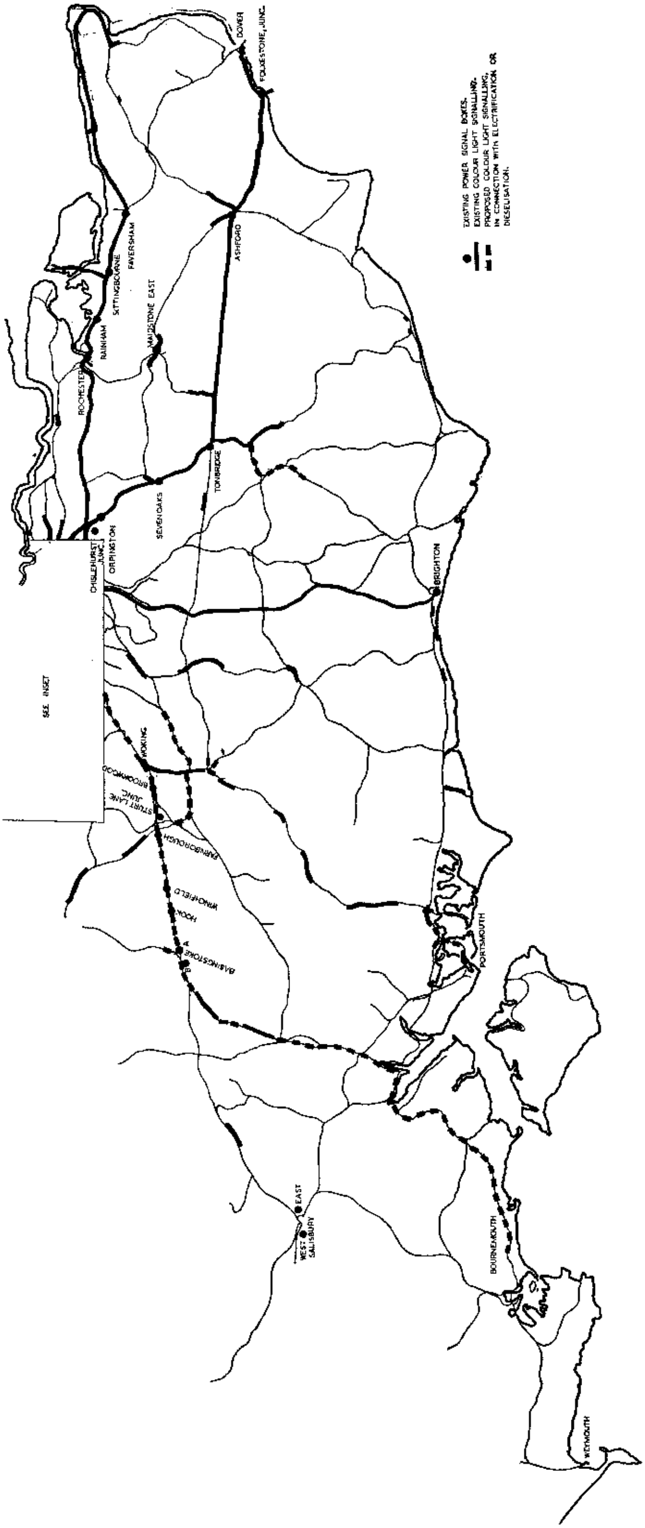

Fig. 23 Continuous colourlight signalling on Southern Region as at 31.12.62

Obviously every line does not justify multiple-aspect signalling and it is not unreasonable to relate it to the traffic handled, coupled with increased safety and better train running.

Conclusion

It is recognised that the character of the traffic on the Southern Region differs from that of most others, but from a signalling point of view, the only difference is that the traffic is generally much denser.

The proportions of the various types of traffic differ from other Regions, but all types have to be dealt with. Multiple-unit electric stock varies from 550 H.P. 2-car sets to 4,000 H.P. 14-car boat trains, with good acceleration and pneumatic and electro-pneumatic braking. Locomotive-hauled stock with vacuum braking must be catered for in the signalling, as must unfitted and fully-fitted freight trains, just like any other Region. But above all, every train must be timetabled, or run in a spare path. Train Regulators in signal-boxes are considered unnecessary (although in one or two cases there are Yard Inspectors with a different function), and train supervision offices have only a faintly similar function to the train control offices elsewhere.

The Southern Region at the present time, is not far off being a profitable concern. Further investment would increase traffic to make it so, and in this the signalling side would play its part.

Finally, the Author would like to thank those members of his staff who have helped so willingly in the preparation of this paper.

APPENDIX A

NUMBER OF PASSENGER TRAINS AND PASSENGERS DEALT WITH AT LONDON TERMINAL STATIONS ON AN AVERAGE DAY IN 1959

Station	Number of Tracks		Trains Per Day	Passengers Per Day
	Up	Down		
South Eastern Division				
Holborn, Blackfriars, Elephant & Castle	2	2	321	66,839
Cannon Street	3	3	308	74,939
Charing Cross	2	2	686	121,947
Waterloo (Eastern)	2	2	—	26,017
London Bridge [1]	5	6	857	197,216
Total			2,172	486,958
Central Division				
Victoria [2]	4	4	973	158,561
London Bridge		See S.E.	Division	
South Western Division				
Waterloo	4	4	1,267	186,346
Waterloo & City	1	1	358	42,118

Note 1 :— Number of trains refer to those terminating and starting from London Bridge. Number of passengers include those alighting and joining other trains.

Note 2 :— Includes S.E. Division services, except Continental.

Gross totals per day [3]
4412 trains, 831,865 passengers.

Note 3 :— Excludes Waterloo & City.

Gross total of passengers arriving in heaviest hour—181,274

APPENDIX B

CONTINUOUS COLOURLIGHT SIGNALLING INSTALLED 1925-1940

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
21st Mar. 1926	Holborn to Elephant & Castle	$3\frac{3}{4}$	Holborn Blackfriars Jct.	86L 120L
27th June 1926	Charing Cross to Borough Market Jct. & Cannon St.	$9\frac{3}{4}$	Charing Cross Borough Market Jct. Cannon St. (Old Box) (new box 15.12.1957)	100L 35L 140L
17th June 1928	London Bridge	15	London Bridge	311L
30th June 1929	St. Johns, Parks Bridge & Branches	$14\frac{1}{2}$		—
1st Dec. 1929	Spa Road to New Cross	$16\frac{1}{4}$	North Kent East Jct.	83L
5th June 1932	Coulsdon Nth. No. 2 to Balcombe Tnl.	$54\frac{3}{4}$		—
12th June 1932	Haywards Heath	8		—
6th Oct. 1932	Balcombe Tnl. to to Clayton Cutting (excl. Haywards Heath	$29\frac{1}{2}$		—
16th Oct. 1932	Preston Pk. to Brighton	$12\frac{3}{4}$	Brighton	225L
8th July 1934	Sole St. to Rochester Bge. Jct.	$7\frac{3}{4}$		—
16th Feb. 1936	Streatham Common to Thornton Heath	$4\frac{1}{2}$		—
17th May 1936	Malden to Vauxhall	$49\frac{1}{2}$	Clapham Jct. 'A' West London Jct.	103L 59L
28th June 1936	Hampton Court Jcn. to Malden	$15\frac{1}{4}$		—

APPENDIX B—(*cont'd.*)

CONTINUOUS COLOURLIGHT SIGNALLING INSTALLED 1925-1940

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
18th Oct. 1936	Vauxhall to Waterloo	9½	Waterloo	309L
2nd May 1937	Coulsdon North	2¼		
20th June 1937	Portsmouth Harbour	1½	(new power signalbox 1.6.1946)	—
27th June 1937	Woking to Guildford	25¾	Woking	131L
	Stockheath Crsg. to Farlington Jct.	5¼		—
18th July 1937	Haslemere	4¾		—
24th April 1938	Horsham	6		—
1st May 1938	Havant	4½		—
15th May 1938	Dorking North	5¾		—
16th Oct. 1938	Battersea Park Jc. & & Battersea Pier 'A'	5¾	Battersea Park Jct.	31L
4th June 1939	Victoria Central	7	Victoria Central	225L
25th June 1939	Victoria Eastern	6	Victoria Eastern (existing G.R.S. Co.'s frame)	174L
28th Jan. 1940	Richmond	4¼		—
26th May 1940	Clapham Jc. 'E' to Point Pleasant Jc.	5¼	Clapham Jct. 'E' (existing E.P. frame)	40L
27th Oct. 1940	Waterloo and City	3¼	Bank (panel with auto working facilities)	4R
		Total 338		

APPENDIX C

CONTINUOUS COLOURLIGHT SIGNALLING INSTALLED 1945-1958

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
1st June 1946	New signalbox (existing box destroyed by enemy action 10/11.1.41)		Portsmouth Harbour	47L
11th Aug. 1946	New Signalbox (Existing signalbox destroyed by enemy action 19.4.41)		Blackfriars Jct.	119L
8th Oct. 1950	Bricklayers Arms Jct. to Anerley	26	Bricklayers Arms Jct. New Cross Gate Forest Hill	55L 71L 47L
5th Oct. 1952	Streatham Common to Selhurst Jct.	9¾		—
12th Oct. 1952	Pouparts Jct. to Streatham Common & Branches.	31¾	Clapham Jct. 'B' Balham Streatham Jct.	103L 43L 79L
21st Mar. 1954	Norwood Jct. Gloucester Rd. Jct. & Branches	18¼	Norwood Jc. Gloucester Rd. Jct.	107L 131L
8th May 1955	East Croydon to Coulsdon North	25¼	East Croydon South Croydon Purley	103L 31L 71L
2nd June 1957	Frant to Wadhurst	10½		—
15th Dec. 1957	New Signalbox (existing box destroyed by fire 5.4.57)		Cannon Street	167L
22nd Mar. 1958	Keymer Crossing	1½	Keymer Crossing*	11R
		Total 122½		

*Miniature panel in mechanical box

APPENDIX D

CONTINUOUS COLOURLIGHT SIGNALLING INSTALLED 1959-1962

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
8th Feb. 1959	Wandsworth Road to Denmark Hill	5½		—
22nd Feb. 1959	Point Pleasant Jct. to Richmond	16¾	Barnes	46R
8th Mar. 1959	Factory Jct. to Herne Hill & Nunhead	19½	Shepherds Lane	23L
22nd Mar. 1959	Nunhead to Beckenham Hill	5½		—
12th April 1959	West Dulwich to Beckenham Jct.	12½	Beckenham Jct.	49R
26th April 1959	Beechings Crossing to Newington	15	Rainham	23R
3rd May 1959	Graveney Crossing to Westgate-on-Sea	31½		
10th May 1959	Farningham Road to to Gillingham	27¾	Rochester Farningham Road*	43R 4R
24th May 1959	Western Jc. (Sittingbourne) to Graveney Crsg.	38¾	Faversham	70R
			Sittingbourne Field Stations:— Kemsley Halt Swale Halt Queenborough Sheerness	63R)) 5R) 4R) 13R) 15R) Total:— 100R
31st May 1959	Beckenham Jct. to Swanley & Bches.	59	Shortlands Chislehurst Jct.	52R 87R
7th June 1959	Cuxton Road (re-signalling)	—		—
19th July 1959	Westgate-on-Sea to Ramsgate	17¾		—

* Miniature panel in mechanical box as total 100R relates to Sittingbourne and satelites only.

APPENDIX D—(*cont'd.*)

CONTINUOUS COLOURLIGHT SIGNALLING INSTALLED 1959-1962

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
18th Sept. 1960	Minster to Ramsgate	$6\frac{3}{4}$		—
17th Dec. 1961	Folkestone Harbour	$0\frac{3}{4}$		—
4th Feb. 1962	Hither Green to Elmstead Woods & Branches	26	Hither Green	147R
18th Feb. 1962	Smeeth to Archcliffe Jct. & Branches	$36\frac{1}{2}$	Folkestone Jct.	123R
4th Mar. 1962	Orpington to Tonbridge 'A' & Branches	$36\frac{3}{4}$	Orpington Sevenoaks	57R 62R
18th Mar. 1962	Tonbridge to Paddock Wood & High Brooms	$18\frac{3}{4}$	Tonbridge (exclu. Paddock Wd. & Headcorn)	143R (total 190R)
25th Mar. 1962	Tunbridge Wells Ctl. Goods & Grove Jct.	6		—
1st April 1962	Paddock Wood & Branch to Headcorn	$32\frac{3}{4}$	Paddock Wood (emerg. control) Tonbridge Headcorn (when closed) Tonbridge	43R 4R
8th April 1962	Maidstone East	$5\frac{1}{4}$	Maidstone East	47L
29th April 1962	Headcorn to Westenhanger & Branches	$43\frac{1}{4}$	Ashford (exclu. Headcorn) Headcorn (when closed) Ashford	271R 4R Total: 275R
27th May 1962	Chislet Colliery	$3\frac{1}{2}$		—

*Miniature panel in mechanical box

APPENDIX D—(*cont'd*)

CONTINUOUS COLOUR LIGHT SIGNALLING INSTALLED 1959-1962

Date	Line	Track Miles	Power Signal Boxes	No. of Lever (L) Routes (R)
14th Oct. 1962	Streatham Jct. to Mitcham Jct.	$3\frac{1}{2}$	Eastfields Road Crossing	2R (plus barriers)
15th Dec. 1962	Denmark Hill (abolition of box)	$3\frac{1}{2}$		—
		Total $472\frac{3}{4}$		

GRAND TOTAL $933\frac{1}{4}$

APPENDIX E

KENT COAST ELECTRIFICATION

SIGNALLING COSTS AND DATA

CONTINUOUS COLOURLIGHT SIGNALLING AREA

	Phase I	Phase II
Route miles	97	95
Track miles	230	212
Cost	£4.3m.	£4.4m.
Cost per track mile	£19,000	£20,750
Single rail track circuits	351	446
Double rail track circuits	579	515
Multiple-aspect signals	361	347
Shunt signals	279	233
Point Machines	275	447
Cost per running signal	£12,000	£12,750
Planning commenced	Mid 1956	Mid 1959
Tenders accepted	May 1957	September 1960
All installations in service	July 1959	April 1962
Like for like renewal cost	—	£1.94m.
Additional capital required	—	£2.46m.
Train miles in area (new service)	—	23,000 per day
Net increased annual charges, including interest at 6%	—	£193,000
Additional cost per train mile during life of installation	—	5.5d.

DISCUSSION

Mr. A. A. Cardani, opening the discussion, said that this excellent Paper called for admiration for the achievements on the Southern Region, and not without a little envy from other quarters somewhat less fortunate. He rose therefore to the defence of the tripole lamp which the author had questioned as an alternative to the SL.17.

The author mentioned the additional first cost of the tripole lamp—a little bit excessively perhaps—but it was modest in relation to the savings in routine lamp changing which the tripole lamp made possible. From figure 21 he took it that, ignoring partial failures, a 0.2 per cent total failure rate in something like 8,000 lamps represented something like 16 total failures a year. On the Western Region, with approximately about one third of that number of lamps in service, but which were of the tripole type, the number of total failures which have been brought to his notice over a period of three years had been only one. Not only that; they had not set up any routine changing, but allowed the lamps to run until the main filament failed. They got a life several times better than the rated 1,000 hour.

He was also very interested, and thanked the author for the information about the loading of the signalmen operating panels, and, in particular, the fairly large part that telephone work played. On the Western Region they had had occasions where it had been the telephone load that had been the "straw that had broken the camel's back", and had made an additional man necessary to operate the panel. He wondered if the author had given any thought to mechanising some of the more standard or repetitive telephone messages to avoid verbal exchanges? These could be very time-consuming.

Turning to the justification of signalling schemes, he felt he must challenge a paragraph where the author referred to dispensing with existing connections, as putting a premium on inefficiency. He did not think that was necessarily so. Surely the change from mechanical semaphore signalling to power signalling, with the greater fluidity it brought with it, can prompt connections to be given up. He was thinking more particularly of loops and side-tracking facilities, in which case he thought they were a fair and proper claim for the scheme.

Another feature that perhaps the author might care to cover was the question of quantifying the train delays which a resignalling scheme could save.

And finally, seeing that perhaps they were in for a series of Arctic winters, he wondered if the author would support him in the claim that power signalling rendered railway operations so much more immune from severe weather, that that in itself could be a selling point, if not a point of justification.

Mr. L. J. M. Knotts, considered that Mr. Tyler's Paper was a valuable historical document, quite apart from its extremely interesting technical, financial and operational content.

As an old Southern man he should perhaps not be critical of that Region's methods, and he was not prepared to be highly critical, even if he could be, because he was well aware of the various considerations which had governed the policy in the past and which continued to some extent at present. Mr. Tyler did not indicate, as Mr. Cardani had mentioned, that his Region's practice involved lamp changing. He did not indicate disagreement with the use of parallel filament lamps in the signals, but confined himself to pointing out the experience and results with the SL.17. He made a very good showing for it, and Mr. Knotts thought quite rightly so. He too would like the author to enlarge on the question of lamp changing periods and also to what extent he considered that lamp changing was necessary. The merits of the S.L17 versus the independent double filament lamp could be argued, but like many another question, it often became a matter of opinion as to what was best, and he suggested this might in part answer the point he made on page 192 where he stated that before a higher standard was adopted it should be ascertained whether the existing standard was inadequate. Incidentally, could it be said that the existing standard was in fact, universal on British Railways? If Mr. Tyler agreed that the signal ahead should be proved to have been at red before the signal on the approach to it could display a "proceed" aspect would he not agree that the proving of the integrity of the filament was very desirable? Perhaps this, too, could be considered a matter of opinion, but he might feel strongly on the point.

In conclusion Mr. Knotts wished to join with the author in his happy and appreciative reference to Mr. W. Challis, who did so much pioneer work in colour-light signalling. Also to congratulate him on the very useful new ideas on the work load for signalmen in operating route setting systems. He thought all this was very timely, and had in the past been somewhat conjectural, rather than having been subjected to the objective analysis he had now made. Perhaps the operating department had within the last few years obtained a good deal of experience with these new installations, and had learned to judge the probable manning required; but the analysis which he had prepared would be of great interest to them and provided a very useful yardstick.

Mr. R.C. Hider, said he would like to ask Mr. Tyler if he had invented or used any other checks on the work load that he might put on the signalmen, other than the number of push-botton operations. He was thinking from the observations of the diagram and other indications that he had made a rather interesting reference to the number of telephone calls that had to be made. It occurred to him that perhaps it might be necessary to take account of features such as those in determining the load that might be put on the signalman.

Mr. F. W. Young, in continuing the discussion said that in taking the reference to justification and financial losses, one must agree with Mr. Tyler that the fundamental requirement was agreed policy.

He wondered if they ought not to devise —and he thought it should not be beyond the wit of the signal engineers—a basic formula which would take into account the financial values of the reduction of delays, more efficient shunting, and greater efficiency in bad weather resultant upon new signalling; but having devised such a formula, which he thought they could probably find acceptable to themselves, the great problem would then be to devise means of persuading their colleagues to accept it.

On the purely practical aspect, he would like to raise two particular points. One was with regard to the P.C.P. corrugated steel cable. On the Southern Region they now had very wide experience with this type of cable, and where it was used for track circuit connections it was the practice to use a metal disconnection box, which was obviously fairly costly. He wondered whether it had been thought that the time had been reached when perhaps the disconnection box could be dispensed with, and in lieu cut back the steel armouring sufficiently far to permit direct connection to the rails, taping it up with one of the modern plastic tapes and protecting the conductor in the four foot with a plastic sleeve, thereby eliminating the obstruction and reducing the overall cost. He would welcome the experience of the Southern Region on this point.

One other practical point: Mr. Tyler said that geographical circuitry was employed at Paddock Wood for the first time. Did experience show that it was feasible to do any extensive pretesting of the units; and if that was possible, did that produce the net result of a considerable reduction in testing time on site?

Lastly, in the early part of the Paper, Mr. Tyler had made reference to the change that had to be made by the Southern, by the employment of contractors to carry out physical work. As he had said, that was obviously a very great wrench, but was unavoidable for the reasons he quoted.

He wondered whether the change from the previous method, when only railway forces had been employed, in order to achieve greater output, had produced any special problems either in recruitment or training of staff for the maintenance of the mass of new signalling. If so, was it necessary to take any special steps to meet this new problem.

Mr. J. H. Currey said he was interested in the various references to the testing periods, and the period of possession. Referring to the 8 hours for the type of scheme on the Southern he would like to ask whether the 8 hours was absolute possession, with no trains running at all except those required for the work in hand. To have no traffic at all was a great advantage, because of the very rigid schedule. All work could be laid down beforehand, and should be very well adhered to. It was worth spending a lot of money, which in the end was a very small part of the cost of a major changeover scheme but ensured that work went smoothly during the changeover period. The traffic was known, of course, beforehand from the timetable; but unfortunately, on the day, it did not always run to the timetable, and considerable difficulties could arise from that point of view.

He would like to go back to the question of the SL.17 lamp. While he had no real disagreement with the parallel filament lamp itself, he was very surprised that Mr. Tyler should uphold so much the SL.17, which he had always thought was one of the worst types of parallel filament lamps ever devised. He was rather reserved on the light output of that second filament. In actual fact on the SL.17, while the second filament could get a little extra voltage, by the practice adopted of having a transformer with poor regulation where it is run on A.C.—so that when the main filament burns out the voltage rises—, that could not be done on a battery, and under the best conditions of voltage that secondary filament was out of focus and light output dropped to 50 per cent of the full output. Under the worst conditions indeed it might be down to only 30 per cent. Could that really be considered a satisfactory signal for a driver to come up against unexpectedly in bad weather conditions. He would hesitate to consider it a safe lamp to work on its auxillary filament.

There was one point which was a little noticeable in that graph which Mr. Tyler showed: the percentage rate of total failures of the lamp had been increasing over the whole period. It was not only a question of the total failures increasing. The actual percentage failures of those in use did show a continual increase. Did the author think there was any particular reason for this. Did he blame the lamp manufacturers?

Mr. A. R. Brown said that Mr. Tyler had left severely alone one aspect of the introduction of a new signalling scheme of a major nature, and perhaps he could enlighten them a little on that. That aspect was the maintenance, and its costs for a scheme of such a nature. Could he tell them if the maintenance staff now was larger in numbers than before? Had the number of technicians been increased, and what was more important, did it cost more to maintain that section than it did prior to its installation?

Mr. H. W. Hadaway said that Mr. Tyler had given great emphasis to the subject of the signalman's work load, and from the experience he had had in that matter, it was a subject that was worth exploring; he was interested to know that the Southern Region did devote so much time to that particular point. Mr. Tyler had examined other systems both here and abroad; and knowing that systems existed where a route operation was made by one push-button movement he wondered why he had used a system which required three push-button movements for each route operation. He would be interested if Mr. Tyler would explain the factors which had led him to the conclusion that this was the best method, when obviously there was so much desire to cut down the work of the signalman.

The second point follows up the matter that Mr. Currey spoke about concerning the changeover arrangements, and Mr. Tyler's statement that changeovers had to be carried out completely within the period of 8 hours. Mr. Currey mentioned that a lot depended upon whether you had possession or partial possession for traffic movement during that time. He would like to assume that you had complete possession, and that you would not have train movements at all. But there were many types of changeovers. A major changeover involving an existing installation, such as Waterloo, would seem to present many difficulties in the way of completing the changeover and the testing involved with a period of 8 hours. It would demand much detailed organisation and the setting up of firm principles, and he wondered if Mr. Tyler could tell them how he would achieve that result.

Mr. E. G. Brentnall, said that in congratulating Mr. Tyler on his Paper, he would be congratulating him still more on the success of the inauguration of Phase 1 and Phase 2 schemes. They had been magnificent efforts.

In noting the times in which the two phases had been completed, he was forced to the conclusion that the Traffic Department seemed to make up its mind quicker on some Regions than on others! Also, Mr. Tyler had been able to plan his schemes without concerning himself as to any effects from A.C. traction.

He did not propose to join in the arguments about the advantages of the tripole lamp over the SL.17 lamp, except to say that he agreed with everything all the people taking part in the discussion had said about the tripole lamps!

Mr. Tyler had mentioned that he felt some interest should be taken in the financial arrangements of the advantages due to colour-light signalling, and Mr. Brentnall agreed whole-heartedly with him on that point. He considered that they should compare not only the running of trains, but the saving in staff and particularly the effect which they had experienced on the L.M. Region when signalmen failed to turn up for duty.

On the L.M. Region they made an attempt recently, on a small scale, to try and assess what savings did accrue on a section of line of 15 route miles between Crewe and Liverpool which includes territory covered by a relatively small route relay power signalbox at Weaver Junction. Detailed examination had been made of box-to-box running for one summer and winter week in 1960 prior to modernisation, and for the same weeks in 1961 after completion of modernisation. In addition to the signalling remodelling the track had been improved by the installation of fast-running junctions at Weaver Junction to allow for greater speeds through them.

The results were rather startling. There were approximately 6,000 trains of all types, and of these improved running had occurred to 977 of them with saving in train hours of 198. Two loops were concerned in the section under review, and reduced standing time in these concerned 156 trains and 76 train hours. This improved working over 15 route miles is equivalent to 7,124 train hours per annum, or 475 train hours per route mile per annum.

He appreciated that if a train got to its destination earlier, it might stand there for a longer time; but in the aggregate, with a large number of trains, surely it would be possible to save locomotive time. It should be borne in mind that the percentage saving reduction in time for trains put into the loops was 54 per cent, with a reduction of the time in the loop per train of 37 per cent. These were substantial figures, and he felt they should be considered in estimating the financial results.

He did not agree with Mr. Tyler, as Mr. Cardani had already pointed out, that cutting out of junctions was not worthwhile, bearing in mind that the cost of a double junction was of the order of £30,000, and that of a loop £20,000.

Mr. R. Dell said he would like to add his tribute to the very great development which had been made by the Southern Region in signalling. Their problem was very similar to those which they had on London Transport, and they had always tended to look upon the Southern very much as contemporaries in signalling development. So far as practically all the items in the Paper were concerned he found himself entirely in agreement with Mr. Tyler, in fact even so far as to say that he liked his SL.17 lamp.

There was only one question he would like to ask. He did not understand the working of the signals in the tunnels. It seemed to him that if the signals could not be used to stop the train, then he could not see how they could add any contribution to closer headway. It seemed to him that it was a long section working, with two signals repeating each other.

Mr. L. W. H. Lowther said that with reference to the figures which Mr. Tyler had given in appendix E, it appeared that there had been an increase in annual charges of £193,000, which included interest at 6 per cent. That interest was presumably charged on the £2.46 m. of additional capital, and thus amounted to £147,600, leaving a net figure of £45,000. Did that last figure cover only the additional cost of labour and material debited to the Signal Department, or did it include any contribution to the renewal fund.

Mr. J. F. H. Tyler replied that he should have said earlier that there were two corrections to be made to the Paper. On page 192 the figure of 0.19d. should really have been 2.67d. and in appendix E, 0.22d. should have been 5.5d. He didn't think it made much difference.

Mr. R. J. Post said that he would like to put a very small question. Figure 22 showed Twickenham and St. Margarets as having colourlight signalling. He had looked out of the train window that morning and had seen the semaphores going up and down. Was there to be an extension of colourlights into this area.

Mr. N. S. Hurford had noticed from the Paper that the Southern Region had adopted a steel all-welded structure for their signal bridges. He recalled an extensive use of reinforced concrete on the Central Section. Did that indicate that the reinforced concrete had been found to give trouble in practice, or had it been found to be dearer?

Mr. J. F. H. Tyler, replying to the discussion referred first of all, to the comments of Mr. Cardani about the SL.17 lamp. He would say that he entirely agreed that the independent double filament 12-volt 16/24-watt lamp was a better lamp than the SL.17. He was not denying that; but if one worked on the Southern, and somebody said that the lamp they had been using for 30 years was no good, it would soon be thought they were not on the right lines. The SL.17 lamp had given extremely good service. They did not use it in cases of isolated colourlight signals. With regular spacing, quite a different outlook could be given to the use of a lamp which has an auxiliary filament, which was not quite as good as the 16/24-watt lamp. It may well be that the auxiliary filament could do with an extra boost when the main filament burnt out. They had not had complaints from drivers.

The SL.17 lamp was rated at 1,000 hours. They put new lamps in the red and the yellow aspects and left them there for 4,000 hours. They then took them out and put them in the green aspect for another 4,000 hours, so he did not think they lost a great deal of life by regular changing rather than leaving them, as Mr. Cardani had said, until the main filament burnt out. After all, they were getting nearly 8,000 hours out of these lamps, although the rated life was only 1,000 hours.

He agreed that the graph on figure 21 did show an increase. He was afraid he must admit that. He was sorry he had to put that graph in. He had to show a period where they had had a bad patch of lamps.

Regarding the loading of the signalman with telephone work, this Mr. Tyler said was surprisingly high; but on the other hand it did not take a great deal of time. The signalman said "O.K. Bill" and put the receiver down. Now that was not a telephone conversation in the usual sense. He thought also that there was something in what Mr. Cardani suggested that representative messages could be easily turned into an indication put up in front of the panel. Whether the work load of the signalman would be altered greatly as a result he could not say. The time was probably less, and it was better because there was a permanent record. There was no room for any misunderstanding.

On the question of permanent way connections, he did not think it was always fair to say that all the connections that could be done away with were eliminated as a result of multi-aspect signalling. Sometimes many could have been got rid of under mechanical signalling. There were also those that could not be dispensed with without power signalling; but he did not think it was fair to claim the lot.

On the question of quantifying train delays, he thought they were fortunate on the Southern. They did not meet the problem as much as other regions. Most of the train delays, and the money which could be put down as a saving for multi-aspect signalling, was very largely in freight work, and he did not think they had quite the same problem to deal with on the Southern as there were on other Regions. But there was an interesting thought on that question of train delays which arose from considering an interval service. Assuming there was a 10-minute service, and then assume that somewhere along the line one of those trains was running 10 minutes late: by the nature of the thing, trains would sort themselves out, and by the end of the day every train would be running 10 minutes late. From the point of view of the customer, this did not matter, for he did not know whether he was catching the train ahead, or the one which should have arrived at the particular time. Therefore he felt that to quantify such a saving in delay would be a little difficult. They did not put down much in the way of train delays. They had tried very hard to put something down to train delays, but it was not easy at all. The traffic people had been trying to help them.

On the question of arctic winters, he did not really know what he could say as far as signalling was concerned. There was a tremendous saving on power signalling, but how could one assess the weather! He felt that the accountants would not accept an estimate of the money which would have been saved if power signalling had existed throughout the country during the last few weeks.

In reply to Mr. Knotts, he had already mentioned the question of lamp changing. It worked very well. That practice had gone on for many years and usually they had very few failures. Mr. Knotts had asked whether proving was desirable. Well, the new standard demanded proving. It demanded an indication to the signalbox that an auxiliary filament had failed, not just a filament, but one which lay in a certain direction. It demanded lamp proving to put each signal to danger in the event of the signal ahead being out. Obviously this cost money.

Mr. Hider had asked about other aspects of the work load of the signalman—the observation of the diagram and so on. What they had done was to say that they wanted the diagram as small as they could possibly have it. They did not want it ridiculously small, but they did want it so that within an angle of about 120° from the eye, the signalman had that part of the diagram from which he had to carry out his share of work. It did seem to him that the less the movement of the head the easier it was for the signalman. If he had to be continually moving his head up and down, an indication might pass unnoticed. The time taken to observe panel indications was not taken into account in assessing the signalman's work load, as it was no more than a second or so. They thought that with the operation of the push-buttons being such a large part of the signalman's load that they could ignore it. To get the information they put counters in the relay room and meters on the telephone equipment, and the technicians made regular notes of what the readings were. They did do that for all the signalboxes, and they had one or two interesting results, particularly in the division of work between signalmen where they found, in one or two cases, that the load was by no means equal.

In reply to Mr. Young he quite agreed that it would be a good thing if they could find some basic formula and persuade the accountant to accept it—something that would assist them in these schemes, and would enable them to quantify the advantages of colourlight signalling. It would be of the greatest help.

The interesting thing was this: if you consider a station—say a two-box mechanical layout with perhaps two junctions at one end and one at the other, and estimate for a power box to embrace the two existing signalboxes, their experience had shown that a return of 5 or 7 per cent was common. Extend the scheme to the branches, and get rid of a few signal boxes, and the return increases to about 16 per cent.

Regarding P.C.P. corrugated steel protected cable, the disconnection box was not much of an obstruction. He could not see any objection to Mr. Young's suggestion to cut back the corrugated sheath and put end core straight on to the rails; but the disconnection box has the great advantage that one could disconnect without disturbing the rail connection.

At Paddock Wood the relay sets were tested with an automatic tester and the testing did not take long. All testing was done before the changeover.

As far as the training of staff was concerned, they did of course lose an awful lot when they gave up carrying out their own installations.

In reply to Mr. Currey, the 8-hour possession on the Kent coast lines, was (with the co-operation of their friends on the operating side) an absolute possession. Even if there was some traffic they would attempt an 8-hour changeover. Nevertheless there obviously cannot be much traffic, as there is not all that much time. He had never seen so much preparation for changeovers elsewhere as was done on the Southern. Nothing was left to chance.

Mr. Brown mentioned the question of maintenance. The signalling previously was plain simple signalling, with not a particularly short headway, and simple block working, with a few odd track circuits. The number of maintenance men had obviously gone up. One cannot have it otherwise. They must have more staff with more equipment to maintain, and therefore it cost more.

Mr. Hadaway mentioned the signalman's work load and the three push-button movements. The three push-button movements could very easily be reduced to two because they were now inclined to think that the passage of the train should cancel the route. The press-press idea arrived purely and simply from the use of the entrance-exit principle. One had got the minimum number of buttons on the panel.

Mr. Brentnall had made some kind remarks, and he noted particularly the figures he quoted in regard to the saving in train delays; but unfortunately, they did not seem to be able to take advantage of that on the same scale as other people. One reason is that freight trains are timetabled.

He was glad to hear Mr. Dell say he liked the SL.17 lamp. As regards the tunnel signalling, imagine a signal at the entrance to the tunnel, a signal in the tunnel and a signal on the outside of the tunnel at the leaving end: the entrance signal was controlled not only by the track circuit immediately ahead, but also by the track circuit between the tunnel signal and the one outside, or if that particular track circuit is occupied, by the signal ahead of the tunnel being off. In other words it was assumed that a train between the tunnel signal and the signal outside would proceed clear of the tunnel if the latter was off. This arrangement did not affect the double yellow or green headway, but did prevent a train entering the tunnel and stopping at the tunnel signal.

Mr. Lowther had mentioned the figure of £193,000. The increased annual charges would be the additional maintenance costs due to additional time and material spent on maintenance. The renewal charges for the signalling formed a sort of sinking fund which would enable the installation to be replaced at the end of its working life. There was also the interest on the new capital which had to be raised in order to do the job. Broadly speaking schemes were financed in this way. The renewal would cost, on a like-for-like basis, so much. It would cost so much more to be able to produce the scheme that was wanted. The difference between these two figures was the new capital which has to be raised.

New signalling shown at Twickenham and St. Margarets is a slip. The work was not yet completed.

The reinforced concrete structure referred to by Mr. Hurford was extremely heavy. There were quite a number of them about. They were very difficult things to handle, because they had to be transported specially. The welded structure was very much lighter and simpler.

The President Mr. R. A. Green, in winding up the discussion said that it was his pleasure to propose a vote of thanks to Mr. Tyler. Undoubtedly the Southern Region was unique in many respects. He would think that not the least of the problems was that of doing every change-over in the night of 8 hours. He could only think that the signature tune was "Never on Sundays". He had made up his mind to keep off the SL.17 lamp. They had had radical changes before. For instance they had changed over the lower quadrant semaphores to upper quandrant. Perhaps it would be a case of v+SL.17.

The President concluded by proposing a very hearty vote of thanks to Mr. Tyler, which was carried with acclamation.