Technical Meeting of the Institution
held at
The Institution of Electrical Engineers
Tuesday, March 10th, 1953

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

After the minutes of the Technical Meeting held on February 18th, 1953, had been read and confirmed, the **President** introduced Mr. C. F. Challis, who had kindly consented to open an informal discussion on "The Planning and Execution of Major Signalling Changeovers."

Introduction to the "Planning and Execution of Major Signalling Changeovers"

By C. F. CHALLIS

The inauguration of a major resignalling scheme is an infrequent occurrence but is none the less important when it does take place.

In selecting the form of changeover a number of varying factors must be considered, for although the same general principles apply for most changeovers, the interpretation of them differs widely according to circumstances, and no precise formula can be laid down. The form of the proposed and existing systems, the extent of possession times, the staff available and permanent way alterations, are some of these factors.

As the most likely major changeover in Great Britain would be from mechanical to colour light signalling, incorporating continuous track circuiting and one or more new signal boxes, I am adopting that as my example. Where there are new signal boxes, new signal positions and few or no existing track circuits the task is simplified, since new track circuits can be brought into work, but not in service; signals can be ready except for fusing; interlockings can be tested beforehand. The predominant factor then becomes one of sufficient staff to deal with the installation of point movements, and a balance has to be struck between

personnel available for the changeover, and the perhaps costly and wasteful alternatives of breaking the scheme down into smaller stages, with possible complications for maintenance staff, signalmen and train crews, as well as operating disadvantages.

If there is already continuous track circuiting, and I.B.J. positions are greatly changed, that may well become the key to the changeover, as may also be the case if the new signalling is to be controlled from an existing box.

The time allowed for a changeover varies as much as the other factors. On the Southern Region, with its electrified system, and comparative lack of night trains it has so far been possible to have six to eight hours complete or nearly complete possession of the area concerned, so the greatest single limiting factor has been staff available. But there must be many installations on main lines, important junctions or termini with considerable all-night working, where it is considered impracticable to suspend through and shunting movements. Once this has to be accepted, the effect on changeover duration is considerable, since the time taken in securing points and in hand signalling greatly exceeds the time taken by trains passing through the area. There is also psychological value in the staff knowing that there are no train movements at all. The passage of one train through the area could lengthen the changeover noticeably. On the other hand a changeover where a complete possession is not possible has perhaps compensating factors in that during the following day there may not be extensive traffic to suffer unduly by being hand signalled, or signalled under the protection of Rule 77. On the Southern Region this procedure would cause such delays as to make worth while the complete suspension of traffic for the changeover. In this a balance must be struck with the traffic department.

The presence of permanent way alterations bring further complications which must be resolved in the same way. If they are carried out beforehand, the alterations fall on the old signalling. If they can be laid in beforehand but not brought into use until the changeover, that is ideal, but is seldom possible. If they take place during the changeover, then it is certain to delay completion, although temporary signalling alterations may be avoided. If they follow a changeover, suitable provision can probably be made in the final arrangements. In the two latter cases pre-testing of points and track circuits is not possible. As

with the previous items, a balance must be struck, but this time between the civil and signal engineers.

As can be seen the matter of liaison between the signal engineer, the civil engineer and the traffic superintendent looms large in the preliminary planning. Besides the direct question of possession times, permanent way alterations and the method of carrying out the changeover, there are many subsidiary ones. The civil engineer must be advised of the proposed changeover date in good time so that his domestic programmes can be arranged to cause minimum interference. On the Southern Region the Civil Engineer is asked not to carry out any works at all in the area (unless they are concerned with the changeover), nor permanent way alterations at the near approaches, and to postpone if possible all works entailing the attendance of signal and telecommunications staff in areas from which personnel from the latter department will be drawn.

The traffic superintendent is consulted in the preparation of a programme of preliminary works and testing, which may take many weeks. There are also discussions on the new working, facilities for training signalmen at new signal boxes and such matters.

Stage Works and Preliminary Testing

The extent of stage works and preliminary testing will depend on the method adopted for the ultimate changeover. If it is broken down into smaller stages there are bound to be temporary stage works at the divisions. Permanent way alterations will, according to their extent, bring lesser or greater stage works.

Less formidable in extent if not in number are such minor works as altering detection to make way for new fittings, abolition of bars, adjustments in the limits of existing track circuits to suit final I.B.J. positions, and so on. Where existing signal boxes are retained (at the approaches to the area), locking alterations are carried out and tested in advance if possible, levers being fixed if necessary. The object of such works is not only to reduce the opening night alterations, but to reduce the need for testing.

On the Southern Region pre-testing of new apparatus is carried out to achieve maximum efficiency with minimum changeover time. New signal box lever frames and control circuits are

tested under simulated working conditions. Well in advance of the changeover, by arrangement with the Motive Power Department, new signals are illuminated during certain daylight hours ; this assists train crews to become more readily accustomed to new signal positions and permits signal testing, including aspect sequence, to be carried out. In areas where colour light signals already exist special arrangements have to be made.

Where new signals obstruct the view of existing ones, if practicable, the semaphore signals are re-sited so that the new signal can be erected and tested beforehand, or the post may be erected, the signal connected and tested, but left on its side.

Where points are being converted to power operation they are tried out and tested under convenient possessions during the weeks preceding the changeover. This eliminates most of the minor hitches which may otherwise occur. Testing is carried out under final conditions from the relevant lever in the new signal box. When the points have been tried and reconnected to the existing lever, the new fittings are left adjacent to the machine, tied up and labelled. Since it is reasonable to suppose there will be no troubles in changing over on opening night, more machines can be dealt with than if prior trials had not taken place. An alternative way is to convert the point working beforehand, and work them from the existing box. This may be very costly as well as difficult, although in some circumstances it is unavoidable.

Track circuits are also brought into work and tested during these weeks, and signalmen who are in the new boxes for training purposes, are invited to make useful observation on the working. Where unsuitably positioned existing track circuits preclude this, the new track circuits affected are tried out under convenient possessions. Final I.B.J. positions are installed and bonded round.

Needless to say, pre-testing is only commenced after all cable termination is completed, and no subsequent disconnections are permitted unless the apparatus affected is re-tested.

As a result of these preliminaries the only testing to be done during the changeover (except for isolated difficulties that cannot be overcome) is to observe that the running and shunt signal indications respond to the lever. On point levers, as an added precaution, normal and reverse indication, near and far ends are tried in addition to proving correspondence to lever, and the points are operated a few times.

The Changeover

It is most important that all concerned, that is, supervisors, leading men, linemen, fitters and installers should know just what work they have to do, to whom they are responsible, and who is responsible to them. To this end a detailed programme is prepared and circulated in advance, which shows the names and duties of everyone concerned with the changeover, and all men are issued with the sheet or sheets listing their duties, which also includes the names of the men they will be with, where to report for duty, where to take up position pending commencement of possession, and the names of leading men and immediate supervisor. Leading men engaged on demolition work are also issued with a small key diagram showing signals they are to deal with and their locality.

The first page of the programme gives information concerning the areas and times of the possession, times of any trains that will be entering the area, general instructions and safety precautions. This sheet is issued to all staff, with the relevant duties sheet concerned. A separate sheet lays down the procedure and wording to be used when testing point movements ; this is issued to supervisors, linemen responsible for trying out point movements, and to points telephone operators. This instruction, incidentally, insists on identification of switch positions by " left or right hand switch closed," instead of points " normal or reversed."

In preparing the programme the following general principles are followed :—

The basis for points is groups of four men (chief installer or installer, assistant installer and two labourers) for a group of four machines. For every two groups of fitters there is an electrical group for detection (lineman, assistant, and labourer). The lineman is responsible for carrying out the testing of all eight machines. This basis is flexible and is varied according to circumstances. Attention is paid to selecting the best men for the most difficult work and also to maintaining teams of men who normally work together.

Groups of electrical staff are made up according to requirements for track circuit and other connections, wiring alterations, and so forth, and these men are, so far as possible, men who have been engaged on the installation. There are teams of electrical men in the new relay rooms, mostly those who carried out the

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wiring, and led by the man in charge of signal box wiring. There are supervisors for the various outdoor staff, and in each signal box is a supervisor responsible for trying and bringing into use all functions, who is in overall control of the area controlled by that signal box. He does not leave the box until satisfactory completion of the possession, relying on his outside supervisors to cope with any difficulties.

The area supervisors, as I will call them, are responsible to another supervisor in charge of the whole changeover, who is in turn responsible to the signal engineer.

Staff engaged on demolition are made up mostly of mechanical and construction gangs, with competent fitters as leading men. The groups will vary from three or four, to twelve or fifteen. All semaphore arms, fittings and lamps are removed, and such signal structures as will interfere with new signals. The majority of the posts are taken down at a later date, although advantage is taken of the possession to take down difficult posts if staff are available. All old shunt signals are removed, and because of conductor rails, all cross runs of point rodding and signal wires are taken out, the remainder being removed at a later date. Other groups deal with treadles and fouling bars. There are separate supervisors for demolition but they are responsible to the area supervisors.

To allow for adverse weather conditions, absentees and other eventualities, the essential work to be carried out should take less time than the possession permits, but I would like to say that on all the major signalling installations carried out on the Southern Region, absenteeism has been negligible.

In the signal boxes stress is laid on the exclusion of all staff who have no immediate business there and is confined to the area supervisor, a technical assistant who co-operates with him in testing and recording, a traffic department supervisor and signalman. Cardboard discs marked " not tested " are slipped over all levers, and are removed as each lever is tried and put into service; separate card recording the times at which each is tested serves as a cross check.

Since such a changeover requires about thirty supervisors and up to five hundred men spread over an area of several miles, it follows that there should be adequate communications if the area supervisors are to be aware of progress of the work. There is the usual inter-signal box telecommunication which is available from the commencement of the possession. There is also com-

munication from each new signal box to practically every new signal. In areas where there are point movements, hand telephones are temporarily installed at strategic points, connected to the controlling signal box, and certain men are detailed to remain at them, relaying all requests and messages. Shouting between the signal box and outside is discouraged, stress being laid on quiet and efficient control.

Many more skilled men are wanted for the changeover than were engaged on the installation, and these men are drawn from maintenance staff of nearby districts, usually the London area. All supervisors and leading men in this category visit the site of their night's work beforehand to get their bearings and learn at first hand what they will have to do.

Care is taken in selecting personnel from areas where similar apparatus is in service, so far as this is possible, and all local routine works are stopped to give full staff availability.

The assembling of so many men at a number of points (a large proportion of whom may not be familiar with the locality) and danger due to the conductor rail, have their own problems. So in the interests of safety it is thought advisable to lose some time and not permit any men on to the running lines until the possession is effective and the traction current switched off throughout the whole area. To this end the civil engineer has representatives at all points giving access to the area who, when advised by a local traffic official that the possession is effective, notify a supervisor, who will be located at the existing signal box nearest to the strategic centre. When the last report reaches him, he advises the signal and telecommunications supervisor that possession is complete. Similarly a representative of the mechanical and electrical engineer has been collecting reports of traction current off and on receipt of the last one he, too, advises the signal and telecommunications supervisor. Where necessary, temporary telephone arrangements are made to expedite this procedure. On receipt of the second message the supervisors at signal boxes are advised, and they disseminate the news. This procedure takes about ten minutes. Meanwhile, staff have reported for duty, formed into groups and proceeded to a predetermined site to await the information that they can start work.

A similar procedure is carried out at the close of the possession, when the changeover supervisor is satisfied the block can be lifted and traction current restored. Shortly before this,

selected permanent way staff patrol the area to make certain there are no obstructions, and no potential traction short circuits.

Lighting for the changeover, in addition to the usual hand lamps, is provided by Tilley flood lamps, supplied and serviced by district engineers' staff. Traffic department staff provide tea-making facilities everywhere possible and this is appreciated and is of valuable assistance in getting the job done.

The most recent changeover on the Southern Region covered 34 track miles, 3 new signal boxes (103, 79 and 43 levers), 240 track circuits and 103 point machines; 120 running signals and 43 shunting signals replaced over 200 semaphore arms and 40 shunt signals; eleven signal boxes were abolished. There was complete possession of the whole area for six hours.

I have not intended to go into details of every aspect of a major changeover, but hope that I have said sufficient to start a discussion on this important subject.

DISCUSSION

Mr. J. H. Currey referred to the type of changeover at a busy terminal station where the traffic was steam hauled. Although traffic might be reduced appreciably, it was bound to be considerable. A passenger train might be brought into the station; a light engine required to haul out the empty stock, and the train engine had possibly to take another route to its shed. Every one of those moves had to be made under hand-signalling, and took a great deal of time. Whilst that was not so important during the early stages when work could be covered on the freer areas, during the later stages, work might be held up for as much as half-an-hour, due to one train movement, and before there was time to begin again, a second train had to be dealt with. As a result, probably a good deal more temporary and preliminary stage work was necessary, carrying the actual changeoever over a period of several week-ends. That meant a good deal of temporary wiring in a new power box, which was always a source of danger. The complete wiring had probably been installed, tested and found satisfactory, but temporary wiring had to be superimposed on the permanent, the work covering possibly two or three week-ends or even more. Under such conditions, very great care had to be taken to see that the temporary wiring for the different stages was distinct, one from another and from the permanent wiring,

which involved much additional testing. Testing under traffic conditions in a large box called for particular care.

During the actual changeover period, men were located at strategic points with telephones and these were sometimes left unmanned, despite strict orders to the contrary. To safeguard against this, it had been found very useful to make use of the paging loud speaker system over the area.

The London Midland Region had found it essential to have certain meal times strictly laid down. Each man knew the time he was expected to go for his meal and the supervisor saw to it that he went at the stated time to avoid possible overcrowding.

Mr. J. H. Fraser referred to a large changeover where the traffic was entirely steam hauled and where exceptional trouble was taken to obtain possession, even to the extent of terminating trains at stations outside the area and operating bus services for the passengers. Goods trains had been routed in different directions and some trains were cancelled. It had helped greatly in speeding up the changeover. A detail sometimes overlooked was the training of hand-signalmen. Quite an intensive service of trains could be safely run if the men were properly trained and suitable telecommunications were provided. An item of interest was that in some Regions, points were not clipped. A clip, or scotch, was interpreted as a wedge, and hard wood wedges were knocked in quite quickly and easily and made a good deal of difference in hand-signalling.

Mr. F. G. Hathaway said that in some of the earlier changeovers with which he had been associated, if the job had been finished before the stipulated time had expired, it was handed over to the traffic department; but in some later installations, even if the job were ready, it was not necessarily handed over until the stipulated time. He asked what was the practice on the Southern Region. Regarding communications, he enquired if the question of radio had been considered, particularly "walkie-talkie" sets for adjustments of track circuits.

Mr. C. F. Challis replied that the particular job he mentioned had been ready only a very short while before the stipulated time. Had they finished a matter of hours before, he could see no reason why they should not have handed over to the traffic department, but it would have been of no advantage, as the signal engineers had complete possession, all trains being stopped.

Mr. Hathaway suggested it might prove a saving to withdraw their staff directly they had finished. **Mr. Challis** said that in the case he had in mind the men could have returned to their depot, but as they would have no means of getting home, they would still have had to be paid. He did not think a job was likely to be finished a great deal in advance of schedule. He felt that time did not permit a discussion on the question of radio as a means of communication during these works.

Mr. A. Moss spoke of the Liverpool Street to Shenfield electrification scheme when, from early June in 1949 until the end of September, changeovers took place every week-end; fortunately, there was not one wet week-end during the whole period. The traffic department were unable to cancel any trains whatever, all they could do was to give possession of a certain line for a certain number of hours, as the normal series of excursion trains had to be run from Liverpool Street to the east coast resorts. The procedure adopted was to assess the staff available and divide them into gangs; each man had a schedule and knew exactly what he had to do. A great help was the provision of suitable amenities for the staff, such as arrangements for meals and for sleeping on the job. They did not use any loud speaker equipment for communication; but had used telephones, a man being stationed at every telephone and being in communication with a certain group working in the vicinity. Mr. Moss referred to the practice of changing over the points beforehand and coupling them up with the mechanical signal box and said that when this was possible, it saved time on the day of opening. Testing took an appreciable time; at Liverpool Street, it had taken about ten weeks, working double shifts. Allowance had to be made for eventualities so far as they could be foreseen, but in the case of Liverpool Street, work was well in hand when there was a cable fire down the line, which held up normal procedure. That was something which could not have been foreseen. He queried whether the training of signalmen was the function of the signal department or not. On the Eastern Region, the signal and telecommunications people trained the supervisor on the operating side, and took the view that it was his job to train his own signalmen. It would be rather a task for them to train three shifts of three or four signalmen. Regarding the completion of work before the time of possession was up; they were given a definite time by the traffic department and handed back possession at the time

stated. If they finished an hour or two earlier, they employed the time for their own benefit.

Mr. C. F. Challis said that on the Southern Region, points were not changed beforehand. The training of signalmen was not undertaken by the signal department, but they made the signal box available to the traffic department to get them used to the new method of working, and they did the training.

Mr. H. Firminger said that on London Transport he had to deal with smaller installations than Mr. Challis, but did not think he could hold up a changeover until the current were switched off. He asked if the Southern Region considered it to be really necessary. He also asked Mr. Challis how was the equipment set up for pre-testing signalling installations as far as the cabin was concerned ; was it automatic, or was it tested by staff in the relay room giving indications back ? Did they leave the test equipment on for training signalmen? London Transport had found radio equipment very valuable as it enabled a person to keep in touch with a particular man. Instead of relying on a number of people stationed at telephones, one or two people with " walkie-talkie " sets were able to go round to various points and report back to the signal cabin.

Mr. C. F. Challis replied that men went to a pre-selected site and waited until they had notification of the traction current being off in the area. The Southern Region thought that worth while, as there might be two or three hundred men working in an area with which they were not familiar. They certainly did not withdraw the men before the restoration of the current because they would then be working in daylight, but warning was given of the restoration of the traction current. As to pre-testing ; taking a pair of points as a typical example, a supervisor would be at the lever, and when the disconnection had been made from former working, they were tried out under final conditions. There would be another supervisor at the points to ensure that the proper sequence was being observed, and they relied on the final relays and the final wiring to give indications in the signal box.

Major A. N. Stacey recognised that Mr. Challis had concentrated on the larger examples of changeover from semaphore signals to colour-light signals, and appreciated the complications in an area such as London. He recalled some interesting changeovers under traffic conditions in other places. In one of

these, on a four-track main line, on a week day, the 9.45 a.m. train travelled under semaphore signals and the 10.5 a.m. steam train under colour-light signals, without any delay.

Mr. B. F. Wagenrieder stressed the importance of full information on traffic working being given by the district inspector at the meetings held prior to the carrying out of installations.

Mr. A. Moss said that signal engineers were much indebted to traffic officials who were always a great help to them and co-operated in every possible way. This view was endorsed by Mr. Challis.

Mr. F. W. Young further emphasised the importance of adequate training of hand-signalmen. Not only must they know where to go, but it was vital that they should be given practice on the ground at least once beforehand. Every set of points should be marked with something very distinctive, such as black on white, to indicate the number and the normal lie of the points. Close liaison with the operating department was essential so that the signal engineer was conversant with all traffic movements and so that adjustments could be made to deal with trains that might be running late. Certain trains could not be cancelled, but the operating department were sometimes able to hold them back for a number of hours at the week-end and it was important that the signalling work ran to time so that when the held back traffic began to flow, the way was clear for it. In the case of a mechanical to mechanical changeover, it assisted if possession could be obtained beforehand and the points worked from the new lever prior to the day of the changeover. After such a test, apparatus should be clearly labelled ; similarly, all rodding and mechanical wiring should be clearly labelled at the point of changeover with the new and old numbers. Where there was no room to install a new lever frame beside an existing frame, very little could be done beforehand, except to test the new frame in the workshop. It was a great help to the operating department if the signal engineer not only gave facilities for the training of signalmen but also provided a sketch of the layout and a chart showing all levers and routes which could be set up. These could be taken away and studied in good time.

Mr. A. Cardani asked if spare apparatus were available at a changeover in case of accident or unforeseen faults developing.

He said he had a limited experience with " walkie-talkie " equipment and found it very useful in setting up track circuits as it enabled communication to be maintained with men at each end. However, when working with a mobile station with one fixed receiving call from several " walkie-talkie " sets on the same frequency, there was a tendency for confusion to arise.

The Western Region employed signalmen for the purpose of hand-signalling as it was thought that they did the work much more competently, being fully conversant with the working of the signal box.

Mr. Challis replied that spare equipment was usually available as it was allotted to a district under maintenance and was there at the time of the changeover. He noted with interest the use of " walkie-talkie " equipment for track circuit testing.

Mr. T. G. Robinson enquired as to the actual type of " walkie-talkie " equipment used for a changeover and the method of calling. He spoke of an army type of set incorporating four channels, but said it was limited in range to little more than half-a-mile, also ground contours and other obstructions limited its use.

Mr. R. Dell replied that one must have single frequency, as in dual frequency working, one frequency was used for speaking in one direction and the other in the opposite direction. This had the disadvantage that where several mobile sets were in use, they could not hear one another and were liable to cut in on the speech of another station. One could only get a single channel allocation from the G.P.O., so the four-channel working would not be possible. The G.P.O. were very insistent on stability of frequency to avoid interference with other sets in adjacent channels. London Transport used a transportable set which could be taken to a signal cabin. It had a 12 watt capacity, was run from motor car batteries and had a range of probably 10 miles. A second transportable set could be taken to a convenient place on the track or could be moved about on a platelayer's trolley and formed a mobile headquarters for testing personnel. The " walkie-talkies," carried over the shoulder, could communicate with either the signal cabin or the mobile set. This proved extremely useful, both for testing equipment at a changeover and for testing long track circuits.

Mr. J. Runnett asked what the various Regions did to ensure that the linemen were competent to take charge of the apparatus during the temporary stages leading up to the final changeover.

Mr. Challis explained that included in the opening night programme was a sheet setting out the immediate post-opening period arrangements for linemen, assistants and supervisors. The long term policy was that throughout the installation every attempt was made to interest the local linemen in the work that was going on ; they took part in the stage moves as far as possible and were trained with a view to their taking over the maintenance.

Mr. C. C. Bennett raised the question as to the best time of year to carry out a changeover. Was it better to do it in the winter when there was less traffic, or in good weather with more daylight but the possibility of excursion traffic ? He was also interested in the type of telephones used on outside work, as he had had experience of instruments that required buttons to be held up or handles to be turned.

Mr. Challis replied that if they had a free choice they would carry out a changeover during summer traffic. The ideal time was just after the commencement of winter traffic, but before one would expect real winter weather. He would, however, recommend that work must be finished before November.

Mr. W. J. R. Brett said that on the Southern Region, as the point testing telephones were usually in their final position before they started testing, they used the telephone normally there, which was the double operated ringing type.

Mr. O. H. Hoffman added that the telephones, if portable, were of the Post Office leather covered type or those in bakelite cases which had superseded them.

The **President** said that all would agree that the meeting had produced a most interesting and valuable discussion. They were indebted to Mr. Challis for the able manner in which he had introduced the subject and answered the many points that had been raised. It gave him much pleasure to move a very cordial vote of thanks to Mr. Challis, and the vote was carried with acclamation.