The First Five Years of the Modernisation Plan in the Eastern Region

By H. L. F. TUFF* (Member)

The paper which I am about to read to you deals with the signalling projects which have been carried out in the Eastern Region since the Modernisation Plan was introduced. It will be appreciated that a great deal of the subject matter is a factual description of the main projects though I have included information regarding some of the devices which have been used for the first time—at least in the Eastern Region.

The plan for the modernisation of British Railways was announced in the latter months of 1955. At this time the Eastern Region had in hand three major projects. The 1500 volt D.C. electrification system from Liverpool Street which had been in service since 1949 was in process of being extended from Shenfield to Chelmsford and a start had been made on the extension of the same system from Shenfield to Southend. The large new marshalling yard at Temple Mills—brought into use in 1958—was well under way. This latter scheme necessitated the installation of two power signalboxes and a route setting system for the sorting sidings. Work was also in hand on the widening of the lines from Potters Bar to Greenwood on the Great Northern section.

Towards the end of 1955 the decision was taken to the effect that the supply to be used for electric traction would be 25kV. at 50 c.p.s. Tests were immediately organised between Fenchurch Street and Bow Junction and between Shenfield and Ingatestone to determine the effect of 50 c.p.s. currents on signalling and telecommunications equipment. Sections of the overhead equipment were isolated and temporarily fed with 50 c.p.s. current at 6,600 volts. A large number of measurements were then taken on the cores of both signalling and telecommunications cables and on track circuit equipment.

The change in traction policy meant that the planning for many of the works which had been in hand for some time had now to be reconsidered in its entirety to cater for A.C. traction conditions.

The electrification of the heavily worked suburban lines from Liverpool Street to Enfield and Chingford had already been under consideration and detailed planning for the work was now put in hand. In addition to the two important branches mentioned above, the lines to Hertford East and Bishop's Stortford were also incorporated in the scheme. Previously the services to Hertford East and Bishop's Stortford used the Lea Valley line from Clapton Junction to Cheshunt. This is a busy line and in order to improve the service opportunity was taken to rehabilitate the Churchbury Loop (since renamed the Southbury Loop) which runs from Bury Street Junction (between Bush Hill Park and Enfield Town) to Cheshunt.

In these days when the accent is on closing lines of railway it comes as something of a surprise to hear of a line which has been revived and given a new lease of life. A few remarks on the history of the Southbury Loop may therefore be of interest at this juncture. The construction of the line was authorised in July 1882 and it was opened for service on October 1st, 1891. Traffic did not come up to expectations and the passenger service was withdrawn exactly 18 years after its introduction. A frequent service operated for the convenience of munition workers for four years during the first world war. Since then the line has been maintained to passenger standards in order to provide an alternative route for traffic on the Lea Valley line. During recent years the growth of surburban dwellings in the area served by the loop has justified its rehabilitation and it is now used by the Hertford East and Bishop's Stortford electric trains.

Early in 1956 when the planning work in connection with the London, Tilbury and Southend, and North East London

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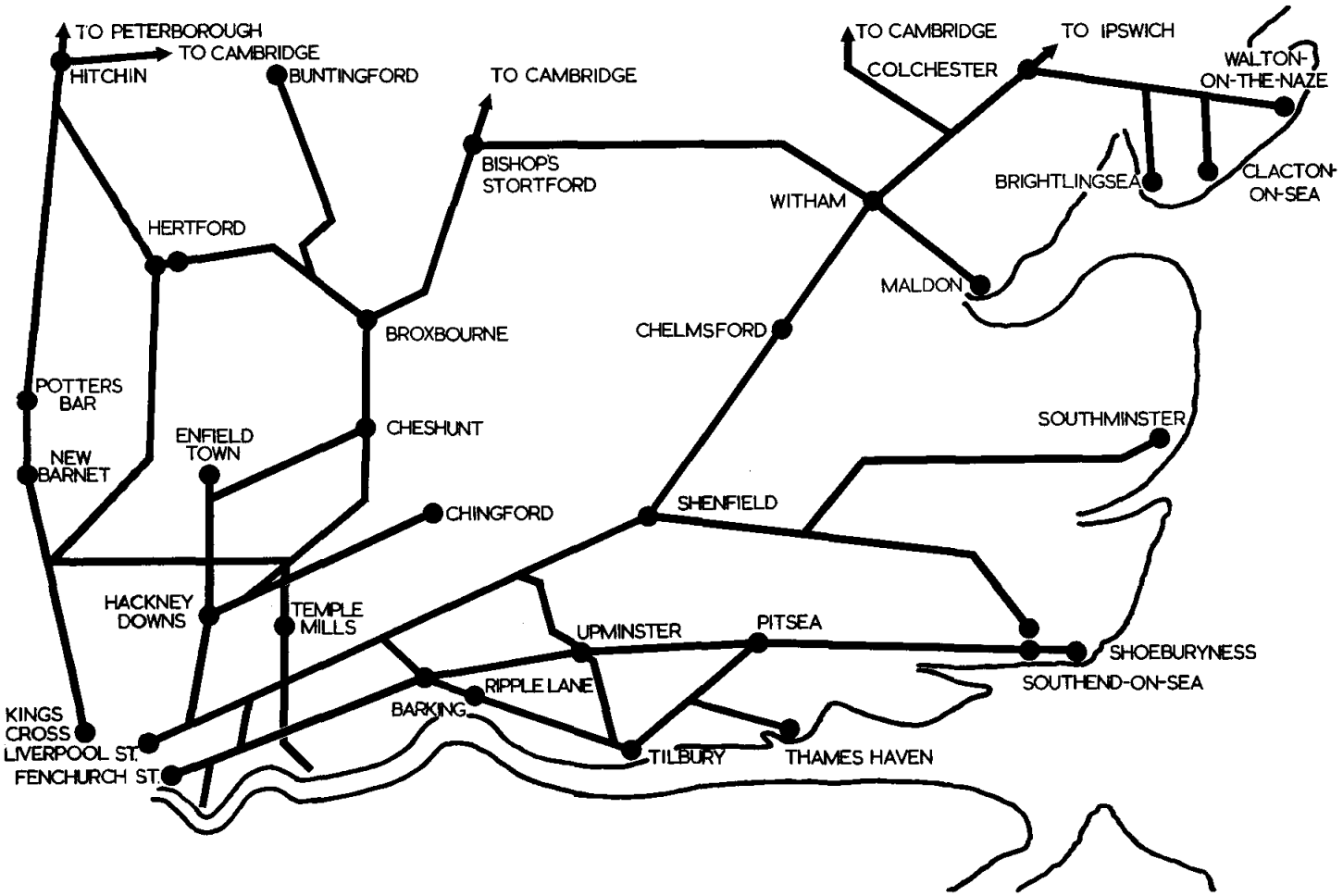

TO PETERBOROUGH
TO CAMBRIDGE
HITCHIN
BUNTINGFORD
TO CAMBRIDGE
TO CAMBRIDGE
TO IPSWICH
COLCHESTER
WALTON-ON-THE-NAZE
BISHOP'S STORTFORD
WITHAM
BRIGHTLINGSEA
CLACTON-ON-SEA
HERTFORD
MALDON
BROXBOURNE
CHELMSFORD
POTTERS BAR
SOUTHMINSTER
ENFIELD TOWN
CHESHUNT
NEW BARNET
CHINGFORD
SHENFIELD
HACKNEY DOWNS
TEMPLE MILLS
UPMINSTER
PITSEA
SHOEBURYNESS
SOUTHEND-ON-SEA
RIPPLE LANE
BARKING
KINGS CROSS
LIVERPOOL ST.
FENCHURCH ST.
TILBURY
THAMES HAVEN

lines was in full swing, it was decided to carry out a pilot electrification scheme from Colchester to Clacton and Walton. This was done in order to provide a testing ground for the new types of signalling equipment which were being produced for use in A.C. traction areas, and also to give an opportunity for training motormen and for trying out the new rolling stock.

The adoption of A.C. traction for the schemes to which I have already referred immediately raised the question of the future of the services already operating on the D.C. system. After much deliberation it was decided to convert the D.C. lines to A.C. traction. By doing so, interavailability of rolling stock and concentration of repair and maintenance depots could be carried out in the most convenient and economic manner.

The A.W.S. system has been steadily extended and braking distances at very many places on the G.N. Main Line have been increased to make the best possible use of the powerful new diesel electric locomotives which are in service on that line.

A fully automatic marshalling yard with electronic control of the siding points has been commissioned at Ripple Lane near Barking and work on another automatic marshalling yard with its associated signalling in the Sheffield area has commenced. The latest electrification project has been the closing of the gap between Chelmsford and Colchester to enable through electric services to operate from London to Clacton and Walton.

At the time of the announcement of the Modernisation Plan the office organisation existing in the Signal and Telecommunications Department was much too small to cope with the large amount of new work which was imminent and recruiting and training of new staff was commenced immediately. Dilution of experienced personnel enabled the new entrants to be trained as quickly as possible and eventually each member of the technical staff was fitted into the niche for which he showed the greatest talent. The outside staff had also to be vastly augmented—to a great extent by temporary labour forces which could be decreased as the works were completed. This was necessary because despite the fact that virtually all the new signalling work was put out to contract, a great deal of stage-work had to be carried out by the Region's own forces to cope with the permanent way alterations, adjustments to the pole routes to allow erection of the traction equipment, etc.

DETAILS OF THE MAJOR PROJECTS

1. The Colchester—Clacton—Walton Scheme

These lines were originally signalled on the semaphore system operated from 13 mechanical lever frames. The Thorpe-le-Soken/Clacton section is sub-divided by a set of automatic signals and the Walton Branch, which is single line, is worked on the Tokenless System which employs direction levers with continuous track circuiting.

In carrying out the resignalling, opportunity was taken to close the signalboxes between Wivenhoe and Thorpe-le-Soken and to introduce automatic signals on this section. The junction at Hythe was also remotely controlled from East Gate Junction (near Colchester).

The new signalling is of a simple nature. The existing lever frames at the boxes which were to be kept open were retained with electrical equipment added as required. Direct current circuits and apparatus, immunised against operation from 50 c.p.s. currents, was used throughout.

While the scheme itself produced no problems from an installation point of view, it gave ample opportunity to investigate the difficulties in procedure necessitated by the increased clearances and sighting obstructions posed by the use of traction equipment of a type of which we had had no previous experience. The inception of electric traction constituted an interesting landmark in railway history in that the new service was the first to operate on a commercial basis in this country using 25kV. traction.

The new signalling worked very well and it was gratifying to find that the calculations and decisions made as a result of the earlier tests were justified in practice.

After the scheme had been in operation for a short time, two small 83⅓ c.p.s. mechanically coupled generators were installed in a temporary building near Hythe and used to feed a section of line

on which 83⅓ c.p.s. track circuit equipment was given an extensive trial.

The information so derived proved extremely useful in connection with the very large Conversion scheme to which I will refer shortly.

The Walton Branch was the first section of a single line to be electrified on the overhead system and opportunity was taken to investigate the possibility of retaining semaphore signals under overhead traction conditions. The single mast cantilevers were positioned such that a clear line of sight was given on the approach side of each signal.

In order to test the traction power change-over equipment a short section of line near Alresford was arranged for operation at 6.25kV. thus necessitating the use of a few track circuits limited to 200 yards in length. All other track circuits were cut to ensure that none exceeded 500 yards.

2. The North East London Electrification Scheme

The suburban lines from Liverpool Street to Enfield, Chingford, Hertford East and Bishop's Stortford were covered in one scheme.

Colourlight signalling was already in use on the Enfield and Chingford Branches but this system used 50 c.p.s. A.C. track circuits which had to be replaced by equipment of a type immune to A.C. traction. Opportunity was taken to close the signalboxes at Clapton Junction, Wood Street, Burnt Mill and Bishop's Stortford North. In place of the old station at Burnt Mill a completely new station known as HARLOW TOWN was constructed. The signalling at this place is operated from a local interlocking remotely controlled over the Westronic system from the new signalbox built at Harlow Mill. A similar remote control installation is in service to control the interlocking at Clapton Junction from the panel housed in the new signalbox at Hackney Downs.

At Enfield, Chingford and Bishop's Stortford South, the existing lever frames were reduced in size and used for operating points. Panels working on the OCS system were provided for control of signals and to show all indications. The junction at Bury Street is remotely controlled from Enfield Town, the direct wire system being used.

A set of four electrically operated lifting barriers was installed at Ware on the branch line from Broxbourne to Hertford East. The line through Ware is single and passes over a level crossing at the east end of the station. This crossing was originally protected by hand-operated gates under the care of a Gateman, the gate ground frame being released from the signalbox at the other end of the platform.

Alterations to the level crossing were necessitated by the decision of the Local Council to widen the road at this point. Opportunity was therefore taken to abandon the existing signalbox and in lieu construct a new box adjacent to the crossing. The gates were replaced by four lifting barriers controlled from two buttons mounted on a pedestal located in the corner of the signalbox nearest to the road. Each barrier is independently operated by a small electric motor fed from a 24 v. supply—with a standby battery for use in case of a mains failure.

3. The Conversion of the D.C. lines to A.C. Traction

This constituted the most difficult problem with which the Signal & Telecommunications Department had to deal.

The traction system from Liverpool Street to Southend (Victoria) had to be changed over to the new form of working in one week-end. It was considered to be impracticable to make a corresponding change in the signalling system in the same time and therefore the latter had to be altered to a form suitable for operation under either D.C. or A.C. traction conditions. After much thought and experiment, the now well-known system employing 83⅓ c.p.s. current was selected. A great deal of preparatory work was done in apparatus cases and in the relay rooms. The track circuits were changed over to 83⅓ c.p.s. operation over a period of about eight months, the existing relays being sent to the respective manufacturers in batches for conversion to operation at the new frequency.

On the week-end when the traction system was altered, the only work remaining to be carried out by the Signal Engineer was the alteration to the circuits of 69 motor point controllers. New D.C. controllers had been installed, operated

c.p.s. voltages into the screened phase will arise if two earths, suitably placed, occur at the same time. In order to prevent this, elaborate earth detection devices have been installed. On a large part of the lines concerned the earth detectors are of a very simple type. They employ a D.C. search voltage and are installed in duplicate. Test keys are fitted which are checked by the maintenance staff at regular intervals. In the event of an earth fault alarm being given, a 50 c.p.s. voltmeter is connected across the cable in question and is then observed continuously until the fault has been cleared. This eliminates the chance of a second earth occurring unnoticed and allowing the entry of 50 c.p.s. voltages into the system. An alternative system in use on one section consists, in effect, of two 50 c.p.s. indicating voltmeters. The first is set at a low value and indicates when a small 50 c.p.s. voltage is present in the screened phase. This is the signal for immediate action by the maintenance staff. In the event of the situation worsening a further alarm will be given should the 50 c.p.s. voltage rise to an intolerable value. If this occurs the S. & T. maintenance Technician in charge would have to declare the signalling unreliable until the faults had been cleared.

4. The London, Tilbury and Southend Scheme

Planning commenced for the resignalling of the London, Tilbury and Southend lines about twelve years ago. In the early days the scheme suffered many vicissitudes. Changes in operating policy necessitated alterations. The decision to use A.C. for traction meant that the whole scheme had to be redesigned to cater for the new conditions and last, but by no means least, an enormous staging programme had to be got out in extreme detail in order that the scheme might be introduced with a minmum of disturbance to the very heavy suburban traffic which is operated over these lines.

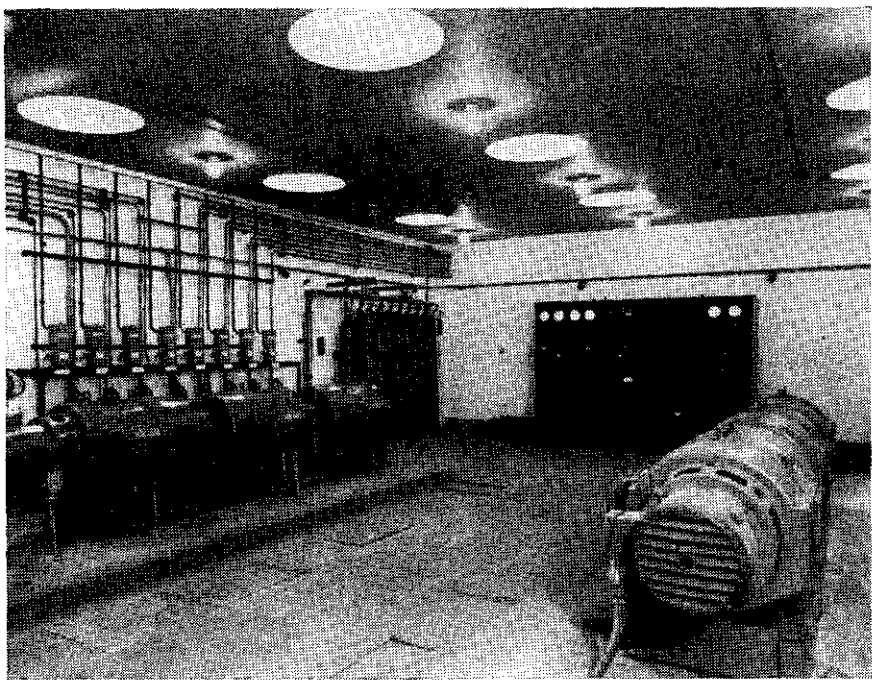
Five signalling contracts were let in connection with the resignalling work and in all 422 colourlight signals, 991 track circuits, 12 hybrid boxes and four new "all panel" boxes were provided. The section from London to Upminster runs parallel with the London Transport Executive D.C. traction system and on this stretch of line therefore, 83⅓ c.p.s. current is used for all signalling purposes.

The main line from Fenchurch Street to Southend is notable for the almost complete absence of level crossings. Introduction of the new signalling thus afforded an excellent opportunity for closing many of the existing signalboxes. In fact, between Fenchurch Street and Upminster East there were previously 22 mechanical signalboxes with 1,434 levers, whereas now there is only the relay interlocking at Barking. The train headway on the Fenchurch Street—Barking—Upminster section is 2 minutes and to enable this to be done required 48 signal sections in each direction. When Leigh-on-Sea and Laindon signalboxes are switched out—a condition which obtains for considerable periods—Pitsea signalbox has indications for 30 automatic sections in the Down and 33 in the Up direction. In order to keep 50 c.p.s. induced voltages within the prescribed limits, track indication circuits are cut at roughly 2 mile intervals. If the conventional method using a separate pair for each track indication had been employed, the circuit division would have been an expensive matter. A new system was therefore introduced on the Fenchurch Street—Upminster section known as the AEI-GRS Type R equipment. I will refer to this system later when speaking on remote control systems generally.

Fenchurch Street signalbox has a power frame which was installed in 1936. This installation remains substantially the same but an independent free-standing panel has been installed from which the remote interlockings at Gas Factory Junction and Stepney East are controlled. At these latter two places, and also at Tilbury (Riverside) a measure of geographical circuitry has been introduced for route setting and to operate certain indications.

5. The Closing of the Gap (Chelmsford—Colchester)

After 50 c.p.s. electric traction had been introduced on the Liverpool Street—Chelmsford Section it only remained to electrify the 20 mile gap between Chelmsford and Colchester to enable through working to take place from London to Clacton and Walton. This section had originally 13 signalboxes with a total of 508 levers. The

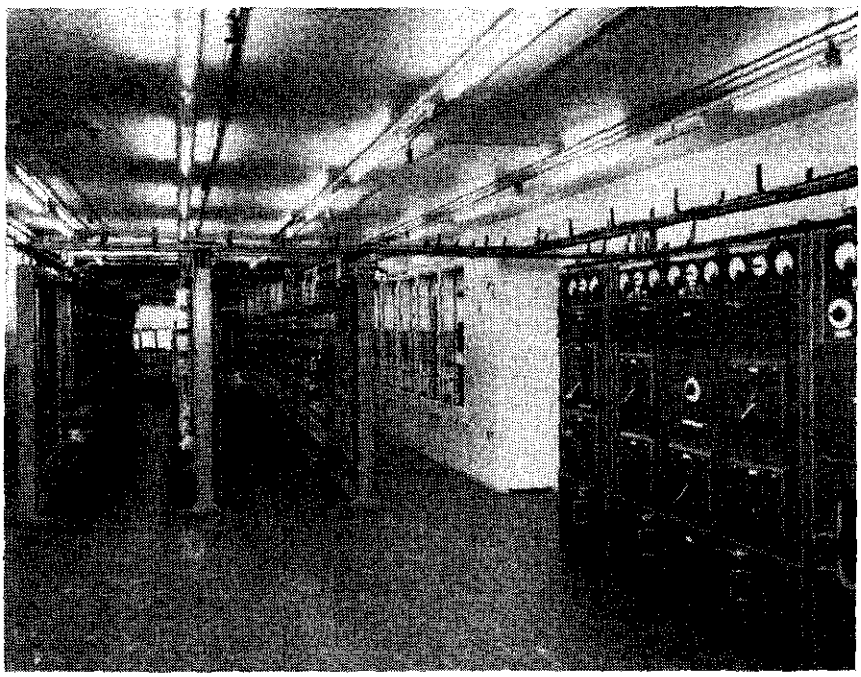


83⅓ c.p.s. Converters at Barking

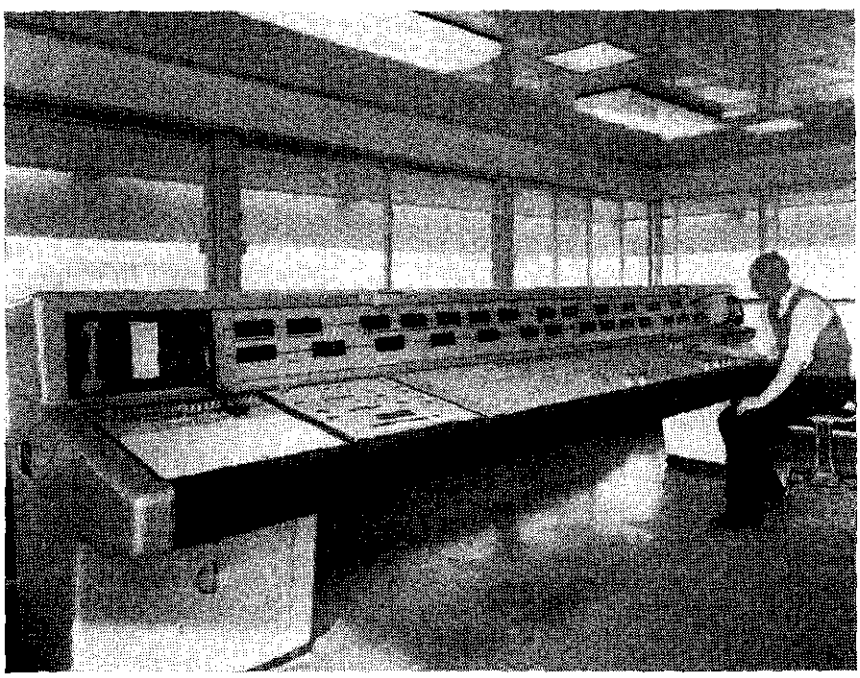
over the contacts of the original A.C. controllers, the final item being to change the line circuits to D.C. operation and remove the A.C. controller.

The existing 50 c.p.s. signalling supply arrangements were retained for signal lighting and for certain transformer-rectifier sets. For track circuits, point detection and some line circuits a completely new power source for the 140 track miles was obtained from 8 duplicated motor generator sets driven from 3-phase 50 c.p.s. autosynchronous motors each attached by adjustable mechanical couplings to two 650 v. 83⅓ c.p.s. generators. The two outputs are in-phase or displaced by approximately 90° according to the design of the equipment they are supplying. Double-rail track circuits have been retained essentially in their present form. Auto-bond track circuits have been resonated in order to avoid the possibility of high 50 c.p.s. voltages occurring across the control coils of the track relays should the track circuit become unbalanced.

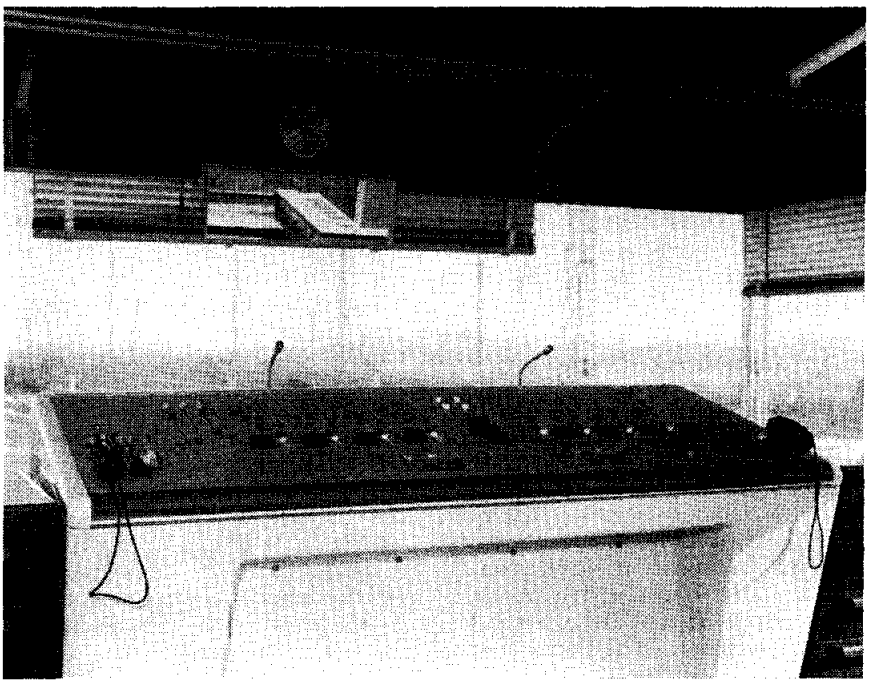
In order to prevent excessive 50 c.p.s. voltages occurring across the relay ends of single-rail track circuits the latter are limited in length to 500 yards in 25 kV. traction areas, and 200 yards where the traction voltage is 6,250. This necessitated the sub-division of several track circuits. Precautions had also to be taken to ensure that line circuits were cut and relayed as required in order to confine the value of induced 50 c.p.s. voltages within the acceptable limits. In view of the fact that to obtain good voltage stabilisation a 3-phase input to the motor generators is required, it is not possible to take the standby supply from the traction network and diesel-driven generators have had to be retained. The immunity of the 83⅓ c.p.s. equipment depends on keeping 50 c.p.s. voltages from being produced simultaneously across both the coils of the double element functions. It is virtually impossible to prevent 50 c.p.s. current from passing through the control winding of track relays and therefore extreme precautions are taken to keep the phase which feeds the local coils completely free from unwanted frequencies. This phase—known as the screened phase—is distinctively coloured at all terminals. The greatest potential source of infiltration of 50



Barking Signal Box Relay Room



Witham Signal Box, General View of Interior



▲ Ripple Lane Control Tower Panel

◀ Harlow Mill Westronic Cubicle
Front View

box at Marks Tey was retained. All the other mechanical installations were abolished and two new signalboxes housing Entrance—Exit type panels were commissioned at Witham and Colchester. The work at Colchester was particularly involved, as the station was rebuilt thus necessitating considerable permanent way alterations with the consequent signalling stage works. In fact a temporary mechanical signalbox had to be brought into use for a period.

6. Ripple Lane Marshalling Yard

The north bank of the River Thames is a rapidly developing industrial area and in the early 1950's it was decided to construct a new Marshalling Yard at Ripple Lane which is situated about 1½ miles east of Barking. This yard which has 8 arrival sidings and 52 classification sidings was brought into use in March 1961. As at Temple Mills, Ripple Lane Yard is worked on the chalking system. The Shunter in the cabin at the top of the Hump reads chalked numbers which have been written on the leading end of the first wagon in each cut and then operates buttons which set the routes into the sorting sidings. The information derived from the pressing of these buttons passes into a relay indication store which can hold a maximum of 3 routes. As the wagons pass over the Hump the routeing information is released under track circuit control and the routes into the sidings are set accordingly. After leaving the indication store the route setting information is handled electronically —fully transistorised storage circuits being used. The storage circuits in the "route pass on" system are of the printed circuit type. The control of the wagons in the two primary and eight secondary retarders is fully automatic.

A loud speaking telephone system is provided between strategic points in the yard and also a radio telephone link between the Control Tower, Hump Cabin and the humping engines.

The communications required for all the offices, etc., associated with the Yard are provided by an automatic telephone exchange.

Where Ripple Road crosses the line near Barking, two additional tracks were added. The two-track wheel operated gates of the conventional pattern were replaced by new gates of metal construction, hydraulically operated and controlled from a new cabin adjacent to the crossing. A road traffic light system is included in the arrangements at this place.

REMOTE CONTROL AND INDICATION SYSTEMS

During the course of the planning of the North East London Electrification Scheme it was decided to introduce remote control at Clapton Junction—operated from the panel in the new signalbox at Hackney Downs, and at the new station at Harlow Town—operated from Harlow Mill Signalbox. Both these installations use the now well established "Westronic" system which only requires one pair of wires between the parent and out-stations. The cable used is a 1/.064" quad, polythene insulated, filled and sheathed. This equipment works on the time division scanning system, a complete scan on the Hackney Downs-Clapton equipment taking 1.2 seconds and covering 120 channels in this time. The four frequency generators and the counting chain circuits required to operate this system are in the form of printed circuits on jack-in cards. An interesting feature associated with these installations is the provision of "reassurance" buttons on the panel. Adjacent to each track circuit indication on the panel is a push-button which when operated produces an effect in the transmitting end of the remote control equipment the same as if the track circuit had become occupied. Neither the track relay nor the TPRs are affected when this button is used, but an "occupied" indication is given on the panel. The purpose of this device is to enable the Signalman to make the remote control equipment go through the process of transmitting an "Occupied" and "Clear" signal should there be any doubt in the Signalman's mind regarding the correctness of the indication which is being displayed.

In the two D.C. Multiplex remote control systems installed between Fenchurch Street and Stepney, and Fenchurch Street and Gas Factory Junction, the Instruction and Indication functions are controlled over independent voice frequency channels —it being possible to carry 12 channels in 1 pair of wires. In actual practice it was found that the lowest frequency used,

540 c.p.s., was the frequency most liable to interference from the inductive effect of A.C. traction and while the possibility of this interference causing failure is not high, this channel is not in normal service but can be used as a spare in the event of failure of one of the working circuits. The Gas Factory Junction system has 64 outgoing and 164 incoming channels. For the Stepney system the corresponding figures are 33 and 89 respectively. Each frequency has its own transmitter and receiver which are of the "jack-in" rack mounted type thus permitting easy interchangeability and maintenance.

The AEI-GRS Type "R" equipment to which I have referred earlier, employs different frequencies for each channel—again only one pair of wires is required for several channels. The frequency separation is only 5 c.p.s. and an electro-mechanical method of filtering is employed. The frequency allocated to each location is produced on site from a transistorised oscillator and is then fed to a coil in the centre of which is a reed tuned to the precise frequency. The vibration of this reed is carried via a mechanical coupling bar to a similar reed which is inside a second coil. It will be seen that the frequency produced on this second coil must be of the precise frequency required. The filtered frequency is then fed over contacts of the track relay to the line.

At the signalbox end of the circuit a number of receiving units are connected across the line. Each of these receiving units has a coil with a reed tuned to the frequency associated with that particular circuit. Again, the vibrations of the reed are transmitted via a mechanical coupling to a second reed which generates a current in the coil surrounding it which can then be used to operate an indicator. 101 indications on the L.T.S. Lines are operated by means of this system, split up between 7 circuits. This system is particularly suitable for conveying track circuit indications to a signalbox because the independent frequency generators are small and easily located beside the track relay.

CAR PARKING CONTROL

At Harlow Town Station an ingenious arrangement has been introduced to enable

Car Parking Payment Apparatus at Harlow Town

car parking fees to be collected without the need for an attendant. Entry to the park is via a barrier which is automatically raised on the approach of a car, falling again when the vehicle has passed through. At the Exit there is a further barrier. This also operates automatically but only if the correct payment is inserted in the coin box of the apparatus which is positioned within easy reach of the car driver. Facilities are incorporated in this unit for season ticket holders who use a special card to release the Exit barrier.

TELECOMMUNICATIONS

Apart from the schemes which have been carried out recently to improve the telecommunications facilities in the Region, a great deal of work was required in the telecommunications field in association with the electrification schemes to which I have already referred.

New telecommunications cables have been laid along all the lines newly electrified. These cables are of the air spaced, paper insulated, aluminium sheathed type. All the circuits previously carried on the aerial line routes are now in the cables and in addition, circuits have had to be provided for the Chief Mechanical and Electrical Engineer in order to control remotely all the traction feeder stations and track sectioning cabins, and also to provide telephone circuits along the electrified lines for the use of trainmen and others.

The use of A.C. for traction has meant that a very high standard of balance in the telephone circuits must be maintained in the future in order to avoid 50 c.p.s. interference in the circuits. The provision of loading coils and repeaters has compensated for the losses due to the introduction of cable into circuits previously carried on open wires. Voice frequency telegraph equipment has been introduced to ensure balanced conditions for telegraph circuits.

The terminating arrangements have had to be dealt with very carefully to ensure that the possiblity of out of balance conditions arising is kept to an absolute minimum. On the Liverpool Street—Chelmsford and Southend lines the existing lead covered cables were retained. A new cable had to be provided to cater for the Chief Mechanical and Electrical Engineer's traction supervisory and telephone circuits. This cable had an aluminium sheath in order to provide screening for the lead covered cables.

All the telecommunications cables are carried in the same cable route as the signalling cables. The route consists in the main of ground level concrete trough. In places where this form of construction is not practicable, e.g. where there are surface drains—cement asbestos trough carried on concrete posts has been used.

The abolition of many intermediate signalboxes and the concentration of the work into a small number of power operated installations has made necessary the provision of train describing equipment on a large scale. The existing installation operating outwards from Liverpool Street was extended beyond Hackney Downs in order to cope with the intensified service operating on the Enfield and Chingford branches. From Shenfield to Colchester a new automatic train describer installation has been provided.

On the L.T.S. direct line from Fenchurch Street to Shoeburyness a very comphrehensive system of train description, incorporating all the latest developments including the use of cathode ray tubes for displays, has been introduced. This system is fully automatic from the point where the description is put into the equipment.

A contract has been let for the provision of train reporting apparatus operating on the Fenchurch Street—Shoeburyness line. Twelve reporting points have been selected in each direction. When a train passes one of the reporting points, information is extracted automatically from the train describer system and transmitted by means of V.F. telegraphy to the control office at Fenchurch Street. At the latter place an electric typewriter (one for each direction of traffic) accepts the transmitted information and prints the train number together with the time. The form on which the information is printed has 12 columns —one for each reporting point—and it is possible, by drawing lines between the same numbers on the form to construct a train graph.

In order to secure the economic benefits of carrying out the modernisation of telecommunications in the electrified areas, arrangements were made to provide certain of these exchanges at the same time as the electrification work was in progress. Three exchanges were provided on the L.T.S. area, with two on the North East London

Section and one at Colchester. These exchanges have been designed and installed in accordance with the plan for an automatic telephone network to cover the whole of British Railways. A contract was placed for twelve 12-channel carrier systems which will form an important part in the eventual scheme for providing interdialling facilities throughout the Region, when the modernisation of railway telecommunications is undertaken.

New manual telephone exchanges have been provided at the Traction Control Offices at Pitsea and Romford. In the case of Romford the exchange gives facility for connection to electrification telephone circuits over the whole of the Liverpool Street—Clacton section, and the North East London electrified lines and has capacity for possible future extension covering a large part of East Anglia.

Following on the success of the Train Control Announcing System, using recorded announcements, which was introduced at Stratford some years ago, a comparable installation has recently been brought into use at Barking on the L.T.S. Line. The equipment has capacity for a total of 50 announcements. The appropriate announcement is selected by push-buttons in the signalbox. A suitable time before the train arrives at the station an announcement is automatically broadcast giving details of the places at which the approaching train will call. When the train comes to a stand in the platform a further similar announcement is made. The equipment in the signalbox allows four preselections to be stored for each of the platforms to which the system applies.

A number of conventional public address systems have been installed and also platform train indicators. A pilot scheme has been introduced in the Norwich area for improving the arrangements for delivery and collection of parcels. The vans are equipped with mobile radio sets, the main transmitting point being at Norwich. At Harlow and Barking there are electric clock systems extending over the whole of the station areas. The master clock at Harlow is crystal controlled.

I hope that the foregoing somewhat concentrated description of the variety of equipment which has been introduced in the Eastern Region in recent years has proved of interest.

In conclusion, I would like to express my grateful thanks to Mr. R. A. Green for permission to read this paper and to the many people who have helped me in its compilation.

DISCUSSION

Mr. J. S. S. Davis, in opening the discussion said he thought the Paper itself and particularly when taken in conjunction with the well-planned, well organised, educative and enjoyable visit which they had had a week ago, provided a most valuable record for the Institution of the remarkable amount of work that had been carried out in the 5-year period which Mr. Tuff had covered. His only regret was that the excellent coloured slides would not be reproduced in the Institution Proceedings.

Mr. Davis continuing said that there were a number of points arising out of the Paper on which he would welcome a little further information. One of these was: What were the traffic requirements which they had set out to meet? That is to say, what were those in terms of headway. The author had mentioned headway in one particular section, but only in passing. In what way was that headway met in terms of signal aspects? Was it possible to meet them with three-aspect signals or did they have to go to four-aspects? Or did they have to contemplate anything beyond that?

The marshalling yard at Rippleside was described as being fully automatic. He would like to know if any consideration was given to the possibility of sending the make-up of the train and the number of cuts over teleprinter network, and so operating the whole of the automatic route setting without the necessity of checking wagons, and without the hump yard attendant having to translate these into routes to the tower. He mentioned this in view of the fact that the discharging points for that yard in some cases, he would imagine, are relatively close at hand.

On page 80 reference was made to the A.W.S. system, and it was stated that at many places braking distances had been increased to make the best possible use of the powerful new diesel electric locomotives. Could Mr. Tuff please say what the percentage increase in braking distance had been. Mr. Davis was a little surprised there had been an increase, because if the maximum speed had increased, he would have thought that the percentage of retardation would also have increased and that the previous braking distance might have been adequate.

The reference to the semaphore signalling being retained on the Walton Branch, as mentioned on page 81, was very interesting. He asked what precautions were necessary to protect the electrical signalling circuits, and also whether it was necessary to carry out insulation of the mechanical signal wires and rodding, or to insulate the lever frame. Were any other precautions taken?

In a review such as this Paper represented, he felt it might be of interest to ask the author whether any lessons have been learnt from the experience of these five years. If the work had to be started all over again, was there anything that would have been done in a different way, or were there any features that have not come up to expectations?

He had already mentioned that this Paper, with its record of the complete resignalling of the L.T.S. Line, was a valuable one to have on the records of the Institution; but he would like to add that it was all-valuable from the manufacturing standpoint as a record of large scale supply of signalling equipment. The President, in accepting the triptych presented to the Institution that evening by Mr. Horler, noted that it was only at the half-way mark; that prompted him to say that when research came to be done some fifty years from now the author of the 'centenary book' would find this Paper of considerable help.

Mr. H. L. F. Tuff, replying to Mr. Davis said that on the question of headways, he had referred to a certain section where a two-minute headway had been asked for. There was a two-minute headway on that section, and varying headways on other sections of the line, but he was sorry he could not quote the headways specifically. Obviously on sections such as the one north of Broxbourne, towards Bishops Stortford, the headway would be less than that required on the Enfield and Chingford branches. On that particular section (Broxbourne–Bishops Stortford) they had both 3 and 4 aspect systems. They had quite a stretch of 3 aspect signalling, but the majority of the signalling was 3 aspect. It had generally been possible to achieve the headways with conventional signalling. There were a few cases where additional double yellows had to be used to get braking distance, particularly in some cases where steam working still applied. In some cases where it was necessary to work locomotive hauled trains the speed was restricted.

Turning to the marshalling yard at Ripple Lane, he explained that he should have made it clear that it was fully automatic in the sense that the control of the wagons, when they are running down the hump through the retarders, was fully automatic. The route setting was, in principle, the same as that at Temple Mills.

He was sorry he could not comment on the question of the use of teleprinted information. It was a fairly long time ago, having regard to the speed of developments now-a-days, since those schemes were planned, and today they would review the methods which had been tried in the last year or two and perhaps do something different.

On the question of A.W.S., it was coincidental that this work came at the same time as the resignalling schemes. The question of braking distances on the Great Northern line had, of course, no connection with the A.W.S. The percentage increase varied from place to place. At a guess, he would say that the average increase was 20 per cent.

On the Walton branch semaphore signalling was retained for various reasons, the most outstanding one, of course, being that it was an experiment to see if semaphore signalling was a good proposition in an electric traction area, using the overhead system. The electrical precautions which they took were fairly standard. The mechanical signal wires were insulated at both ends. The repeater circuits were of the double wire type. Earth circuits had to be cut out completely.

Apart from that, there was little electric signalling involved.

Touching on Mr. Davis's last question as to what they might do if they had to start all over again, Mr. Tuff felt there were two factors which, in his view, might influence their outlook; they were the greater use of remote control, and the use of lifting barriers instead of gates.

Mr. J. C. Kubale, said that Mr. Tuff's Paper gave an interesting and valuable record of what had been achieved during five years by a Region of British Railways which had been in the forefront of the development, and in use of the equipment that had been described. It also enabled those of them who were associated with the Eastern Region to recall the early, and at times, exciting tests which were carried out on that Region to determine the design of apparatus to be used with the new A.C. traction system which was then being adopted.

Mr. B. Reynolds, said that Mr. Davis had referred to the record value of this Paper, and no doubt he had in mind the members in England who were able to get to the Jubilee Technical Convention and see the equipment for themselves. In his view, however, the Paper formed an even more important record for those members in overseas countries whose railways were contemplating electrification, since it does give many valuable pointers to what can and cannot be done, and also what cannot be done practicably and what is a good proposition.

He would like to put two questions to Mr. Tuff: in one part of the Paper it was mentioned that on one of the remote systems of indication there was a frequency separation of only 5 cycles. That would seem to him to be very close, and he would like to ask how far from each basic frequency could a drift be tolerated. It would not seem to need to drift very far before interfering with the adjoining indications.

The second point concerned a reference to a remote control system which appeared to cover a relatively short distance. Mr. Tuff had said that one of those installations was between Hackney Downs and Clapton Junction. This seemed a very short distance to call for a multiplex control, and he believed that over a number of longer distances elsewhere, direct wire control had been possible. He would like to ask Mr. Tuff whether as a result of the work in the last five years it had been possible to ascertain what would be the limit to the length of a direct wire system before a multiplex system became necessary.

Mr. H. L. Tuff, in reply said that the discrimination was within $\frac{1}{2}$ c.p.s. which is only 10 per cent of the band width between adjacent channels.

The question of direct wire *versus* remote control opened a big field for discussion. In one instance that he could quote, at Enfield, the distance was fairly short, about 900 yards. The number of channels was relatively few and he believed that a remote control system would be an economic proposition over that short distance. They had direct wire from Barking to East Ham, also from Tilbury to Tilbury North Junction, but where they did use remote control, for example, Fenchurch Street to Stepney, there could not be any doubt whatever of the economic advantage because of the large number of instructions and indications handled over the system.

Development of remote control systems had gone on apace, even from the time when they were first deciding to introduce them—which is already four years ago—and there must be a borderline beyond which the direct line system was uneconomic. He would have thought that over a distance of 1 to $1\frac{1}{2}$ miles it was still economically possible to use the direct wire system unless a large number of circuits were involved.

Mr. A. J. Mullarkey said if owing to the fact that Mr. Tuff was using a number of different types of equipment, from mechanical, electro-mechanical, electronic, and even radio and radar could he tell them whether any difficulties had been experienced in the maintenance of all this equipment. Did Mr. Tuff consider that the contractors had supplied sufficient facilities for adequate maintenance. Also, had he had any difficulties in the training of personnel in the servicing of such a wide and diverse range of apparatus.

Mr. H. L. Tuff replied that two fields had been introduced here—signalling and telecommunications. Signalling maintenance had developed from the days when it was carried out mostly by a lineman with an oil-can, to the present situation, which in most recent installations had varying amounts of electronic gear as well. That

development had been steady. It had not come all of a sudden, and it had been found that the technicians had developed in step with the equipment, and they were able to maintain it adequately at the present time.

In the case of the telecommunications field it was not so very long ago that the telecommunications were relatively simple. They had introduced teleprinters steadily, and they had now got to the present state, where they employed the latest techniques and the most up-to-date methods. Again, those who had shown an aptitude in that direction had been encouraged to take jobs involving maintenance in this type of equipment and had been given special training. As a result they were getting a reasonably good standard of maintenance on all these new equipments as they introduced them. It had not come to his attention that there was any lack of information, and he thought it was only fair to all the contractors concerned to say that they did in fact get adequate information to enable good maintenance to be carried out.

Mr. A. R. Brown, said that Mr. Tuff's Paper had given a wonderful record of the new work over the past 5 years, but there was really no place in it for the part he would wish to mention: that is the stage work. In operations of this size, it would be obvious to all members present that major stage works must have been carried out, particularly at places like Barking and Liverpool Street, and to a lesser extent at Colchester. Subsequent stages followed rapidly one upon another. This work became quite onerous, particularly because of the rapid change in the permanent way; and to cope with this, it was necessary to have temporary relay rooms. Again the changeovers came so rapidly in some instances that there was no time to take out the existing wiring in the relay rooms, and one saw the trees growing and growing in size, knowing that at times there must have been three quarters of the wires not in use. During this period one thought that perhaps some type of "plug-in" relay room might be helpful. Whilst that can be "pie in the sky" at least he wondered if it would not be possible to get portable relay rooms put up, wired into a stage, brought into service, and then taken away again. Then another relay room would be brought in later. He wondered if any members on other Regions had been faced with this problem, and had considered this.

Secondly, there had been the staging, particularly at Liverpool Street, on an existing panel. It was rather difficult in many cases to alter the panel faceplate within the transition period to produce a result worthy of the panel, and also difficult to alter and test the interlocking machine in the time available. For example, at Liverpool Street some 200 sheets of wiring had to be connected in or taken out of the interlocking circuits and then tested before the machine could be brought back into work for the Monday morning services. That was on a non-miniaturised panel with no plug-in relays.

He wondered if Mr. Tuff could give them some observations on whether they were going to have better facilities for doing alterations on the miniaturised panels, and with plug-in relays without terminals?

Mr. H. L. Tuff agreed that stagework was a very big item, and there was no doubt that the degree of success which they had enjoyed with these large new works might not have been so great had the stage works done by their own people, under great difficulty, not been so successful. Herein lay a side-issue which he would like to mention: that was, the extraordinarily good relations between themselves and the traffic and engineering departments, without whose co-operation, bringing into use of new work could not have been effected with anything like the smoothness which they enjoyed over these two very intensive years, 1960 and 1961.

Regarding the stage work on miniature panels, they were already considering this. A good deal of thought had been given to developing some portable units that they could move around and adapt for use in the different circumstances, and then take them out again and adjust them ready for the next stage. Something of that nature would be very useful should they be faced with a similar programme in the not-too-distant future.

Mr. J. Boura, said that it had occurred to him that as they went from installation to installation, there was a tendency to condense their facilities into smaller space. They had other facilities, such as train describers as well as the signalling equipment itself, and those all tended to become condensed on or near the panel.

There is an increased tendency to get everything on the panel. They gave the signalman a variety of coloured lights and knobs.

Did Mr. Tuff feel that in this aim to make life easier for the signalman, they might be making things more difficult for him? Had there been any researches into this particular field?—i.e. the human side of operating a signalling panel. He asked for Mr. Tuff's views on this particular problem, and what limitations he felt there were in this field.

Mr. H. L. Tuff replied that he thought the problem was covered by the word "ergonomics". In other words, their endeavours were to make the job easier, because providing that this was done in the right way, the job would then be done more efficiently. If they made it harder, they had missed the point somewhere and had not applied the best ergonomic principles.

Miniaturisation resulted in concentrating components together. The object was obvious—to relieve a signalman from having to move about to see things and do things on the panel. They could keep on making equipment smaller, but fingers remain the same size. There is an optimum amount of energy which could be used. He would have thought that the installations they had completed recently were just about the optimum size. To crown the panels with a great deal more equipment would make them confusing. At least in their latest installations the signalman could sit and still see everything and reach everything. There must be a point where the optimum size was achieved.

Mr. D. Hotchkiss said that he would like to raise a point about control panels, from the visit on September 29th. The signal aspect indication did not seem to bear any relationship to the direction of traffic to which the signal applied. This was particularly apparent on the Barking panel, where a signal which he noticed had indications on both sides of the track. Nearby there was another signal which referred to the opposite direction, again with indications on both sides of the track. Neither of these signals showed the post. The easy way of deciding to which way the signal referred wasn't there. He asked if Mr. Tuff could explain why the Eastern Region did not show the post on the diagram?

Mr. H. L. F. Tuff replied that in future cases the signal profile would be shown.

The President, Mr. R. A. Green in concluding the discussion said that it just remained for him to congratulate Mr. Tuff for the presentation of his Paper. He thought all would agree he had gathered together a variety of works and techniques into one Paper which had formed a most interesting and informative record. He would say also that he could not think of any other name to deal with the title of the Paper that evening. Mr. Tuff had been very vitally concerned with all the works in the Paper, and had been much involved in them, and he thought he was very well fitted to have dealt with the title of the Paper. The President asked members to extend to Mr. Tuff a hearty vote of thanks which was received with acclamation.