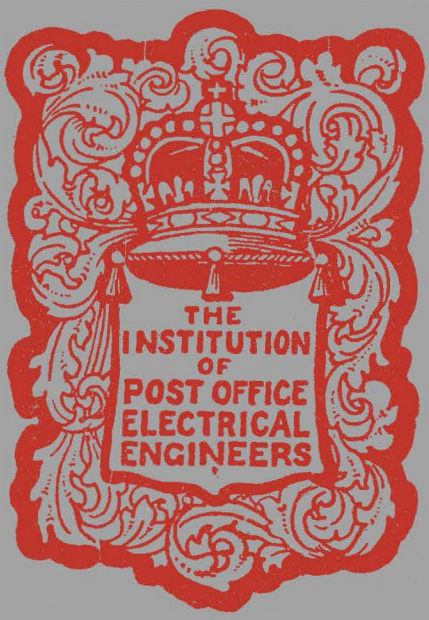
THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



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PART 4

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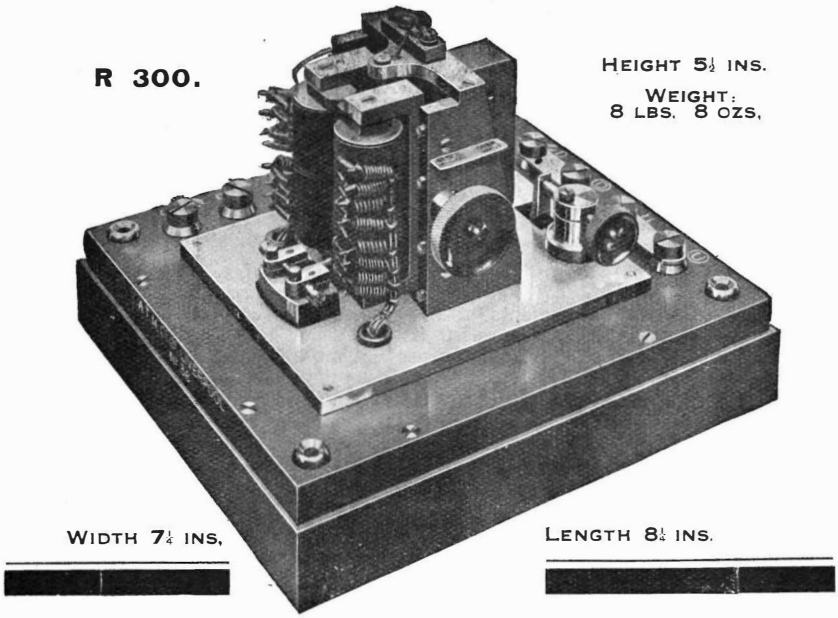

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A QUARTERLY JOURNAL.

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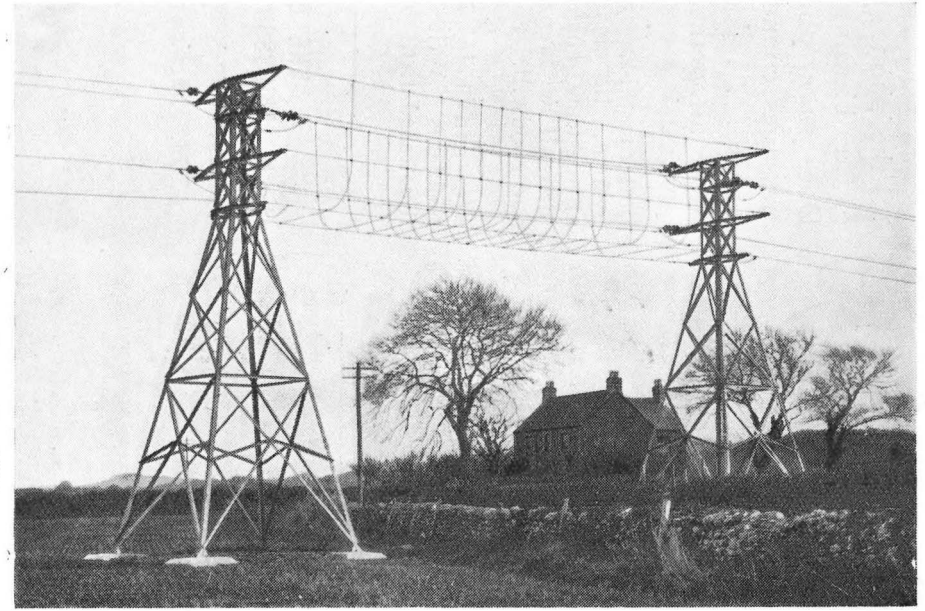

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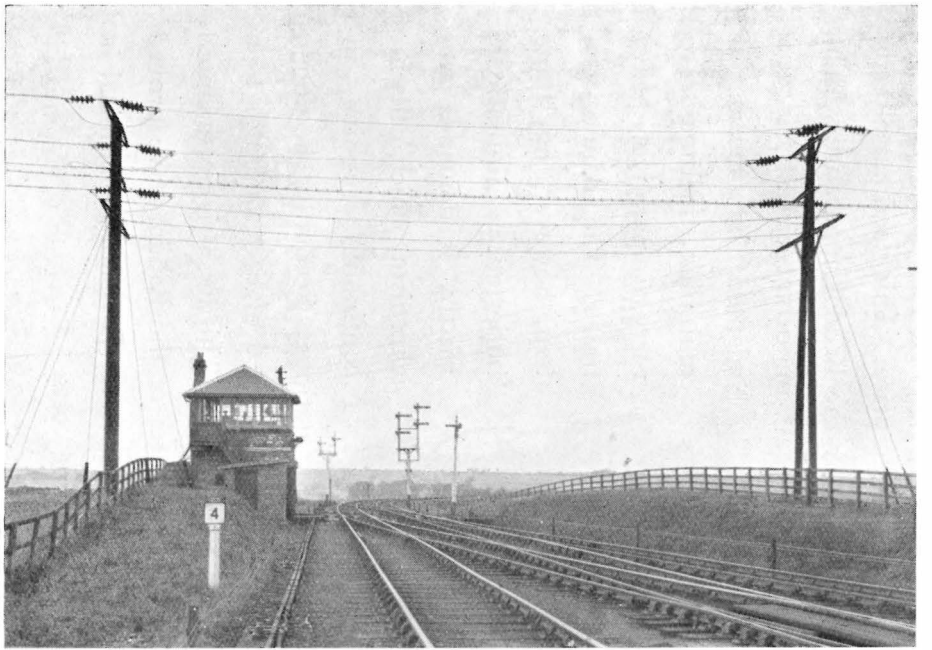

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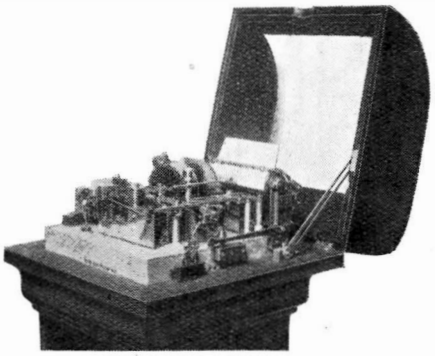

3. *Ease, convenience and uniformity of operation and adjustment*, enabling the ordinary operator to understand and work any and every machine in the service. This is very important from the point of view of the training and maintaining the staff.

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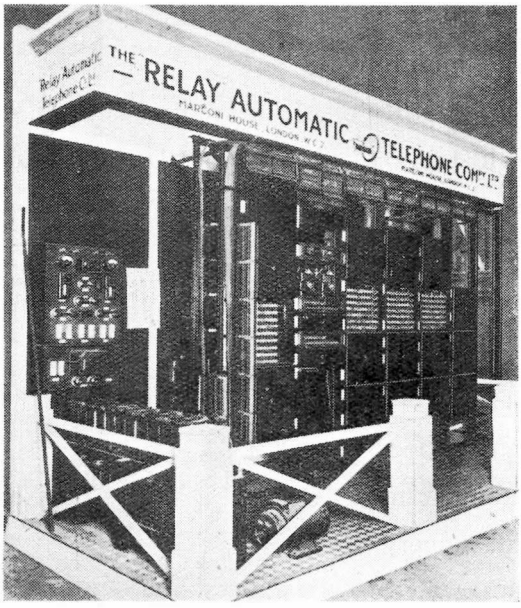

The Relay Automatic Telephone Exchange which linked up every part of the great Wembley Exhibition

Wembley's Tribute

The following letter is from Lieut.-General Sir Travers Clarke, K.C.B., K.C.M.G., the Director General of the British Empire Exhibition :—

"AT the close of the 1925 season of the British Empire Exhibition, I wish to express to you my sense of appreciation of the satisfactory work done by the Relay Automatic Telephone Company system at Wembley Park during 1924 and 1925.

The system, which has been employed for communication in the Administrative Offices and throughout the grounds, has worked very well and has been a great aid to the staff in carrying out their work.

It was satisfactory to note that British engineering enterprise had coped so well with the problem of Automatic Telephone communication."

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No mechanical switches—no oiling nor cleaning, cannot wear out, minimum maintenance.

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THE
Post Office Electrical Engineers' Journal

THE POST OFFICE AND AUTOMATIC TELEPHONES.

Summary of a paper read by Col. T. F. Purves, O.B.E., before the Institution of Electrical Engineers.

" In the art and practice of telephony the development of means whereby one talking circuit can be connected, at will, with any other has always presented a leading problem, second only to those involved in the actual transmission of speech.

" Although its study has been accompanied by a large amount of invention, it is essentially a problem in pure engineering. The object accomplished is one which, in itself, is simple, and the immense amount of effort and ingenuity which has been expended upon it by many hundreds of engineers has been directed wholly to securing its accomplishment at minimum cost in money and time.

" The various systems of switching classed as ' Automatic ' perform no new function in telephony; rather do they represent the culmination of a continuous process, in which electrical and mechanical devices have been increasingly utilised in order to reduce the amount of human effort required to place a telephone subscriber in communication with the correspondent with whom he desires to speak. In this economy of effort the subscriber has shared, and in modern ' manual ' switching systems the only manipulative act required of him is that he should lift the telephone receiver from its rest before speaking, and replace it when he has finished.

" The adoption of the automatic system represents a reversal of this policy of economy of operation, so far as the subscriber is concerned, since it throws upon him the whole of the manipulation required to effect the ordinary local calls which generally constitute the bulk of his transactions, and for that reason the introduction of automatic exchanges in any telephone area is generally a matter of considerable public interest.

" The desire of the general public for information is catered for by the daily Press, and, at the other extreme, the professional telephone engineer has at his disposal a great mass of technical literature in many forms, in the multitudinous details of which the electrical engineer who is interested in only a general way may be pardoned for sometimes complaining that he ' cannot see the wood for trees.' I shall therefore endeavour to give a general description of the function of automatic switching apparatus in telephony, with a few main details of the most recent inno-

vations incorporated in the system which is now being installed in new exchanges in London."

The paper described the operation of ordinary Strowger step by step mechanism and detailed the functions to be performed and also gave particulars of the development of Strowger automatic equipment in this country from 1912, detailing the circumstances in which decisions are given for the introduction of automatic equipment when manual exchanges fall due for replacement. The decisions have been given as a result of financial comparative studies and it has been found that the economy of providing automatic or manual equipment could in many cases be determined without detailed individual calculation by the application of the following general principles :—

" (1) In an area where the anticipated development on all exchanges in a period of 20 years does not exceed 1000 subscribers' lines, manual equipment is to be provided.

" (2) In all other cases automatic equipment is to be installed, provided that the following traffic conditions obtain :—

(*a*) The ' calling rate ' to average not less than 1.2 calls per subscriber in the busy hour of the day.

(*b*) The proportion of local traffic to be not less than 70 per cent.

(*c*) The number of manual operators' positions required, in association with the automatic exchange, not to exceed 55 per cent. of the number of positions required for a manual system.

The fulfilment of conditions (*a*), (*b*) and (*c*) provides a safe case for the adoption of the automatic system. Cases which fail to satisfy these conditions are treated as border-line cases and are subjected to detailed calculation. The result of the investigation of these doubtful cases has, so far, shown that in more than 80 per cent. of them the automatic system represents an economy."

" Experience has shown that there are few areas where the 10 years development will reach or exceed 2000 subscribers' lines in which the automatic system will not show a comparative saving and as a result it recently was decided that it is safe to install the automatic system without detailed financial comparisons with manual if the following conditions will be satisfied within that period :—

(1) The average subscriber's calling rate to be not less than 5 calls per day.

(2) The number of local calls switched automatically to be not less than 4000 per day.

(3) The proportion of originated calls requiring to be handled manually to be not more than 40 per cent.

" On the other hand, if the number of local calls which might be switched automatically will not exceed 3000 per day within the 10 years period, manual equipment will be installed without question.

" The introduction of the automatic system does not necessarily involve any appreciable modification of the private branch exchange switchboards working in the area. A great many private automatic exchanges have nevertheless been installed by the Post Office to meet the wishes of its subscribers. Some of these exchanges provide for over 500 lines. The majority of them are of the Relay Automatic Telephone Co.'s type."

The paper dealt in detail with the studies that are undertaken to deal with the comparative financial position as affecting the positions of exchanges and the lay-out of external plant. An important consideration is the fact that with a manual system 10,000 line units are in general use, but when changing a system over to automatic working, the general geographical lay-out of the area may be such as to encourage the adoption of smaller units leading to shorter average subscribers' lines of light copper, thus

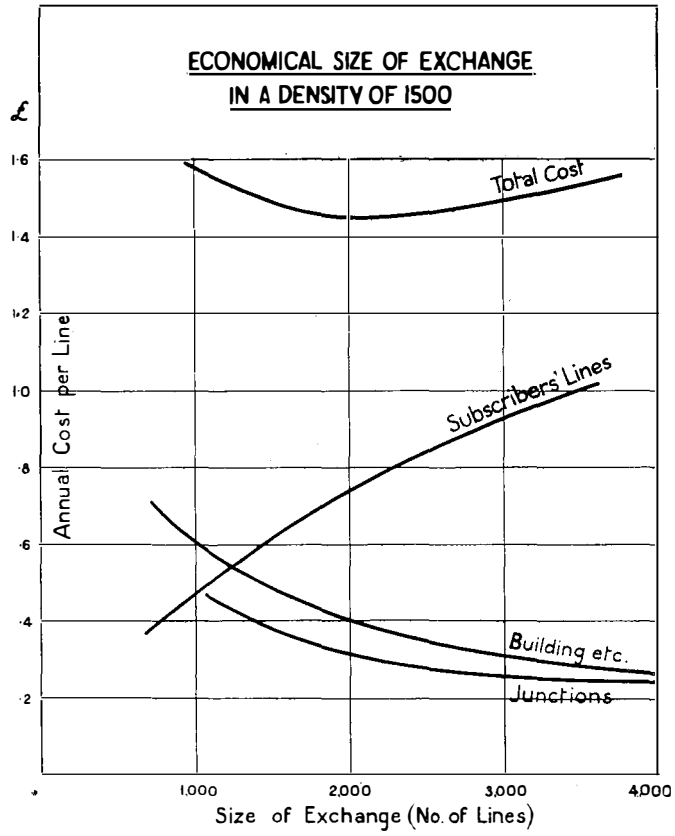


FIG. 1.

reducing the subscribers' copper costs at the expense of somewhat increased cost in the junction lines. Fig. 1 illustrates this principle in a case where the economical size for exchange units will be 2,000 lines assuming a density of 1,500.

As regards the lay-out of internal plant, attention was drawn to the adoption by the Post Office of the system of grading between the banks of one rank of switches and the wipers of the

next rank. Fig. **2** shows the case of grading between 24 point line switches and first selectors. Assuming the standard grade of service to be 1 in 500, it has been found that the average traffic per switch would be as indicated in the following extract from the paper :—

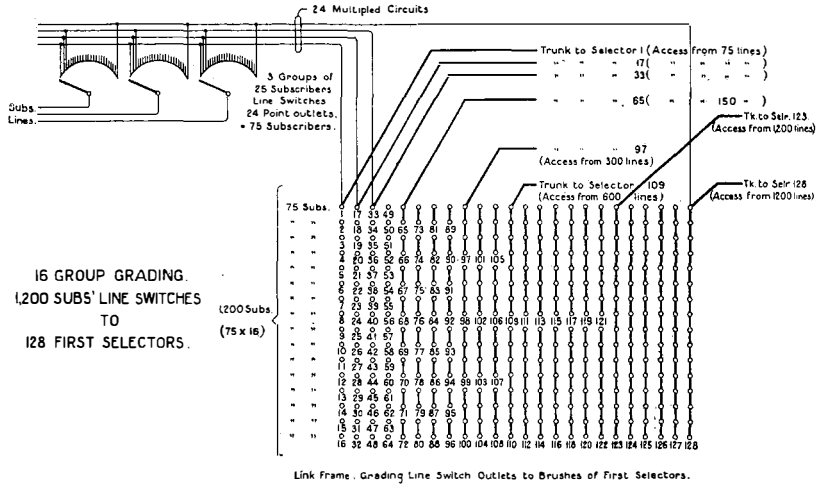


FIG. **2.**

" As an illustration of the way in which the fluctuations of traffic are proportionately reduced as the size of a group increases, it may be of interest to consider the case of a number of subscribers each making two calls per busy hour with a holding time of 3 minutes. If these are arranged in a group of 10 having a common outlet, the resulting traffic would be equivalent to 1 traffic unit, and if the calls were made at absolutely uniform intervals they would all be carried by a single switching channel, continuously occupied. Similarly, a group of 250 lines would originate 25 traffic units and require 25 switching channels under the same conditions.

" Actually, if this provision were made the following percentages of calls would be lost :—

	Per cent.
For 10 lines (1 traffic unit and 1 switch) the loss would be	50
For 100 lines (10 traffic units and 10 switches) the loss would be	21.5
For 250 lines (25 traffic units and 25 switches) the loss would be	15
For 1000 lines (100 traffic units and 100 switches) the loss would be ...	7.6

" The matter may be looked at in another way as follows : Assuming that the standard grade of service of 1 in 500 is given, it is found that the average traffic per switch for the numbers of switches quoted above and in two graded cases would be as follows :—

10 Switches will be asked to carry 3.43 traffic units per hour; average traffic units per switch	0.343
25 Switches will be asked to carry 13.76 traffic units per hour; average traffic units per switch	0.55
100 Switches will be asked to carry 76.4 traffic units per hour; average traffic units per switch	0.764

100 Switches (10-contact grading), 43.6 traffic units per hour; average traffic units per switch 0.436

100 Switches (25-contact grading), 64.08 traffic units per hour; average traffic units per switch 0.641

" In the first three cases the preselectors finding their outlets *via* these switches are assumed to have a sufficient number of contacts to secure full availability in the two last (graded) cases the preselectors would have only 10 and 25 contacts respectively."

" Services Reserved for Manual Operation.

" The conversion of an area to automatic working does not involve the complete elimination of the manual operator. Some classes of traffic can at present be handled more conveniently and economically by manual than by automatic means and, in general practice, all calls for which more than the unit fee is charged will be dealt with by an operator who will record each call on a ticket in order that the proper debit may be made to the calling subscriber. In the Post Office system, operators are retained for trunk and toll circuit calls, extra-fee junction calls, phonogram (*i.e.*, telegraph message) calls, call-office and coin-box station calls, and for ' inquiry ' and ' information ' calls.

" Until recently all coin-box and call-office traffic was handled manually, but a new form of coin-collecting box has now been introduced which provides for the deposit of the local unit fee automatically. The attention of an operator will only be required for calls involving the deposit of additional coins in the box. The use of this new coin box in association with automatic systems will, in the first instance, be confined to provincial areas.

" For all calls to points outside the unit-fee area, the originating automatic subscriber dials a number which will obtain the attention of an operator in his own local exchange, or in the trunk or toll exchange, to whom he gives his demand. The call is then handled and recorded on a ticket in the regular manual fashion throughout.

" The method known as ' dialling out,' which permits the calling subscriber to obtain direct communication with an operator at the distant exchange required, is frequently advocated, but has not been adopted by the Post Office for extra-fee traffic, on account of the disadvantage of removing the supervision of such calls from the operator at the home exchange. The distant operator cannot conveniently be placed in a position to check the identity of the calling subscriber against whom the extra charge is to be debited.

" The converse procedure of ' dialling in ' is, however, in common use. A subscriber on a manual exchange who requires a subscriber on an automatic exchange, reached by means of a junction or direct trunk line, makes the demand to his local operator as usual. This operator then completes the call by dialling from her cord circuit over the junction or trunk line directly into the switches at the automatic exchange, and thus sets up the desired connection without the intervention of an operator at the called exchange. This method of operating is adopted in all cases where line conditions permit, in preference to the alternative method of passing the demand verbally by order wire, or over a signalling junction to a manual operator at the required automatic exchange for completion.

" The character of the line has, however, a restrictive effect upon the extent to which ' dialling in ' can be employed. The method is practicable on almost any length of unloaded physical line, but the introduction of loading coils and repeaters and the use of phantom circuits give rise to certain difficulties. The trasmission constants of a loaded line introduce a marked degree of distortion in the dialled impulses, but in the few cases where this trouble would be sufficient to affect working efficiency it would be possible to remove the difficulty by the use of special methods and apparatus.

" Repeaters and phantom circuits are, however, obstacles which have not yet been fully overcome. A solution has been found to the cognate problem of sending

calling and supervisory signals over such circuits, and considerable progress has been made with the solution of the dialling problem. A method which promises a satisfactory result involves the use of high-frequency alternating currents, the application of which to the line at the sending end is controlled by the dial impulses. At the receiving end, these trains of high-frequency alternations operate on the grid of a valve having in its plate circuit a relay which, in turn, controls the stepping relay of the selector switch.

" In ordinary local areas of medium size an endeavour is always made to change over from manual to automatic working simultaneously at all the exchanges in the area, but this is often impracticable, and in such cases one or more exchanges remain manual whilst the remainder are automatic. Under such conditions the methods of ' dialling in ' and ' dialling out ' are both adopted for interchange of traffic between the two systems, and each call is dealt with by one operator only.

" There is no objection to allowing an automatic subscriber to dial out to the operator at a manual exchange in the case of unit-free traffic, since the registration of the call is automatic and the operator, who has no extra charges to record, is not concerned with identity of the calling subscriber."

Argent Co, 1400 Bway.....GRE eley 5513
Argentina Brazil & Chile Shipping Co
70 Wall.HAN over 0307
Argentine Genl Consulate, 17 Batry pl..REC tor 6948
Argentine Impt & Expt Corp, Prod Ex...BRO ad 1768
Argentine Mercantile Corp, 42 Bway.....BRO ad 5066
Argentine Naval Commission, 2 W 67..COL mbus 5623
Argentine Quebracho Co, 80 Maiden la....JOH n 1652
Argentine Railway Co, 25 Broad.....BRO ad 1383
Argentine Trading Co, 1164 Bway.....MAD Sq 1871
Argeres Bros, Restrnt, 86 6th av.....SPR ing 5337
Argero A. Grocer, 119 9th av.....CHE lsea 6255
Arghis A, Tobacco, 74 Wall.....HAN over 6311
Argirople Theodore, Jwlr, 406 8th av..FAR ragut 9772
Argo Packing Corpn, 705 Greenwich...FAR ragut 4505
Argon Dress Co, 24 E 12.....STU yvsnt 2011
Argonaut Supply Corp, 50 Union sq..STU yvsnt 7476
Argonne Steamship Co, 17 Battery pl...REC tor 2493
Argos Ad-Art Co, 1133 Bway.....FAR ragut 5986
Argosy The (A Pub), 280 Bway.....WOR th 8800

FIG. 3.

The main interest in the paper, however, lies in the Author's description of the proposals that have been made for the operation of very large areas such as London, Glasgow, Liverpool, Manchester and Birmingham. The system is to be somewhat similar to that adopted by the Bell Telephone Companies in the large cities of America, where the W.E.Co.'s panel system has been adopted. This involves the introduction of a special directory in which the subscribers' exchange particulars are specially printed—vide Fig. 3, which is an extract from the New York Telephone Directory.

The object in printing the directory in this manner is to enable a single directory to serve for both manual and automatic service, using for the latter purpose a dial with special number plate, as per Fig. 4, where the new or director type is compared with the ordinary dial plate. The automatic subscriber is required to dial the first three letters of the exchange name followed by the four figure number. A modification of the step by step system necessary to permit of this being done economically is embodied in what is known as the Director System, and the following extract from the paper will make the subject clear:—

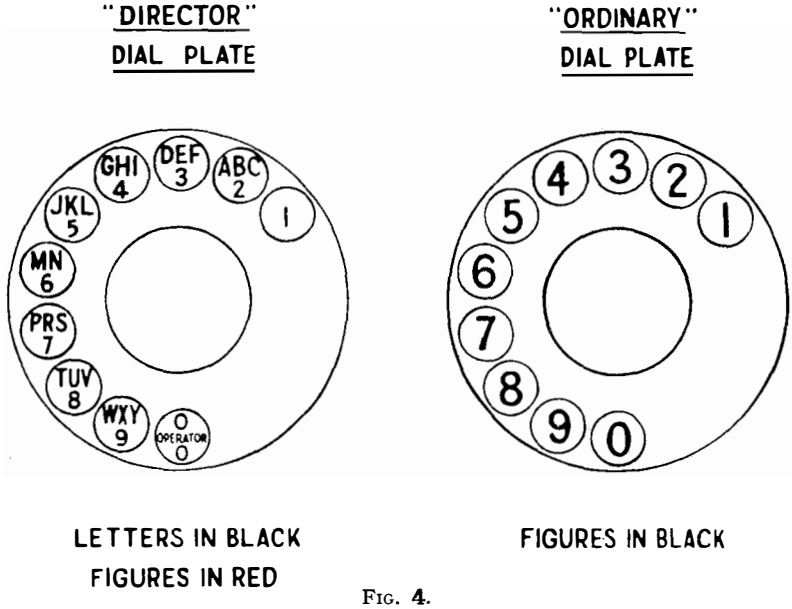


FIG. 4.

"THE CHOICE OF A SYSTEM FOR LONDON.

"Four years ago the development of the 'panel' system had reached a stage which placed it far in advance of other then existing systems in respect of suitability for the equipment of the largest cities. The Post Office was eager to start the introduction of automatics in London, as many large new exchanges were required to provide for development and for the replacement of existing obsolescent or inadequate exchanges, and the installation of these important exchanges on the manual system would have had the effect of postponing by many years the ultimate complete conversion of the area to automatic working. The panel system was, therefore, very closely studied and the opinion reached was so favourable that it was decided to proceed as rapidly as possible with the preliminary arrangements for its adoption. It was admittedly both costly and complex; much design and engineering work still remained to be done before it could be said to have reached a state of comparative finality, and many of its features, which had been developed to meet the telephonic conditions of to-day in New York, could not without modification be applied to the very different conditions of London. On the other hand it was obviously a system of unbounded possibilities and no one doubted that it could be made to meet any legitimate service requirement that might arise. A factor not to be overlooked

was that it had behind it the high prestige of the American Bell System, which had staked very large financial commitments on its success, and whose able engineers would, for years to come, continue to strain every effort to bring it to perfection.

" Plans were prepared for a first panel exchange in London, to be known as ' Blackfriars,' and at the same time the Post Office started to negotiate an agreement with the Western Electric Co., in accordance with which the manufacture of panel equipment would have been commenced in England under conditions that would ultimately have permitted other British telephone manufacturers to obtain a share of the work. While these arrangements were proceeding, the sponsors of step-by-step automatic systems had not been idle or asleep, and early in 1922 the Automatic Telephone Manufacturing Co. called our attention to a notable development of the Strowger system by the Automatic Electric Co., of Chicago, who had succeeded in devising and combining with the step-by-step system a call-storing and translating scheme, which had endowed that system with practically the same elements of numbering and trunking flexibility that had first been conceived in association with the panel system. To this new development the name ' Director System ' was given. The matter was, naturally, one of first-class interest and, although the immediate proposals were in a somewhat embryonic stage, they were at once investigated very fully.

" In association with the Automatic Telephone Manufacturing Co.'s engineers, a miniature multi-exchange system was laid out in such a way as to cover as far as possible all the different types of service required and exchange conditions met with in London, and was installed at the General Post Office as a working model of the director system. (A similar working model formed part of the Post Office exhibit at the British Empire Exhibition at Wembley.) Exhaustive study and trial led to the conclusion that the director system contained all the essentials required as a basis on which to frame a complete equipment of circuits and apparatus admirably fitted for the service of such an area as London, and it was evident that a practicable alternative to the adoption of the panel system had become available. In November 1922 I definitely recommended the adoption of the step-by-step system, with the addition of the ' director.' The main reasons on which that decision was based may be of interest, and are as follows:—

(1) The first cost of director exchanges was somewhat lower than the probable cost of the panel system manufactured in England.

(2) The fundamental electrical plan of the system is very much simpler than that of the panel. Circuits for particular purposes are easier to design and easier to understand.

(3) The Post Office engineering staff was already familiar with step-by-step systems, and it had been found that men could readily be trained to undertake all the duties of maintenance. The difficulties involved in securing and intensively training the requisite staff for handling the panel system—on the large scale of the necessary programme—would certainly have been considerable, and might have involved serious delay.

(4) The apparatus to be employed in the director system was all of existing types which had stood the test of years of actual use, and which could be depended upon to give first-class service. The scheme was purely one of new electrical circuits and combinations. It was possible, even at that early stage, to visualize the lines on which circuits for all purposes might be designed and, in fact, to see right through the eventual London system to a far greater extent than was possible in the case of panel equipment.

(5) The director system applied readily and naturally to small, as well as to large, exchanges and to ' satellite ' * exchanges as well as to main

* A " satellite " exchange is one provided only with subscribers' line switches and local selectors, and dependent upon an adjacent main exchange for all manual services and for the routing and handling of all its external traffic.

exchanges. The panel system had not been developed with a view to serving small or satellite exchanges. The fact that it could be made to do so was not doubted, but it did not appear that the solution was likely to be an economical one. This would be a matter of little importance in New York where the dense population of its large business buildings and apartment houses, combined with its high percentage of telephone development, necessitates that nearly all exchanges must have a capacity approaching 10,000 lines. In the 'down-town' area of New York many of the exchange buildings will have capacity for four or more exchange units of 10,000 lines each. In widespread and less opulent London there have to be very many small exchanges and satellite exchanges, and it is essential to have a system which can be applied economically to such conditions. It is estimated that in 10 or 12 years' time there will be at least 130 separate exchanges in the London area. Of these not more than about 50 will be in the business districts of the City and West End, and of this number only about 30 will have an ultimate capacity of 10,000 lines, while about 20 will be limited to 5,000 lines. The remaining 80 exchanges in the area will include about 50 of 3,000 lines, 20 of 2,000 lines, and 10 of 1,000 lines. (In several cases two or three exchange units of 10,000 lines each will be accommodated in the same building.)

(6) The Post Office was already committed to several variations of the step-by-step system on a considerable scale in the provinces. The possibility of using the same system in London replaced the somewhat dismal prospect of adding another and very complex system to the rather divergent group already established, by the much more attractive prospect of being able to standardize a type of automatic system for general use throughout the country. As a direct result of the adoption of the director system, a large measure of standardization has since been accomplished, as referred to later. It will in future be possible to move staff from one district to another as may be necessary, without confronting the transferred men with unknown types of apparatus and circuits in the exchanges.

(7) Prior to the adoption of the director system, it had been ascertained that arrangements could be made for spreading the work among the regular exchange contractors of the Post Office at an early date. The important question of supply was thus greatly eased, as existing British factories became at once available for production purposes. The necessity for placing even the initial orders abroad was avoided, and the Post Office was able to enlist the co-operation of the skilled engineering staffs of all the contractors who had been producers of step-by-step equipment.

"The negotiations in hand for the introduction of the panel system were therefore broken off and agreements were entered into with the Automatic Telephone Manufacturing Co. for the supply of director switching equipment for the equivalent of about 55,000 exchange lines, and with the Western Electric Co., Messrs. Siemens Brothers and the General Electric Co. for smaller quantities. Provision is made for existing patents, and for future patents during a specified period, to be pooled on terms which will enable the Post Office to call upon all the firms to install plant covered by patents in the possession of any of them. At the end of the period of about three years covered by the contracts it will also be possible to utilize the services of other competent firms who may desire to take up the manufacture of step-by-step automatic equipment. These agreements cleared the way for standardization of system, and before proceeding to specify circuits and layout a very careful comparative study was made of the characteristics of the systems identified with each of the firms named, of all of which the Post Office had had practical experience.

"Subsequent to the decision to adopt the director system, the firm of Siemens Brothers had submitted analogous developments styled the 'translator' and the

' by-path ' systems, applicable to its type of step-by-step equipment, and at a later stage the General Electric Co. also brought forward a proposal to embody in its system an equipment of devices having the same object, which had been termed the ' controller ' system. The ' translator ' and the ' controller ' systems existed, for the most part, on paper, but they furnished interesting evidence of the readiness and flexibility with which the long-established step-by-step system lent itself to the grafting on of developments designed to achieve a newly conceived purpose.

" STANDARDISATION.

" It was recognised that the complete standardization of the automatic system for Post Office use could not be effected in a single step without long initial delay and the temporary paralysis of some of our sources of supply. The most pressing need was to secure that all future automatic exchanges should be of such design that they would be able to intercommunicate directly one with another, without requiring the addition of any special devices or circuit complications for the purpose. First attention was therefore given to the standardization of electrical circuits and operating currents for all inter-exchange purposes, and this has now been accomplished. Each contractor is allowed to supply plant of his own type of mechanical construction, but all types must be capable of operating in the prescribed manner on the circuits which represent, for the time being, the standard methods of fulfilling particular functions. It will therefore be possible to equip any area, large or small, with exchanges supplied by any contractors who may, from time to time, secure the orders for their installation. The subscribers' automatic telephone and calling dial, and the operating impulses sent therefrom, are rigidly standardized, and the same applies to all trains of operating impulses and controlling or signalling currents sent from one exchange to another. Much progress has also been made in the standardization of the circuits which are purely internal to an exchange and do not affect intercommunication with its neighbours. All our contractors are also encouraged to unify the details of the mechanical construction of their apparatus as much as possible, with a view to the gradual evolution of a fully standardized Post Office automatic system. Such standardization has, of course, nothing whatever to do with any ideas of finality or fixation of practice. It simply means that at any given moment there is one standard way of making or doing any given thing. Improvements emanating from any source can be studied and introduced, not in partial and possibly conflicting ways as in a divergent collection of systems, but on a systematic general basis which greatly facilitates effective progress.

" The first standardization study soon narrowed itself down to a choice among various important features in which the systems of the Automatic Telephone Manufacturing Co. and of Messrs. Siemens Brothers differed from each other. These features could not, as a rule, be considered independently; to a great extent the adoption of one dictates the adoption of one or more of the others. The decisions on the points at issue were as follows:—

(1) Impulses over junction circuits to be signalled round the loop, and not over one earthed conductor.

(2) Supervisory signals to manual exchanges and auto-manual positions to be sent by reversal of battery.

(3) Subscribers' talking and signalling current to be fed to the loop at final selectors, or at outgoing junction repeaters.

(4) Main battery to have E.M.F. of 50 volts (25 cells).

(5) Registration on subscribers' meters to be effected by means of a ' booster ' battery.

(6) Subscribers' lines to enter *via* 25-point rotary line switches having a ' home ' position and 24 outlets to selectors.

(7) The ' private ' banks on the levels of group selectors to have 11 points.

(8) The ' busy ' test on private bank contacts to be provided by an earth connection.

(9) Trunk-hunting switches to be stepped forward by individual, self-controlled drive.

" Six of these points (1, 2, 3, 4, 8 and 9) represent the established practice of the Automatic Telephone Manufacturing Co.

" With regard to point (5), the Department's experience with the Automatic Telephone Manufacturing Co.'s standard system of registration—by means of an electro-polarised relay operated by reversal of current when the called subscriber replies—indicates that, although accurate, it requires special testing and voltage-regulation plant to maintain it. For ' booster battery metering ' which has been adopted as preferable, the subscribers' meter, with the normal exchange voltage behind it, is wired to the ' private ' or test wire at the subscribers' rotary line switch. The meter is designed not to operate on this voltage. The ' test ' wire is linked up successively throughout all the switches used in a connection up to the final selector in the case of a local call, or to the outgoing circuit repeater in the case of a junction call. When the called subscriber replies, the operation of relays at the final selector or repeater applies a separate booster battery of 50 volts to the ' test ' wire in series with the main battery for about ½ second. The meter operates on this and its armature remains attracted on the normal battery voltage—the test wire being normally earthed at the final selector or repeater. It is confidently expected that this method will give complete immunity from false registration.

" It should be mentioned that in ' director ' areas a simpler method of operating the subscriber's meter is practicable and has been adopted. In such areas the first selector switch, which is next in the train of switches to the calling subscriber's rotary line switch and meter, contains a relay operated by the reply of the called subscriber. A separate conductor can therefore be provided, at little cost, between the two switches, enabling metering to be effected by the simple closure of the meter circuit when the called subscriber answers.

" The use of subscribers' rotary line switches with a ' home ' position—point (6)—is made necessary by the system of grading the outlets from the line switch banks to the first selectors. With graded outlets it is, of course, necessary that search over a level shall always start from the first outlet on that level.

" The use of an 11th contact on selector levels—point (7)—is dictated by the desire to obtain traffic overflow measurements on each working level.

" As soon as the leading characteristics of the general system had thus been determined the process of assimilating it to the director method of operation, and of designing the circuits and plant layout for all classes of service, began. For many months the engineers and traffic experts of the Post Office automatic group were engaged in almost daily discussions with the engineers of the four large contracting companies who are responsible for the manufacture and installation of the exchange plant. The matter involves the consideration of masses of meticulous technical details, and great numbers of proposals and devices have been suggested, considered, tried out, and accepted or rejected. This work is now complete, so far as the initial system is concerned. Equipment for several large exchanges is now in course of manufacture, and in the cases of the Holborn exchange and the mechanical tandem exchange the work of installation *in situ* has been commenced. It may be mentioned that it takes, under present conditions, about 6 months to plan the traffic and engineering details of a large automatic exchange, about 12 months to manufacture it, and a further 12 months, or more, to install it in position and tune up its circuits for service."

The application of the Director apparatus to the Strowger step by step system is indicated by the following extract from the paper :—

" The Automatic Electric Company's ' Director ' System.

" It has already been mentioned that the addition of the ' director ' to the long-established Strowger automatic system has endowed that system with facilities which enable any required connection to be set up by means of trains of controlling impulses having no necessary relationship with the impulses sent in from the calling dial of the originating subscriber.

" The function of the director is to receive and store the call in its original form, and to proceed to send it out into the exchange switching mechanism, translated into any trains of impulses which may be required by the existing layout of junction routes and switching centres, to steer the call through, link by link, to the line of the required subscriber. As soon as the required connection has been established, the director disconnects itself from the line and becomes available for other calls.

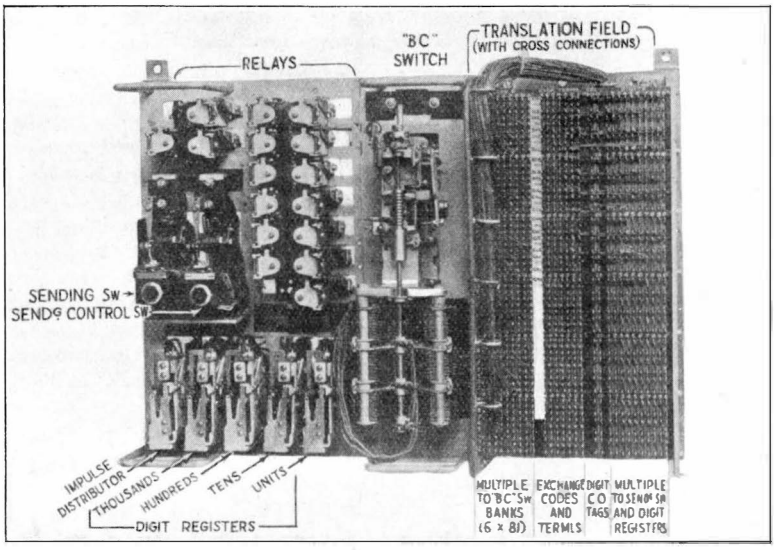


Fig. 5.

" The London subscriber's calling dial will carry a combination of letters and digits similar to that already referred to in connection with the panel system, and the arrangement of exchange names and numbers in the telephone directory will also be identical with that adopted for the panel system.

" It should be noted here that the translation effected by the director applies not only to the number of impulses in a train but also to the number of trains sent. The subscriber will be required to signal 3 letters and 4 digits for each call, but the director can transform these 7 impulse trains into any number of directive trains from 5 to 10. This attainable maximum provides more than adequately for any possible future requirement of the London system, or any other system.

" The director consists of 9 switches with associated relays and a cross-connecting field. Two switches are of the usual Strowger type having vertical and horizontal movements; these are designated the ' A ' switch and ' BC ' switch respectively. Two switches are of the pre-selector type and are designated the ' sending switch ' and the ' sending control switch.' Five switches, designated ' minor switches,' are practically small Strowger switches with rotary movements only. Four of these switches are used as digit-storing registers and one as an impulse distributor.

" The ' A ' digit switches are grouped on separate racks and do not form part of the assembly of an individual director, which includes all the other pieces of apparatus mentioned, mounted on a rectangular frame measuring about 24 in. × 18 in. (see Fig. **5**).

" The ' A ' digit switch receives the first train of impulses dialled by the subscribers, which corresponds to the first code letter of the exchange required. Each level of the ' A ' switch is associated with a separate group of directors set apart for effecting connections with exchanges having names commencing with the same, or an equivalent, letter, and the ' A ' switch, having been dialled to a particular level, searches to find the ' BC ' switch of a free director on that level.

" The second and third trains of dialled impulses are received by the ' BC ' switch ; the second train lifts the switch brushes to one of the 10 levels, and the third train rotates the brushes to a particular set of contacts on that level. The ' BC ' switch is equipped with 6 brushes and 6 separate sets of bank contacts. Thus the dialling of the second and third of the three initial or ' code ' letters of the required

SKETCH TO ILLUSTRATE PRINCIPLES OF THE DIRECTOR SYSTEM.

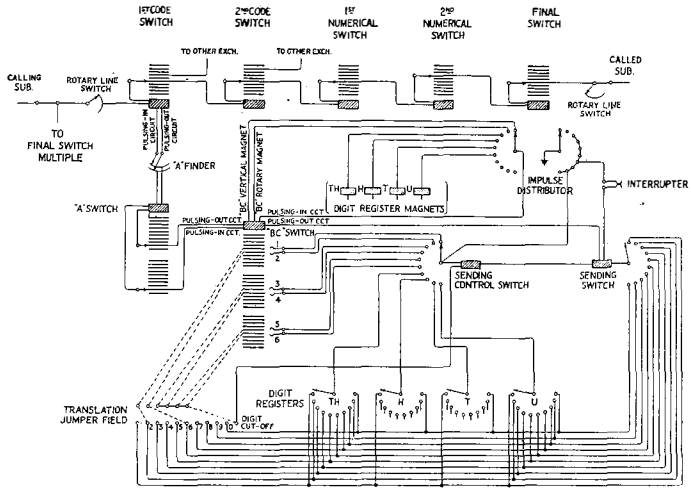


FIG. **6.**

exchange has set the ' BC ' switch of a director in a particular group to 6 particular multipled contacts, and has closed 6 circuits which will always be closed by any subscriber who dials that exchange code. The 6 circuits thus set up, when suitably cross-connected, enable the switches of the director to send out any desired number of trains of impulses from 1 to 6 (each train consisting of any number of impulses from 1 to 10) and so steer the call by its prescribed route to any required exchange, where the direct operation of the final 4 trains, representing the numerical digits of the dialled number, will reach the line of the called subscriber.

" It will be noticed that the initial letter of the exchange code—absorbed in the ' A ' digit switch—does not pass into the director and is not subjected to translation. It is found that the total quantity of apparatus required can be reduced by confining translation to the second and third code digits, and setting apart a group of directors to handle calls for the exchanges having initial letters with the same numerical equivalent. The first train of impulses is therefore used to select the level of the ' A ' switch which gives access to the appropriate group (ABC = level 2 ; DEF = level 3, etc.).

" The directors of each group are capable of serving 81 exchanges, and as 8 group levels are available on the ' A ' switch the total number of exchanges which could be served without mechanical modification of the directors is 648. This is so far above the number of exchanges ultimately required in London that the cross-connection field has been designed to serve 35 exchanges in each director group, or a total of 280. Even with this reduced number abundant spare space can be left, on the directors appropriated to each three initial letters, to avoid any restriction in the choice of exchange names on that account, although such restriction could easily be applied if necessary.

" Under average conditions a director to which properly graded access is provided will carry about 72 calls in the busy hour and will be occupied with each for about 20 seconds. To serve a busy city exchange the installation of from 150 to 180 directors is necessary.

" The operation of the director can be examined in more detail with the aid of Fig. **6**. The subscriber on lifting his receiver obtains, *via* the bank of his rotary line switch, a first code switch in the ordinary exchange system, and at the same time the ' A ' switch-finder hunts to find a free ' A ' switch, from which the subscriber receives the ' dial ' tone informing him that he may proceed to turn in the call. Suppose the subscriber wants the ' Avenue ' exchange and dials AVE 2468, which corresponds to 283 2468. The A is received by the ' A ' switch, the brushes of which are lifted to the second (or ABC) level, and a free ' BC ' switch in the group of directors associated with that level is found.

" The train of 8 impulses corresponding to V is dialled into the vertical magnet of the ' BC ' switch, *via* the impulse distributor, the two brushes of which are standing on the first pair of contacts. At the end of this train the impulse distributor takes one step, and the train of 3 impulses, corresponding to E, are received by the horizontal magnet of the ' BC ' switch. The six brushes of the ' BC ' switch are now set on the third contact of the eighth level in each bank. The impulse distributor brushes now step to its third pair of contacts.

" Dialling proceeds and the trains of dialled impulses representing the called subscriber's number are successively routed by the impulse distributor to the four digit registers which are set in the positions 2 on the thousands register, 4 on the hundreds register, 6 on the tens register and 8 on the units register. The call has now been received and stored in the director, but before this operation is complete the process of sending it forward in its transformed shape has already been begun.

" It may be assumed that direct junctions to the Avenue exchange can be reached through two ranks of code switches at the originating exchange and that the translation in the director required to set up these switches is to be ' 2, 6.' That is to say, only two trains of impulses are required, out of the possible six trains provided for, *via* the six brush circuits of the ' BC ' switch. If additional ranks of code switches at an intermediate switching centre had been involved, a correspondingly greater number of trains would have been necessary. The translation is effected by cross-connecting the first of the particular six bank contacts of the ' BC ' switch to contact No. 2 of the ' sending switch ' bank, and the second bank contact of the ' BC ' switch to contact No. 6 of the sending switch. The superfluous bank contacts (Nos. 3, 4, 5 and 6) of the ' BC ' switch will be connected to the ' sending control switch,' *via* the terminal marked ' D.C.O.' (digit cut-off), in order to step that switch to the correct position for discharging the digit registers at the proper moment.

" After the three code letters have been dialled in, the impulse distributor brushes will have moved to the third pair of contacts and the sending control switch will be standing on its first contact. The earth-connected brush of the impulse distributor will therefore complete a circuit, *via* brush 1 of the ' BC ' switch and the cross-connection, to contact No. 2 of the ' sending switch,' which will thus be earthed. At the same moment the earth-connected brush completes a circuit, permitting impulses from the interrupter springs of a continuously running impulse machine to be directed to the sending switch magnet, and the switch begins to step

over its contacts. At each step an impulse is sent to the first code switch over the 'pulsing-out' circuit indicated in the figure. When the sending switch brush reaches its second contact, which has been 'marked' by the sending control switch, it encounters the earth connection and a relay is operated which prevents further impulses from being sent to the first code switch. The sending control switch now steps forward to the second 'BC' brush circuit and the sending switch returns to normal. Meantime the first code switch brushes have entered the second level of its bank contacts and found an outlet to a free second code switch.

"The sending control switch brush, now standing on its second contact, makes an earth connection, *via* brush circuit No. 2 of the 'BC' switch, with contact No. 6 of the sending switch. The sending switch again steps forward and now sends 6 impulses to the second code switch before its impulses are stopped by the earth on its contact No. 6. The second code switch brushes are stepped to level No. 6 and find a free line to the Avenue exchange, whilst the sending switch again returns to normal and the sending control switch steps to position No. 3. From this position it finds a circuit in turn, *via* brushes Nos. 3, 4, 5 and 6 of the 'BC' switch, which represent superfluous translation circuits and have all been joined, by a cross-connecting wire, to the 'digit cut-off' terminal. The brushes of the sending control switch are therefore carried straight forward to position No. 7. Positions No. 7, 8, 9 and 10 connect with the four 'digit registers' on which the Avenue number of the called subscriber has been stored. From these positions the switch will now successively control the sending of the thousands, hundreds, tens, and units digits. As these do not require translation the bank of the digit registers are multipled directly to the sending switch. The impulses for these digits are sent out over the junction line to Avenue and set up the numerical switches at that exchange. Immediately after the units digit has been sent out from the director the latter is released from the first code switch, all its parts return to normal, and the calling subscriber is connected through to the final numerical switch at Avenue, from which the required subscriber is being rung.

'The 'pulsing-in' circuit over which the subscriber's impulses pass into the director remains entirely separated, at the first code switch, from the 'pulsing-out' circuit over which the director passes forward the call through the code and numerical switches until the connection has been completely set up and the director has been dropped. Pulsing-out commences as soon as the exchange code portion of the number has been dialled in, *i.e.*, as soon as the impulse distributor reaches its third contact and connects earth to the sending control switch and to the interrupter of the impulse machine. The periods of storing the call and of sending it forward thus overlap each other and the actual delay in establishing connection with the called subscriber is, on the average, only about 2 seconds greater than it would be if the call were dialled straight into the switches.

"As a theoretical example of a more complex case of routing, involving the use of intermediate switching centres and the utilization of all the six available translation channels, it might be assumed that a call, say, from Ealing to Ilford, would be dealt with as follows:—The exchange code ILF (453) would have its second and third digits translated in the director to 234567. Digits 2 and 3 would operate first and second code selectors in Ealing, and gain access *via* an outgoing junction to a tandem selector in Holborn. Digits 4 and 5 would operate first and second tandem selectors in Holborn and reach a tandem selector in Maryland. Digits 6 and 7 would operate first and second tandem selectors in Maryland and reach a first numerical selector in Ilford. The four untranslated numerical digits of the subscriber's number would then follow and effect connection with the called line *via* the first and second numerical selector, and a final selector, at Ilford.

"The actual circuit arrangement of the director system is necessarily somewhat complex, and a discussion of it in any detail is not within the scope of this paper. (Mention should, however, be made of an innovation as regards the position of the battery feed to the calling subscribers. Hitherto on the Automatic Telephone Manufacturing Co.'s system this has always been located either at the final

numerical switch or on the outgoing junction repeater. In the director system as adopted by the Post Office it will be located at the first code switch, thereby rendering outgoing junction repeaters unnecessary, except on tandem routes, and effecting a very appreciable economy in London and other large areas where the percentage of junction traffic is large.)

" Director Translations.

" Fig. **7** is a sketch of the arrangement of the translation jumper field. On the left of the drawing six sets of bank contacts each connected to a set of 81 terminals are indicated. Each of these six sets of terminals reproduces the bank contacts of the ' BC ' switch corresponding to each of the six brushes and is wired out to these terminals as indicated by the brush, or ' wiper,' numbers.

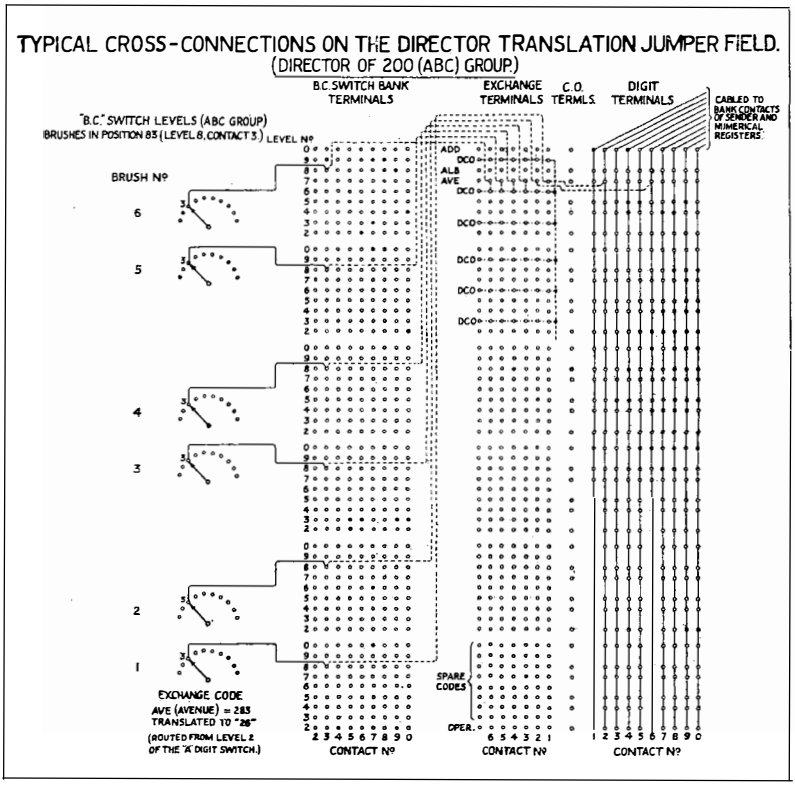


Fig. **7.**

" Levels 2 to 0 and contacts 2 to 0 on each level only are so wired out, level 1 and contact 1 being omitted since there are no letters equivalent to digit 1 on the lettered dial. At the centre of the assembly there are 35 sets of six exchange terminals, each set being labelled with an exchange name and wired to the tags representing the positions on which the six brushes rest when the code of that exchange has been dialled into the ' BC ' switch. Between every two sets of exchange terminals one set of D.C.O. (digit cut-off) terminals is fitted. On the right-hand side are 36 sets of digit terminals numbered 1 to 0, each vertical row of which represents one of the 10 bank contacts on the sending switch and digit registers.

" Cross-connections are made between the six exchange terminals and the 10 digit terminals as required to give the desired translation.

" The terminals marked ' CO ' are used for clearing the director when it is required to route a call by code translation only, without numerical digits. Certain service calls will be dealt with in this manner.

" The terminals marked ' OPER ' are used to route a call to an operator after the dialling of digit 0 by the subscriber. Such a call will find a director but will not operate the ' BC ' switch. A special relay, operated on 0 level calls only, is introduced into the director and sets up connections similar to a setting of the ' BC ' switch brushes, giving at once the desired translation. Arrangements are such that any predetermined director in any group can be reached from the 0 level of the ' A ' digit switch for this service.

" The various cross-connections used to give the different services required may be briefly summed up as follows :—

(1) *Subscriber to subscriber calls* (subscriber dials 3 code and 4 numerical symbols).

(*a*) *Translated to 1 code selection, followed by 4 numericals, e.g.,* if the subscriber dials ' AVE ' 1234, the ' AVE ' exchange terminals will be connected as follows :—

Terminal 1 will be jumpered to the digit terminal corresponding to the pulses required to be sent to the code selectors.

Terminals 2, 3, 4, 5 and 6 will be connected to the nearest ' D.C.O.' terminals.

The numerical digits will be repeated as dialled into the digit registers by the calling subscriber.

(*b*) *Translated to 2, 3, 4, or 5 code selections, followed by 4 numericals.*—The same method is followed as under (*a*), *i.e.,* exchange code terminals are jumpered to the digit terminals required. The unused exchange terminals are always connected to the nearest ' D.C.O.' terminals.

The numerical digits are repeated as dialled.

(*c*) *Translated to 6 code selections, followed by 4 numericals.*—The same method is followed as under (*a*), *i.e.,* exchange code terminals are jumpered to the digit terminals required. As all the exchange terminals are thus used, no connection to the ' D.C.O.' terminals is required.

(2) *Special service calls.*

(*a*) *Subscriber dials special service 3-letter code,* not followed by numericals, *e.g.,* TOL. The same method is followed as under 1 (*a*) or 1 (*b*), *i.e.,* the exchange code terminals are jumpered to the digit terminals necessary to route the call to the destination required. The first unused exchange terminal is jumpered to the nearest ' C.O.' terminal instead of the ' D.C.O.' terminal, and the remaining terminals are left disconnected.

(*b*) *Calls to operator (subscriber dials* ' 0 ').—The exchange terminals designated ' OPER ' are jumpered as described under 2 (*a*) above.

(3) *Vacant exchange codes.*

All vacant exchange code terminals associated with wiper 1 (only) are ' commoned ' and jumpered to the nearest ' SC,' *i.e.,* ' spare code ' terminal. The dialling of one of these dead exchange codes causes the director to be released immediately the third code digit is dialled, and the subscriber receives the ' number unobtainable ' tone signal.

" Call Indicator Working.

" Until the conversion of London to automatic working is fully completed, which may occupy a period of from 15 to 20 years, manual working will exist side by side with automatic working and arrangements are necessary to ensure smooth operation between the two systems during the interim period.

" Traffic from automatic to manual exchanges will be handled by means of ' call indicator ' positions at the manual exchange, as illustrated in Fig. 8. The automatic subscriber will manipulate his calling dial in an identical manner for all calls. If the call be for a manual exchange the operation of the three initial letters of the exchange name will steer the call through to an available incoming junction operator's position at that exchange, and the further operation of the four numerical digits will cause the required subscriber's number to appear visually on a ' call indicator ' in front of the junction operator. This operator will, without speaking to the calling subscriber, connect the circuit manually to the required subscriber's line. She may use any one of her plugs and cords for this purpose; the act of plugging into the subscriber's line jack brings into operation a ' cord trunk finder ' which connects the plug and cord to the junction upon which the displayed number has been pulsed.

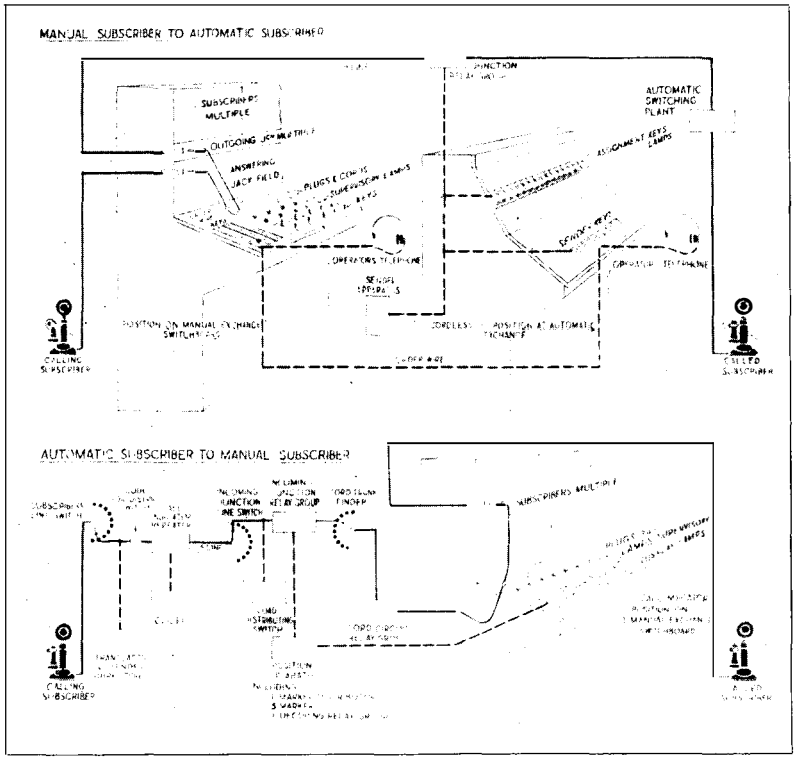


FIG. 8.

" In the converse case for a subscriber connected to an exchange not yet converted to automatic working, two methods are available by which the manual exchange operator may deal with the call if connection with a subscriber on an automatic exchange has been asked for. The first method (see Fig. 8) provides that she shall pass forward the call verbally, by order wire, to an incoming junction operator at a special ' B ' switchboard in the automatic exchange. The latter operator will assign a junction circuit, by pressing an assignment key, and will set up the call by means of a set of plunger keys known as a key sender. The automatic plant does the rest and clears the key sender for further use as soon as the call has been steered through to its destination.

" In the second method the operator who answers the call from the subscriber at the manual exchange is herself provided with sets of key senders, on one of which she can set up the call and so direct it forward through the automatic plant at the distant exchange to the required subscriber's line, without the co-operation of a junction operator. The adoption of one or the other method depends upon the local conditions at the exchanges in the area, but the first method, which avoids the need for special equipment at the answering operators' positions, is generally to be preferred and has been adopted for London. Fig. 9 shows the arrangement of keys on the key senders, and illustrates the manner in which the called number is displayed visually on the call indicator.

" In its operating principles the system of ' call indicator ' working adopted for London is similar to that invented for use in connection with the panel system, but the London system contains several novel features which warrant a further brief reference. It is termed by the Automatic Telephone Manufacturing Co. a ' coder call indicator system ' and its object is to minimize the number of automatic switches

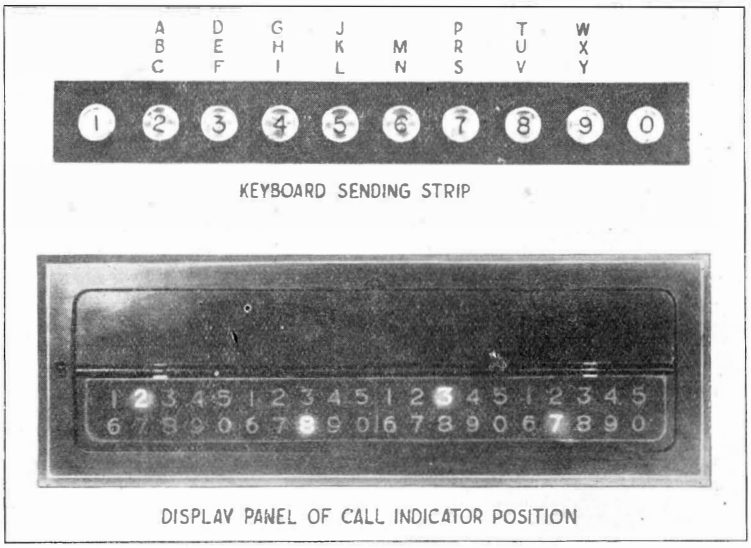


FIG. 9.

necessary to display a call at a manual exchange, and to provide facilities for even traffic distribution of calls from all exchanges among the operators. Its operation is briefly as follows :—

" At the originating automatic exchange the director impulses, instead of passing directly to line and to the distant exchange from the outgoing switch, are stored in the relays of an equipment assembly termed a ' coder,' which is at the same time connected to the junction line. At the manual exchange the connection of the coder to the line at the distant end routes the line to a set of incoming ' decoder ' relays by means of a ' marker ' controlled by a ' marker distributor.' Five markers and one marker distributor are provided for each call indicator position. When the junction line had been routed to the de-coder of the call indicator position the coder at the originating end is permitted to discharge. The decimal settings of the coder relays are translated and transmitted over the line as coded impulses of positive, light negative, and heavy negative currents, and stored in the de-coder relays. As soon as the display lamps are freed from the previous call this setting is transferred to a group of numerical relays which cause the called number to be displayed by the

lamps in the display panel in the usual way. The arrangements are such that while one call is on display at each position, an indefinite number may be stored on coders at the automatic exchange. Whilst one call is being displayed, five markers per position will be connected to junction lines associated with an equal number of waiting coders, and the traffic will thus be kept in order of priority.

" The discharge of the coders into the de-coding relays occupies 1 second, and transference from the de-coder to the display panel is immediate.

" At the manual exchange, traffic reaches the positions in cyclic disengaged order in quantities that correspond to the operators' abilities, and in queue formation at each position. Positions at which either all receiving relay sets or markers are engaged are treated as busy and passed by the marker distributor. A call displayed on the display panel is not directly associated with any one cord circuit on the position. The plugging-in of any idle cord to the multiple jack of the required number immediately starts a finder switch, which hunts for the calling line, connects the cord to it, and switches out the lamps on the display panel.

" The cords are not normally used for the completion of service calls. Such calls are operated by the depression of a service key which causes a finder switch to hunt for the calling line and connect it to a service operator's position. Busy calls receive the engaged tone by the operation of a key in a similar manner. This reduces the number of cords required, and is a factor of value in some cases where the cord capacity of manual exchange ' B ' positions is restricted.

" Each call indicator position is equipped with 36 cord circuits and it is expected that each operator will handle 450 calls during the busy hour. This is probably a conservative estimate.

" It will be appreciated that before the first equipped automatic exchange can be brought into use the whole of the existing manual exchanges in London must be equipped for call indicator working. It follows, therefore, that during the initial stages of automatic working over 90 per cent. of the automatically originated inter-exchange traffic in London will be handled at call indicator positions. This percentage will gradually decrease as more automatic exchanges are brought into use, and will finally be extinguished. An automatic subscriber, however, apart from any local knowledge which he may possess, will be quite in ignorance as to whether his call is going to another automatic exchange or to a manual exchange. His operations will be alike in both cases—he will dial three code letters and four digits, and in both cases he will receive the same tones, etc., to indicate to him the progress of his call. When complete conversion to automatic working has been effected, the whole of the call indicator equipment will have disappeared, together with all coder equipments at the automatic exchanges themselves.

" It may be urged that this method of tackling the problem is wasteful, inasmuch as call indicator equipments will be progressively thrown out of service during the period of transition. An obvious alternative would be to install automatic equipment at each manual exchange, of a capacity sufficient to deal with the incoming junction traffic and having the subscribers' lines multipled on the final selectors in parallel with the multiple on the manual board. Then when the time arrives to convert the manual exchange to full automatic working the automatic plant already installed could be worked into the full scheme at that or another exchange and little wastage of plant would result. The possibilities of this scheme were fully considered, but serious objections to its adoption revealed themselves. These arose mainly from the lack of adequate building accommodation for the interim automatic plant, from the extensive changes to subscribers' numbers to provide for automatic private branch exchange service which would be immediately necessary, and from the need for expensive additions to the manual exchange power plant in order to permit the use of standard 50-volt automatic switches. Considerable difficulty has, in fact, been experienced in many cases in finding adequate accommodation for the plant required at manual exchanges for the call indicator equipment, although the space required is much less than that needed for the alternative scheme.

" Moreover, the wastage of call indicator apparatus will be minimized by the

use in other large areas such as Manchester, Birmingham and Liverpool, of equipment recovered from London exchanges, and probably much of it will remain in service during the greater part of its economic life.

"CORDLESS 'B' POSITIONS.

"Traffic originated at a manual exchange for an automatic exchange can be handled in two different ways, as already indicated. In the method adopted, each automatic exchange is equipped with special manual 'B' positions and demands are passed, by order wire, to these positions from the 'A' operators at the originating manual exchange. The operating procedure at the 'A' positions is identical with the procedure to manual exchange 'B' positions. The 'B' operator at the automatic exchange sets up the call on the automatic switches by means of key sending equipment. As this operator is not required to handle any other class of traffic, key sending equipment is used in preference to dials, since quicker and more efficient operating is obtained thereby.

"The other of these alternative methods would require that all manual exchange 'A' positions in London should be equipped with dials and dial keys, and, since it would not be possible in many cases to dial from the manual exchange cord circuits directly into the automatic switches, it would be necessary to equip most of the incoming junction lines with 'dialling-in' repeaters at the automatic exchange. Further, the increased amount of operating per call at the 'A' positions would so increase the operators' load that a large number of additional 'A' positions would be required in London to handle the volume of traffic during the busy hour. The cost of adopting this alternative, without serious interruption to service, would be so great, as compared with the cost of the method adopted, that the latter was preferred without hesitation.

"In order to cater for traffic from manual exchanges, each automatic exchange will therefore be equipped at the outset with a suite of cordless 'B' positions equipped with key senders (see Fig. 8). The key sending equipment consists of a strip of digit keys associated with four sender finders which route the digit keys to a free sender. The registers which are wired to the bank contacts of the sender finder consist of four groups of four relays, one group for each digit. These relays are operated by the digit keys either singly or in combinations of twos or threes to obtain all digits from 1 to 0. The setting of the relays determines the 'marking' of a contact on the sender switch by means of which impulses are sent out to the exchange numerical switches in a manner very similar to the method used for sending out the numerical impulses from the director.

"The junctions from the manual exchange are brought through the cordless 'B' position and carried on to a first numerical switch on which they terminate. At the position each junction is associated with a group of relays, and an assignment key and lamp for each junction are fitted as part of the face equipment of the position. The operating procedure is simple and is as follows:—

"The 'A' operator at the manual exchange passes a demand by order wire to the cordless 'B' operator. The latter allots a junction and immediately depresses the assignment key of the allotted line. This causes the allotted junction and the operator's digit keys to be connected to a free sender with associated registers. The operator then depresses in proper sequence the four digit keys corresponding to the four figures of the called subscriber's number. These four figures are routed by means of a control switch to the four groups of register relays, which are operated and locked in the proper combination simultaneously with the depression of the digit keys. (After the depression of the last key—the fourth—the set is at once available for another call. The bank contacts of the sender switch are thereby marked and impulses are sent out to the numerical switches. Sending cannot commence, however, until the operator at the manual exchange has taken the allotted junction line. When all sending is finished the sender and registers are disconnected from the junction line and the latter is switched through, *via* the numerical switches, to the called line.

" A supervisory lamp is associated with each junction line at the cordless ' B ' position. After depression of the assignment key on an allotted junction the operator must not proceed with the setting up of the required number on her digit key strip until a signal is received on this lamp to indicate that a free sender has been found. The provision of senders is on such a basis that no delay is likely to occur at this stage. The supervisory lamp will flash until the originating ' A ' operator takes the allotted line, after which it will glow continuously until the ' A ' operator clears at the end of a conversation.

" Should the ' A ' operator connect to a line other than that allotted, the supervisory lamp on that line will flicker rapidly to indicate to the ' B ' operator that a wrong connection has been set up.

" Centralisation on Manual Boards.

" When sufficient automatic exchanges in London are in use the cordless ' B ' positions and special ' A ' positions for operator service, etc., instead of being equipped in each automatic exchange, will be centralized, the centres being so chosen, to serve a group of adjacent exchanges, that economical use of line plant is achieved. There will be a number of such manual centres in London when the automatic traffic in the individual areas has reached a certain density. Great advantages in the design and cost of automatic exchange buildings will result from the centralization of manual board traffic, since these buildings will not be required to accommodate the manual switchroom and operators' quarters.

" The Mechanical Tandem Exchange.

" In the London area there are a large number of comparatively small exchanges with small groups of junction lines to and from each of the larger exchanges.

" As a result of the traffic inefficiency of small groups, and of the fact that order-wire working is ruled out, the busy-hour loads carried by these junctions are very low and their operation is uneconomical. Frequent consideration has therefore been given to the introduction of one or more tandem junction exchanges, at which all the junctions to and from each small exchange could be concentrated and thus form a group suitable for order-wire working. Such a scheme could not, however, be shown to possess any economic advantage, on account of the cost of introducing a third operator on each tandem connection. The development of the automatic call indicator scheme increased the possible speed of operating and so favoured the introduction of tandem junction working, and the advantage of introducing automatic tandem switching plant was, naturally, considerably increased by the decision to adopt the automatic system at London local exchanges. The installation of a mechanical tandem exchange has therefore been pressed forward, in advance of the completion of the first local automatic exchanges.

" The mechanical tandem exchange is now being installed in the same building as the Holborn automatic exchange. In it will be concentrated the outgoing and incoming junctions from the smaller exchanges as well as a number of junctions to practically all the other London exchanges.

" At the beginning of its life, and for the period which will elapse before conversion to automatic working in London is completed, the mechanical tandem exchange will be required to route traffic as follows :—

" From manual exchange to manual exchange.
" From manual exchange to automatic exchange.
" From automatic exchange to automatic exchange.
" From automatic exchange to manual exchange.

" The method of handling this traffic is indicated by Fig. **10**. Traffic from the ' A ' positions of a manual exchange will be dealt with in a similar manner to the traffic incoming to a cordless ' B ' position at an automatic exchange. The ' A ' operator will ' order wire ' the call to the cordless ' B ' operator at the tandem

exchange, who will set up the call to the automatic switches *via* her key sender. In this case, however, since the exchange code must be set up in addition to the subscriber's number, the sender is associated with a translating unit, similar in principle to the director, and with a coder. If the call is for a manual exchange it will be directed to a call indicator position at that exchange, and the numerical portion of the required number—transformed into the correct impulses by the coder at the mechanical tandem exchange—will effect the required display on the lamp panel at the call indicator position. If, however, the call is for an automatic exchange the cross-connections in the translator jumper field will be such as to suppress the operation of the coder, and the numerical digits will go out to the switches at the automatic exchange in the regular manner.

" Traffic originated in an automatic exchange will be carried direct from the levels of the outgoing switches to the first tandem switches at the mechanical tandem exchange. In the case of a call for a manual exchange a coder—interposed between the manual levels on the first tandem switches and the second tandem switches—will come into operation as soon as the second tandem switch has been operated, and

MECHANICAL TANDEM EXCHANGE
ROUTING SCHEME

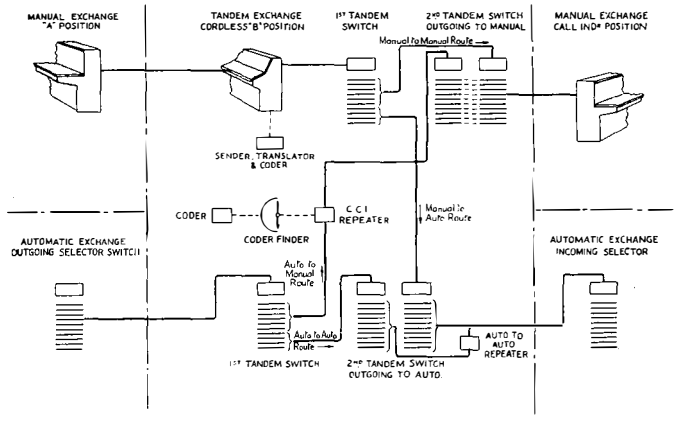


FIG. **10**.

the numerical portion of the required number will be stored in the coder and converted, as already described, for display at the call indicator position. A call for another automatic exchange will pass out *via* levels on the first tandem switches which are not equipped with coders, and the call will be routed straight through the switches as determined by the impulses from the director at the originating automatic exchange.

" As the conversion of London to automatic working proceeds, the traffic incoming to the mechanical tandem exchange from manual exchanges, and the traffic outgoing to call indicator positions, will decrease and will ultimately fall to zero. The whole of the traffic will then be purely automatic, and will be routed direct through the switches, as at other main switching centres in the London system. The cordless ' B ' positions and their equipment will no longer be required for their original purpose, and it will probably be desirable to utilize them for passing traffic from towns in the London toll area into the automatic system. This question will be considered in due course, as the cordless ' B ' positions at the mechanical tandem exchange are freed from local traffic.

"POWER CONSUMPTION.

"At a city exchange of approximately 10,000 lines, and at the mechanical tandem exchange, the operating current at peak load will exceed 2,500 amperes. Two sets of 50-volt storage batteries, each having a capacity of 10,000 ampere-hours, are provided. During busy hours the load on the batteries is eased by running the charging machines in parallel with them.

"VARIOUS CLASSES OF SERVICES PROVIDED.

"The subscribers connected to an automatic exchange will be divided into two groups: (*a*) those to whom trunk calls are permitted and (*b*) those to whom trunk calls are barred. The distinction is of course of the subscribers' own seeking, but it is necessary that the department should guard itself against improper use of the trunk lines by those subscribers who are not entitled to this service. A subscriber who requires a trunk connection will dial TRU if on a director exchange. (The letter 'O' is used for this purpose at non-director exchanges in the provinces.) In the group where trunk calls are permitted the call will be routed to a record operator, but in the group where such calls are barred the call, if made, will be routed to a special operator and dealt with accordingly.

"Subject to this restriction the following classes of service will be provided:—

Subscriber to subscriber—direct.
Subscriber to subscriber—over junction circuits.
Subscriber to subscriber—over trunk lines ('revertive' calls).
Subscriber to subscriber—over toll lines ('no delay' calls).

Coin-box stations and call offices to and from all other subscribers in the system direct, or over junction, trunk, or toll lines.
Private branch exchange traffic with night traffic on selected lines in each group of exchange lines.
Inquiry, information, and directory services.
Dictating messages for onward transmission as telegrams, express letters, or letters.
Receiving telegrams in lieu of delivery by messenger.
Calling for the services of express messengers.

"TONE SIGNALS.

"A system of tone signals designed to give a calling subscriber knowledge of the progress of his call has been standardized for use in both London and the provinces. Before commencing to operate his calling dial the subscriber should listen for a 'dial signal tone,' which indicates that a free selector in the first rank—or, in London, an 'A' digit switch—is available to receive the dialled impulses. Dialling must not commence until this tone—which is continuous at a frequency of 33 per second—has been received.

"If the called subscriber's line is engaged, or if, at any stage of the call, all outlets from a selector switch level are busy, a 'busy tone' will be sent out. This tone has a frequency of 400 per second and is applied for 'off and on' periods of 0.75 sec. The tone is associated with a flashing signal on the supervisory lamp of an operator's cord circuit in the case of a call from a manual exchange subscriber.

"When dialling is completed the subscriber will immediately receive 'ringing tone' to indicate that the required subscriber is being rung, or 'busy tone' to indicate that he is already engaged. The ringing tone is provided by means of a leak from the ringing circuit through a condenser of small capacity on which current pulses at a frequency of 133 per second are superposed. This tone is applied to the line with the same interruptions as the ringing current itself, *i.e.*, a double beat of 1 second with a 2-seconds' interval. The double beat consists of two rings of 0.4 second duration separated by an interval of 0.2 second.

"In areas where the director is not used a further tone known as the 'number

unobtainable tone ' is employed to indicate to the subscriber that he has dialled a ceased or unallotted number. In London this tone will be used to indicate to a subscriber that he has incompletely dialled the required number. Calls for ceased or unallotted numbers will be routed to an operator.

" Private Branch Exchange Lines.

" Most private branch exchanges have more than one line to the exchange and it is of course necessary to arrange that, if a call be received when the particular line representing the exchange number of the private branch exchange (PBX) is engaged, the calling subscriber shall not receive the ' busy ' signal unless all the lines to the PBX have been searched and also found to be engaged.

" It is therefore necessary to arrange that the group of lines to a PBX shall be connected to consecutive positions on the bank multiple of the final switches and to provide all switches on which such groups of lines terminate with means for continuing their rotary motion as a hunting operation throughout the group—after the impulses of the units train have carried their brushes to the first line of the group—until an idle line is found, or the whole group has been searched without success.

" Switches provided with this facility are known as ' rotary final switches ' or ' rotary connectors.' In the case of PBX groups of two or three lines no special difficulty arises, apart from the fact that all the lines must appear on one level of the switch and that a few spare positions for future growth must also be left upon that level. This tends to a certain amount of plant wastage, and also generally involves changing the exchange numbers of a proportion of the subscribers in order to get them properly grouped on the levels of the switches when a transfer to the automatic system is made.

" When, however, the present or probable future requirements of a PBX exceed 10 lines, and therefore exceed the accommodation of a normal switch level, it is necessary to take special steps to ensure the availability of all the lines when a switch is hunting to complete a call for the PBX number. Line-hunting over groups up to 20 in number can be provided by utilizing rotary final switches having 10 double levels of 20 contacts. Each such level absorbs only 10 line numbers in the subscribers' multiple series, the remaining 10 having auxiliary numbers. This scheme is therefore economical from an exchange plant standpoint, as the line capacity of the exchange is not reduced by the existence of lines 11 to 20 in the group, or by the retention of some of these auxiliary positions as spare for the future requirements of the PBX in question.

" The private branch exchanges serving some of the large London stores have 150 exchange lines or more, but it is generally possible to divide the lines so that a group not exceeding 100 is available for outgoing traffic at the public exchange. In such cases additional switches of the pre-selector type are connected to the normal outlets of special third numerical selectors which act as final switches. The 10 outlets of the level appropriated to the PBX in question on each switch are multipled on a graded basis to ' homing ' pre-selectors having access to all the PBX lines in a common group of approximately 50 or 100, according to requirements. Each pre-selector is associated with a set of repeater equipment which provides facilities for battery feed, busy test, ringing and registration.

" In this way all the requirements of very large private branch exchanges can be met in a perfectly satisfactory way, although with a certain sacrifice of uniformity as compared with systems deliberately designed for searching over large groups of lines."

Details were given of the new Post Office standard automatic dial which has been designed to provide the following facilities :—

(1) Immunity from the bell tinkling without the necessity for biassing the bell.

(2) The suppression of the inductive voltage kick during dialling.
(3) The use of a three conductor cord on table sets.
(4) Minimum impulse distortion.

The dial is illustrated in Fig. **11** and the telephone circuit in Fig. **12**. The abolition of the need for fitting bells with special biassing devices and the adoption of a circuit utilising the exist-

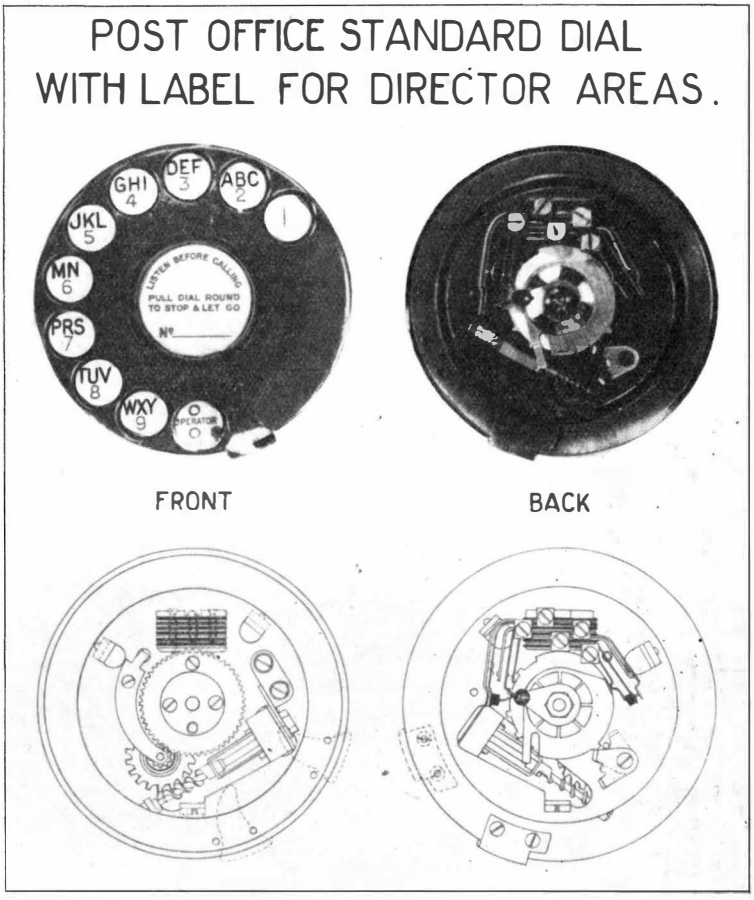


FIG. **11**.

ing C.B. wiring at subscribers' premises in London is estimated to effect a saving of approximately £100,000 in London alone.

The discussion on the paper was very interesting and referred mainly to the importance of the introduction of the new telephone circuit, the adoption of grading and the standardising of loop dialling and the principle of translation.

The Author's replies in connection with these subjects are

indicated in the following extracts from the official report of the discussion :—

" Colonel T. F. PURVES (*in reply*) : I recognize that my paper contains a good deal of technically contentious matter, regarding which it is out of the question to expect universal agreement, and I appreciate the generally helpful and constructive character of the comments made upon it by so many speakers and contributors.

" I agree with Mr. Laidlaw and Mr. Hollings that a considerable proportion of subscribers will probably not listen for the ' dialling tone ' before making a call, at least in cases where the tone is a subsequent addition to an automatic system with the operating of which they have already become familiar. But when the tone has been a feature of the system from their first acquaintance with it—and this will apply to the great bulk of British subscribers—I think it will be used much more systematically, even if in more than 95 per cent. of the cases no trouble will arise from ignoring it. If a call has, for any reason, been ineffective, and the familiar ringing signal is not heard, subscribers will generally learn to listen for the dialling tone before making a second attempt. The tone is also very useful if it is desired to originate a call immediately after completing an incoming call from a private branch exchange, or from a manual or trunk exchange, as its presence is an indication that the connection has been cleared by the operator and that the line is again available. I may remark that the dialling tone is produced by the simple interruption of a battery circuit by an additional running commutator on the general tone-producing

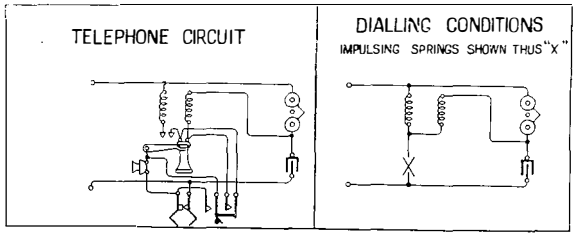


FIG. 12.

machine. There are no difficulties, and little expense, involved in its provision. Mr. Hall suggests that the tone should only be audible where a primary outlet to connecting plant is not available, but under these conditions its presence would be such a rarity that its meaning would probably be forgotten altogether or be confused with that of the ' busy ' signal. I think it is preferable to utilize the tone as a positive indication that the line switch has found an outlet and that calling conditions are normal. The fear that a subscriber whose line is faulty may assume that the absence of the tone indicates non-availability of outlets, and may therefore refrain from reporting the fault, has not much foundation ; subscribers speedily become familiar with the many audible indications that a line is ' alive,' as compared with the ' dead ' condition of a faulty line.

" Mr. Nash makes a kindly and generous reference to the amount of work and responsibility which has to be shouldered by the Post Office engineering staff in connection with such questions as the equipment of the London telephone system with automatic plant, and I greatly appreciate his expression of confidence in the success of the system which has been adopted. At the time when I had to take my courage in both hands and decide to turn away from the practice of the great American Bell telephone organization, for whose example we have so high a regard, I should have been very gratified indeed to know that, even before our first exchange had been installed, one of the leading engineers of the Western Electric Co. would so express himself. Mr. Nash presents an interesting table in which the number

of secondary selecting switches, which would provide full trunking availability, is compared with the additional trunks required to furnish the same standard of service by means of 10-contact switch levels on a direct, graded, basis. I agree that a perfectly satisfactory circuit for secondary pre-selecting switches has not yet been forthcoming, although some telephone administrations appear to be prepared to adopt secondary switches to a considerable extent. Their use, of course, introduces additional switching points which undoubtedly complicate the tracing of calls and, to that extent, hamper the work of the maintenance staff. It is not easy to visualize the service-degrading factor introduced by outgoing secondaries, but it is obvious that without such devices the system is cleaner and easier to maintain. It is felt that the present system introduces quite enough complication and innovation for the maintenance staff to assimilate at the outset, but the Post Office has by no means ' burned its boats ' in this matter. The economies due to the utilization of large groups of selectable junction circuits, and the possibilities presented by the use of secondary switches as a means to that end, are fully appreciated. In the first automatic exchange installed in London, provision is being made for associating outgoing secondary switches with junctions to selected exchanges, so as to obtain actual working experience in the handling of junction groups up to a maximum of 100 lines. If satisfactory service is afforded by this method, there will be no hesitation to adopt it in cases where the overall annual charges will be sufficiently reduced by so doing, which are, of course, likely to be those cases in which the junction circuits are long and of heavy gauge.

" Mr. Morley Ward inquires as to the reason for the adoption of the plan of sending dial impulses around the loop of a junction circuit, instead of over one conductor of the line or over both conductors in parallel. Mr. Christian also refers to the same point. This matter was given very close study, as it was fully realized that the adoption of loop-impulsing would mean a considerable reduction in the permissible maximum resistance of junction circuits, and that, with the impulse-receiving relays at present available, it would in some cases involve the use of heavier-gauge junction circuits than would have been necessary from the standpoint of speech-transmission efficiency. The main consideration in favour of loop-impulsing is, of course, that it provides security against the inductive interference of power and lighting circuits with the telephone signalling impulses. Tests were made from the Central exchange, to various points in London, by means of recording apparatus connected in earthed circuits. The records showed a certain amount of inductive interference, although surges of sufficient magnitude to affect dial signalling were so rare that it seemed improbable that they would in general affect the number of call failures to any recognizable degree. It was felt, however, that abnormal conditions due to faulty power circuits might sometimes cause more or less acute local trouble, and also that the general development of electrical supply systems, and of railway electrification in London and throughout the country during the next decade, might, in spite of the statutory safeguards of the Post Office against prejudicial interference with its communication services, have the effect of progressively worsening the conditions. It was therefore thought desirable to standardize, from the commencement, a system which would enable the department to demonstrate, in any case of trouble, that its own plant was so constructed as to secure the greatest possible immunity from outside electrical interference.

" I am glad that Mr. Morley Ward mentioned the early pioneer work of Mr. William Aitken in connection with the invention of multi-choice grading: this might well have been referred to in the secton of the paper dealing with that subject.

" Mr. Carter and Mr. Harrison both refer to the ingenious pre-director development known as the ' universal switcher.' This system was the subject of interested attention by the Post Office, but we did not at any time feel inclined to adopt it. In addition to the wasteful use of junction plant, which both speakers mention, it required a completely predetermined numbering scheme, and therefore did not obviate some of the main difficulties involved in the introduction of an automatic scheme in large multi-office areas.

" Mr. Deakin has given much information that is both interesting and valuable to a student of the subjects he refers to. I am not quite sure that, in his references to the method of grading illustrated in Fig. 12, he is not overlooking the fact that the advantage of grading from 24-point pre-selectors is not merely the 15 per cent. increase obtained in the traffic-carrying capacity of the first code selectors. By suitable selection of subscribers' lines for connection in each group of 75, and by grading as indicated, the large block of traffic originated by 1,200 subscribers is turned over with approximate uniformity to the outgoing multipled circuits of the selector groups. It is thus presented to the succeeding graded ranks of switches in more manageable form, and the effect of this is to improve the carrying capacity of these subsequent switches, as well as that of the first code selectors. Special traffic curves making allowance for this fact are used in designing the layout of automatic exchanges. The maximum increase in traffic-carrying capacity that can be claimed for ordinary grading from 10-point selector banks throughout the switching system is about 30 per cent. It should be noted also that a graded system using 20-point selector banks has still to be studied, and that this may modify the economic comparison with outgoing secondary switches. A factor to be borne in mind is that the largest groups of junctions are required between large exchanges and that such exchanges, in London, are fairly close together. The circuits in these large groups of junctions thus tend to be both short and of light gauge, and their cost is correspondingly low. As regards tandem working, it should be remembered that the mechanical tandem exchange is being introduced to supersede the direct trunking of small groups of three or four lines. The change from these very inefficient groups to groups connected on a graded basis to 10-point contact banks represents a very material advance.

" As regards the system of service to be adopted for communication between manual and automatic exchanges, it must be recognized that a system which may be specially adapted at the outset to requirements may be unsuitable at later stages. There is no question that the most convenient method of equipping the first group of automatic exchanges in London is the provision of ' Cordless B ' positions, but a time will no doubt come when it will be economical to install sending equipment at the 'A ' operators' positions in the remaining manual exchanges. A study of the comparative economics of dials and key-senders for this purpose has been scheduled for attention in due course. It may well be that considerations of space available in the different manual exchanges will dictate treatment of each on its individual merits. A powerful factor in favour of key-senders will always be the fact that the introduction of these high-efficiency devices reacts favourably on the load which can be carried by ' A ' operators, and has the effect of increasing the traffic-carrying capacity of manual exchanges and avoiding the extension of obsolescent plant.

" I am rather surprised by the emphasis with which Mr. Deakin depreciates order-wire working in general, in spite of the fact that I have always had a decidedly soft side for the alternative of a properly developed direct trunking system. I can assure him that, although his remarks may be justified from the experience and practice of some administrations, they do not apply in this country, where the order-wire system has always proved reasonably satisfactory. The system has to be kept clean; split order wires and tandem order wires are things to be avoided, and perhaps these points have been ignored by those administrations in whose service he reports that the system has been ' a dismal failure.'

" Mr. Grinsted has brought into prominence the very large number of separate switch movements, and circuit openings and closures, involved in the setting up of a connection in the automatic system. It would, indeed, be a hopeless mental task, even for the most expert automatic engineer, to visualize all that is taking place during the few seconds he is engaged in turning in a call on his telephone dial in a ' director ' area. The figures Mr. Grinsted produces show in a striking way the extreme need for the most efficient maintenance of exchange plant.

" His suggestion that congestion at the switches might be minimized by some method of instantaneously throwing back, to the incoming line switch, false calls

caused by permanent loops due to line faults, as well as ' busy ' calls blocked at any point by traffic congestion, is legitimate and the subject is well worthy of attention. It has, indeed, already been considered very carefully, but no way of effecting the desired result has yet been found without involving an additional circuit complication which has to be repeated so frequently throughout the exchange that it is not considered desirable to introduce it at present. The aggregate switch occupation caused by ' busy ' calls will probably not be great, as the subscriber will in most cases release the switches at once by restoring his receiver to the switch hook. False calls due to faulty lines can, with a proper system of alarms and guide lamps, speedily be traced back to the main distribution frame and there plugged out. The London exchanges are therefore being arranged to deal with abnormal loads of this kind by the ordinary supervisory methods of maintenance hitherto employed at all automatic exchanges.

" Mr. Hollings has touched upon one of the disappointing features of automatic telephony, namely, its failure to provide economically for rural telephone service. Mr. Baldwin also referred to the same point. This subject is not altogether within the scope of the paper, but I may say that continuous attention is being paid by the Post Office engineering department to the special problems of rural automatic exchanges. Even at the smallest automatic exchange it is necessary to have a few costly fundamental items for the use of all the subscribers in common, and when the number of lines is small the cost per line of these general items is very high, especially if an electrical power supply is not available. It is then necessary to install an engine and secondary-cell-charging machine, with comparatively high capital and maintenance costs. These restrictions represent part of the price which this country has to pay for its low general development of the use of electrical energy. The extension of rural automatic exchanges will probably follow rapidly on the extended distribution of electrical power in rural communities.

" I have already referred to Mr. Hollings's remarks on the subject of the dialling tone.

" Mr. Hurford has taken rather too literally my round figures of the increase in trunk-hunting capacity secured by the use of secondary switches ; I quite agree that 100 per cent. efficiency could not be obtained in practice. Actually the efficiency of, say, a 10-point primary pre-selector, working into a 10-point secondary pre-selector, may be taken as approximately 85 per cent.

" I am sorry if Section (5) of the paper is calculated to give the impression that designers of large-capacity switches are thought to have been working along the wrong lines. This inference was certainly not intended to be drawn in any general sense. Indeed, in Section (9) I say that the facility for direct selection in large groups is a feature of great utility which was reluctantly given up on account of its essential incompatability with the system which had been adopted for standardization in this country on broad considerations of preponderating advantage. My statement of the capacity of panel automatic exchanges in the service of the American Telephone and Telegraph Co. was based on a summary of the position, prepared in America, which I receive every six months. The latest summary referred to the beginning of this year and included 53 exchanges, with total equipment for 273,167 lines.

" Mr. Hurford states that his much larger figures (58 exchanges with capacity for more than 400,000 lines) include extensions to the original equipment. It therefore seems probable that the summaries in my possession represent the line capacity of each exchange as it stood at the date of the ' cut-over.'

" I quite agree that the amount of call indicator equipment in London will go on increasing for several years before it passes the maximum and begins to become surplus. Mr. Pook also makes a reference to this point. The amount of such equipment used in any particular manual exchange will, of course, steadily increase until the exchange is converted to automatic working, and therefore the last exchange to be converted will have the whole of its ' B ' positions equipped with call indicators. There is no intention that the initiation or the progress of the conversion of provincial

city areas to the automatic system should be in any way dependent upon the rate of recovery of surplus call indicator apparatus in London."

The press reports of this paper were numerous and it has been reprinted in *ex tenso,* in American and other journals. The following, which appeared as a leading article in the *Electrical Review* for March 20th, will perhaps be of interest to our readers as bearing on British Post Office policy during recent years:—

"THE POST OFFICE AND AUTOMATIC TELEPHONES.

"The masterly paper that Col. T. F. Purves, Engineer-in-Chief to the Post Office, read before the Institution of Electrical Engineers on the 5th instant (an abstract of which is concluded in this issue) has a wider circle of interest than even the very large audience that attended. The present position and policy of the Post Office with regard to automatic telephony emphasise the important work that it has performed in building up a national industry, for the British telephone manufacturing industry is a direct outcome of Post Office policy, and the annual value of telephone manufactures produced in this country now runs into the tens of millions sterling. It will be agreed that the Post Office has performed a great national service in this respect.

"Although for various reasons the present telephone development of this country is below what should, and could, be achieved, the progress that is being made is gratifying. In October, 1922, the number of subscribers' telephone stations in Great Britain reached one million, and new stations were being added to the system at the rate of about 5,000 per month. The number has now increased to 1¼ million stations, and new subscribers are being connected at a rate representing a net increase of about 10,000 stations per month. In other words, the system has increased by 25 per cent. in 2½ years, and the rate of increase has, itself, doubled in that period. There is no sign of a diminution in the rate of growth, and the recent formation of the Telephone Development Association to undertake publicity will tend, of course, to hasten it.

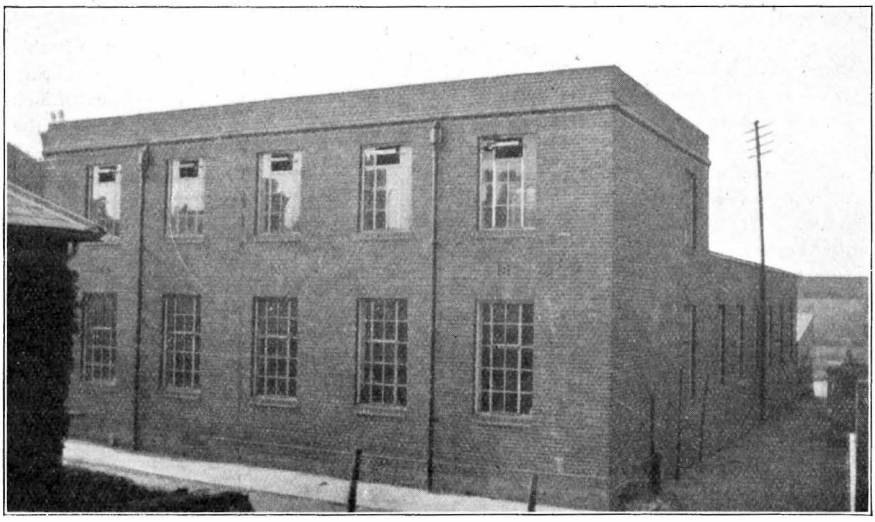
"Mr. G. H. Nash, in the discussion on Col. Purves's paper, drew attention to the fact that there was no mention therein of the large amount of research and the numerous 'studies' that had been necessary on the part of the Post Office staff before a standard could be adopted. In view of the very extensive organisations in the United States that have been in existence for some years for the purpose of dealing with this kind of work, it is only just that the work performed by the Post Office in this country should be recognised. The Post Office, in dealing with the position here, has in some respects a more difficult task than have the American telephone companies in that the Post Office policy has been to encourage a number of *different* manufacturers with a view to securing competitive contracts, whilst in the Bell system one firm manufactures the bulk of the plant. That being so, it is necessary for Post Office engineers very definitely to specify the requirements that have to be met, and to do so in a way that will not hamper particular manufacturers. It follows that the Post Office staff must act as arbitrators in selecting schemes put forward by the different manufacturers, and to do so it has been necessary to build up a body of experts able to express authoritative views and to secure manufacturing co-ordination. This has had a general beneficial effect in that the Colonies and other telephone administrations repeatedly order telephone equipment in Great Britain to Post Office specifications, being satisfied with a product that has the approval of the British Post Office. A measure of standardisation has been achieved that is somewhat surprising, but Col. Purves was careful to point out that the standardisation already accomplished had nothing to do with any ideas of finality or fixation of practice; improvements emanating from any source in future would be introduced if the public service would benefit thereby.

"An important point in connection with the introduction of automatic equipment is the necessity for maintaining a highly-skilled staff for the operation of the plant; without this skill the policy will fail. To meet this need, it has been found necessary to set up a very completely-equipped training school in London which is intended to cover, not merely the theory, but also the practical side of automatic telephony."

THE ALDEBURGH TELEPHONE REPEATER STATION.

R. J. NUNN, A.M.I.E.E.

THIS Repeater Station, the building to accommodate which was erected in 1924, was brought into use early in 1925. The station is situated at the southern end of the small seaside town of Aldeburgh, on the east coast of Suffolk. It was provided for



ALDEBURGH TELEPHONE REPEATER STATION.

repeating the Anglo-Dutch circuits for continental telephone traffic at the junction of the submarine and land cables.

The building consists of a basement for Central Heating Boiler, Cable Chamber, etc.; a ground floor which accommodates the Power Plant and Batteries; a first floor on which are the Repeater Rooms, Staff accommodation, etc.

The site is within 50 yards of the sea; the submarine cables are brought in direct and led into the building through an underground chamber opening out from the basement and thence up to the Repeater Room.

The Power Plant and Batteries were erected by the General Electric Co., and the Repeater Plant by the Western Electric Co. The leading-in, main cable work and balances were installed by the Department's own staff.

A brief general description of the plant installed is as follows :—

Power Plant.

The power for all purposes of the station is supplied by its own plant; the main source of supply being two "Ruston Horizontal, Single Cylinder, Airless Atomiser, Cold Starting, Crude Oil Engines" of 31 normal B.H.P. These engines are

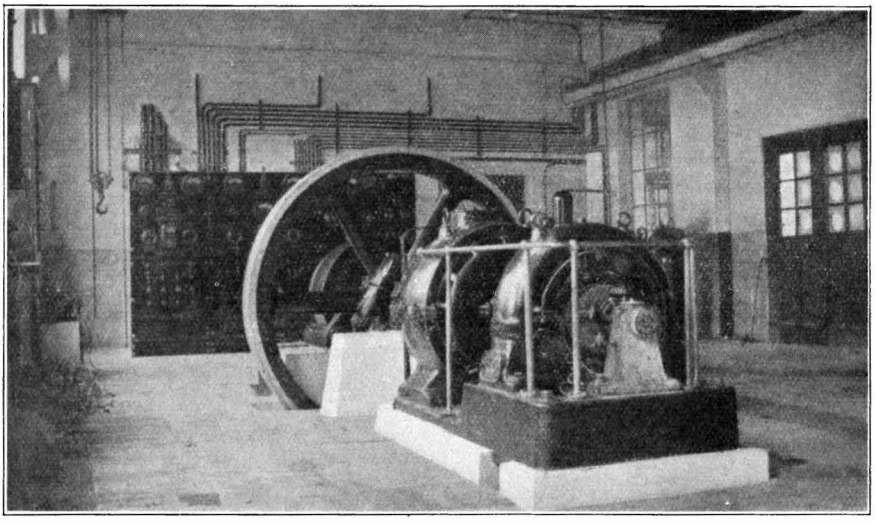


Fig. 1.—One Set Engine and Dynamos.

started up by means of compressed air. Their flywheels are 7 ft. diameter, 10 inch face, weigh 2½ tons, and run normally at a speed of 265 R.P.M. The engine bed foundations are specially constructed with sand pockets around them to reduce vibration to a minimum.

Each engine is direct coupled to two dynamos, one of which gives a voltage of 24 to 32 at 150 amps., the other 150 to 220 volts at 50 amps.; the two dynamos are on one bed. Fig. 1 shows one of the engines with relative dynamos and the power board in the background.

The crude oil fuel is stored in two 1,300 gallon tanks in a chamber below the yard adjacent to the power room. This oil is pumped to two intermediate tanks in the power room, holding 100

gallons each; thence it is fed by gravity to two service fuel tanks of 15 gallons each, one serving each engine.

Associated with the engine water cooling arrangements are Monitor Valves, which automatically cause an audible and visible alarm to be given in case of failure in the water circulation whilst the engines are running.

In addition to the main engines and dynamos the following auxiliary machines are provided in the power room :—

Two Rotary Fuel Pumps to raise the fuel oil from the storage tanks.

Two Air Compressors for engine starting purposes.

Two Heenan Coolers for engine water cooling.

Each of these is driven by a separate electric motor.

Two Ringing Dynamotors for supplying ringing currents to the Repeater units.

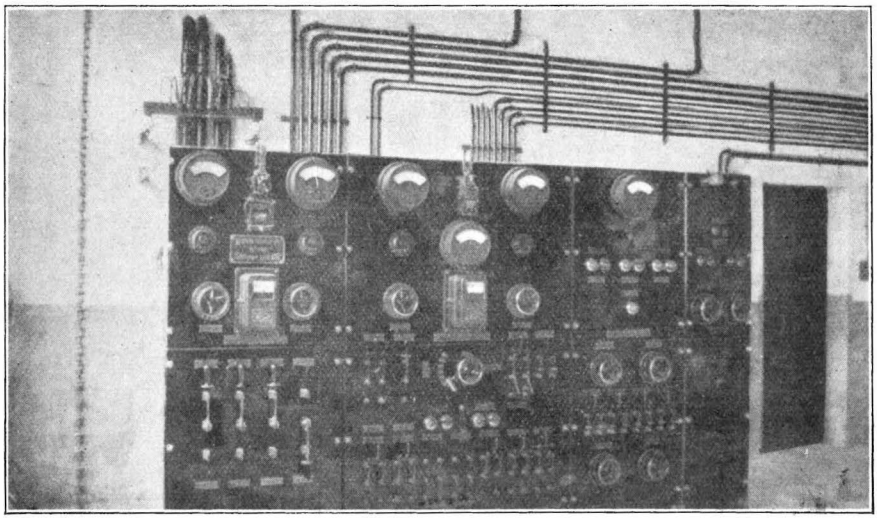


FIG. 2.—POWER BOARD.

All the power plant is thus duplicated and all pipework is interconnected to reduce the risk of failure to a minimum.

A Travelling Crane, by Morris, with a carrying and lifting capacity of 1¼ tons runs the whole length and width of the power room.

The Power Panel, which is shown in Fig. 2, is fitted with Voltmeters, Ammeters and Wattmeters for the main circuits, and full control switches for each battery, generator, and motor.

Battery Room.

The Batteries supplied are the D.P. Company's make and are as follows:—

Two A Batteries, 12 cells each of 400 A.H. capacity, with space for enlarging to 800 A.H. These batteries are used for the filaments of the valves, also for the relays and the alarm circuits.

Three B Batteries, each of 75 cells and 200 A.H. capacity, supply the anode voltages, electric lighting of the building and the power for the auxiliary motors.

Two C Batteries, each of 5 cells and 30 A.H. capacity, supply the grid voltages.

Two D Batteries, each of 10 cells for counter E.M.F., are used in opposition to the B voltages in the plate circuits.

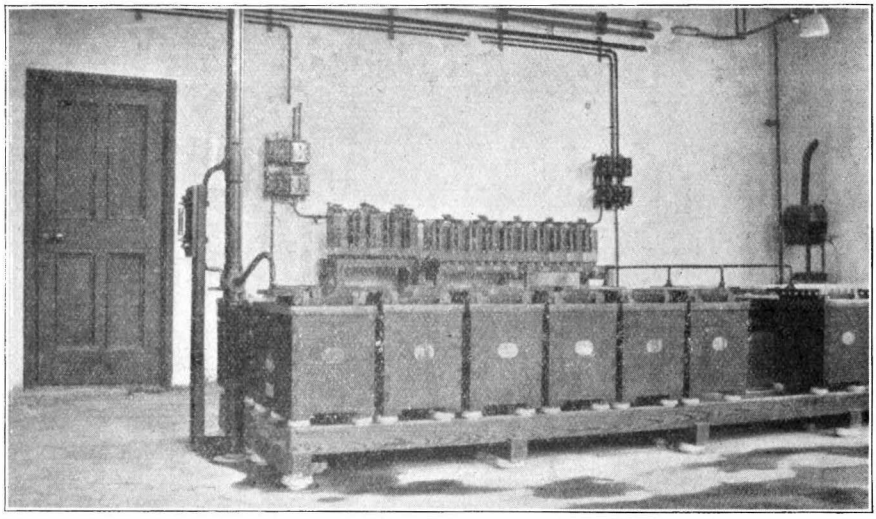


Fig. 3.—One Set of A. Batteries.

There are 70 lighting points in the building supplied with current from the B Batteries. Fig. **3** shows one A Battery and part of the D Batteries. Fig. **4** shows two of the three B Batteries.

Repeater Room.

One Repeater Rack with 8 bays is installed, on which are fitted 16 Western Electric No. 22 type, through line, two-wire Repeaters with filters on up and down sides. At the time of writing there are 9 of these in use.

The necessary auxiliary testing apparatus is fitted on this rack,

which includes a Gain measuring set with Oscillator and Amplifier, monitorial speaking arrangements, meters and control panels.

Audible and visible alarms are associated with repeater battery circuits, which actuate if the voltages or currents fall below or rise above certain limits. A no-ringing alarm is also provided.

There is space on the repeater rack to fit a further 16 units. Figs. **5** and **6** give front and back views of it, with covers removed from 5 of the units.

The Balances, Transformers and Line Test Tablets are fitted on a separate rack in the same room. This room is capable of taking a second repeater rack without structural alterations and arrangements are already in hand for installing one of 9 bays to

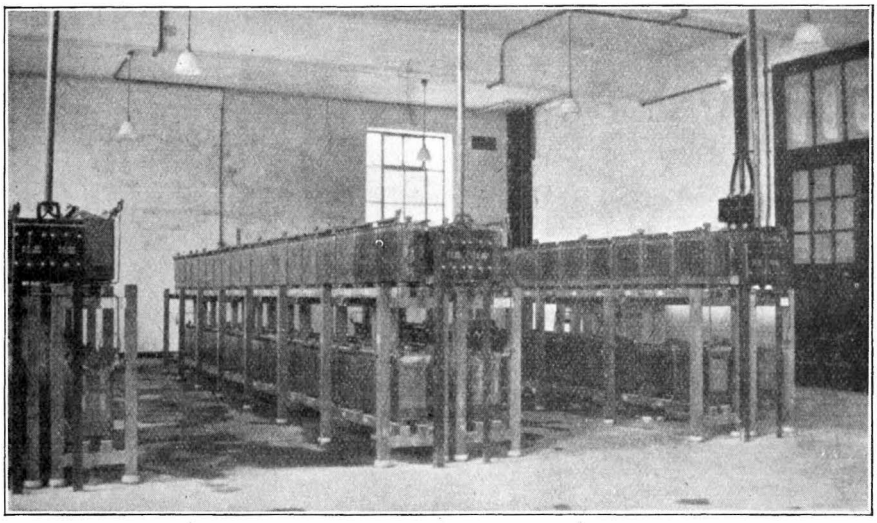


FIG. **4**.—TWO SETS B. BATTERIES.

be fitted with 13 four-wire Repeaters and terminating sets, together with fuse and resistance panels, etc. Full Repeater and Cable Test Desks will also be installed in the near future.

A separate room has been provided for Telegraph Repeaters should they be required.

LINES.

On the land side the lines led into the building at present are 2 pairs of open 600 lb. copper wires and a 14 pair underground cable, 150 lb. conductors, coil-loaded. A further 38-pair cable, 20 lb. conductors, 28 pairs of which will be coil-loaded, will be completed early in 1926. Messrs. Johnson & Phillips have been the contractors in supplying and laying both cables.

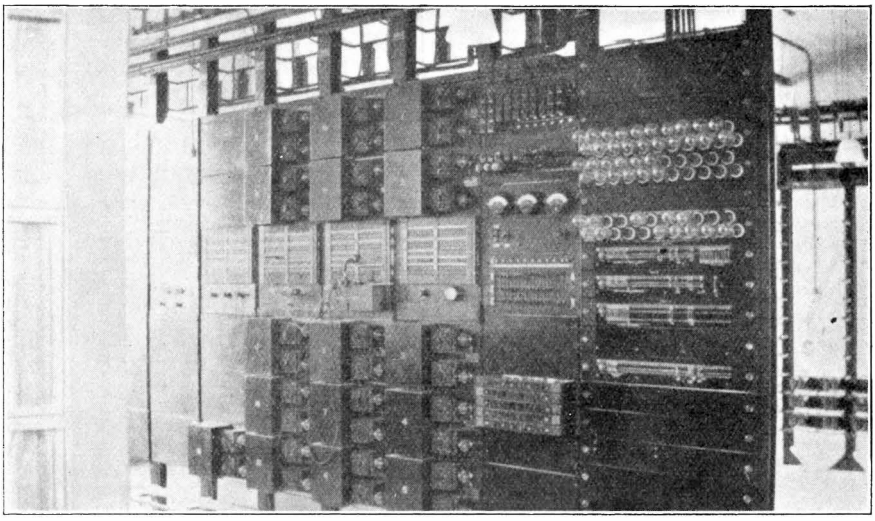


FIG. 5.—REPEATER RACK, FRONT.

On the submarine side there are two cables, one a 4-core G.P. 160 lb. (per naut. mile) conductor, coil-loaded; the other a 16-core A.S.P.C. 165 lbs. (per naut. mile) conductor, continuously loaded, double lead sheathed. These cables land at Domburg in Holland and are approximately 82 naut. miles in length. (An article on the 4-core cable appeared in the *P.O.E.E. Journal* for January, 1924).

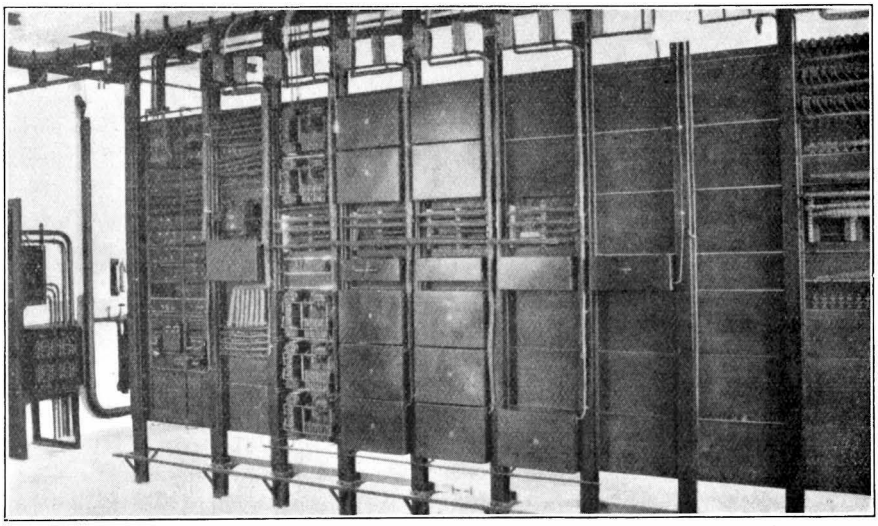


FIG. 6.—REPEATER RACK, BACK.

The following circuits are at present in use:—

6 London to Amsterdam.
4 London to Rotterdam.
1 London to The Hague.

Two of the circuits are worked phantom on the Submarine side and one on the Land side. Two circuits are not repeated at Aldeburgh.

The photos for this article were taken by Mr. W. E. Everson, a member of the Station Staff.

POST OFFICE SERVICES: PROVISION OF INCREASED PUBLIC FACILITIES BY MEANS OF KIOSKS.

F. McCLARENCE, A.M.I.E.E.

EXCEPT in the case of large and important Post Offices public business is generally not transacted during the late evening or the greater part of Sunday, and the majority of sub-offices are closed also for an hour daily at midday and for one afternoon each week: during these periods the telephone service is usually in operation and, of course, letters may be posted, but the telephone call office at the P.O. is not available nor can postage stamps be purchased.

It is not surprising, therefore, that demands have arisen for facilities for making telephone calls and obtaining stamps, and that in consequence two interesting extensions of the public service have now been definitely instituted, namely, the provision, in easily accessible positions, of street kiosks for use as telephone call offices and of stamp-vending machines. Incidentally, these facilities not only meet the original demand but have the further merit that they afford relief at the P.O. counter during the ordinary hours of business. (The principle of installing street kiosks was recognised by the National Telephone Company, but at the time of the transfer in 1912 the number was very small owing no doubt to difficulty experienced in securing the consent of local authorities for suitable sites).

The fact that a street kiosk is available at all times for emergency calls to the Police, Ambulance and Fire Stations is very much appreciated, and in several towns the Councils have considered the service so provided sufficient to meet the needs of their districts, and have dispensed with their own street fire alarms.

Hitherto it has been possible to originate local calls only from a street kiosk, but the Department has recently introduced a new type of coin collector, which accepts payments in pennies, sixpences and shillings, and before long the public will be able to

FIG. 1.—CAST IRON KIOSK: DESIGNED BY SIR GILES GILBERT SCOTT, R.A.

originate trunk calls. It has not yet been decided to accept telegrams from call offices in this manner, but that course appears inevitable, and at a not far distant date it should be possible to

telephone a telegram and pay for it at an unattended call office. Such a facility should be of great service in popularising the telegraph service.

The standard telephone kiosk before the War was a wooden structure, but recently a pattern was introduced made of reinforced concrete in flat sections suitable for erection on the site and 1,500 kiosks of this type have been erected throughout the country; these are much more durable and efficient for their purpose than the wooden pattern, but owing to the limitations of reinforced concrete they do not harmonise in all cases with the surroundings.

More recently a number of municipal authorities prepared designs with a view to having a particular type for the streets of their own towns, but as it was considered that a standard kiosk was required which would be architecturally suitable for erection in the main thoroughfares of any large town, it was decided to consult the Royal Fine Art Commission, to whom a number of designs which had been obtained were submitted.

The Commission regarded the designs as inadequate, and suggested that further designs be obtained from architects nominated by the President of the Royal Institute of British Architects. This recommendation was adopted, and as a result the design submitted by Sir Giles Gilbert Scott, R.A., was selected as the most suitable. (Fig. 1). (It is hardly necessary, perhaps, to mention that Sir Giles Gilbert Scott is well known as the architect of the new Liverpool Cathedral and many well-known buildings and War Memorials).

The new kiosk is made of cast iron sections convenient for erection on the site by the Department's workmen, and the TELEPHONE signs are of opal glass with blue letters, illuminated at night by a light fixed to the ceiling.

In the *Post Office Electrical Engineers' Journal* of July, 1921, a description was given of a stamp-vending machine. The service rendered by these machines has been appreciated by the public, and the demand for them has increased to such an extent that machines for the sale of penny and halfpenny stamps have been installed outside 1,000 Post Offices and arrangements are in hand to provide another 500 during the current year. Very considerable numbers of stamps are sold from these machines, the largest number recorded being 13,000 in four days from one pair of machines.

Suggestions have been received from various sources that stamp machines should be associated with P.O. letter boxes, and a design for this arrangement, which should prove very useful outside Post Offices, is under consideration.

As a further development a kiosk with stamp-vending machines, post letter box and telephone was made up recently

and erected in one of the main thoroughfares of the City of Bath (Fig. 2). Fitted with the Department's multi-coin Collecting Box a kiosk of this description would provide facilities for the purchase of stamps and posting of letters; the sending of tele-

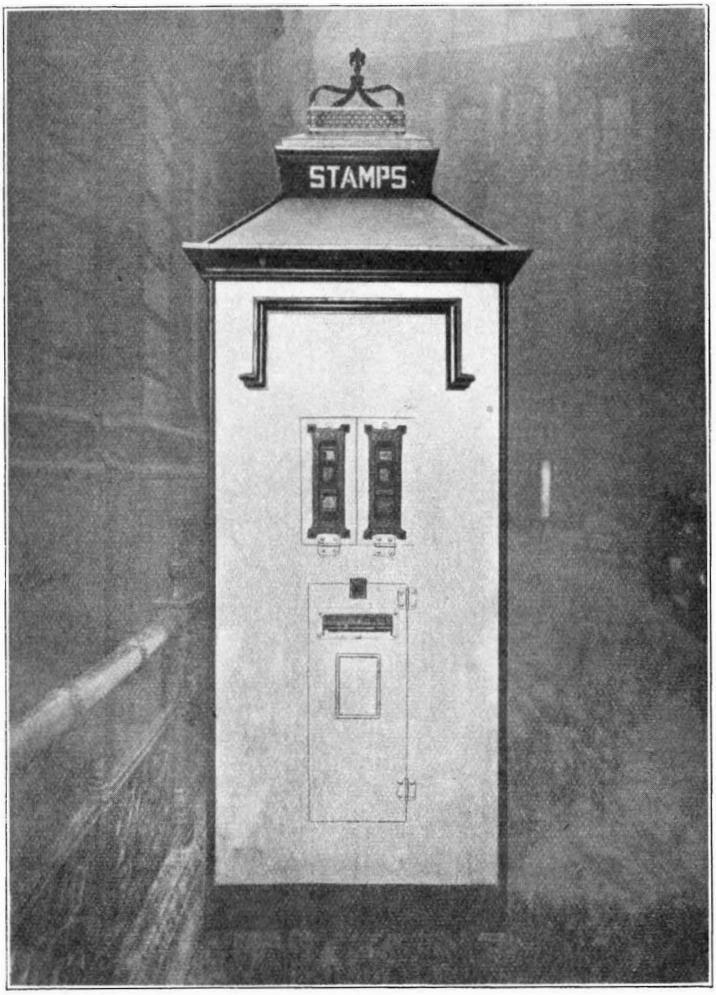


FIG. 2.—THE BATH KIOSK.

grams; the originating of ordinary trunk and local telephone calls; and the summoning of the Police, Ambulance and Fire Brigade.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE, IN EACH ENGINEERING DISTRICT AS AT 30TH SEPT., 1925.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileages.				Engineering District.	Underground Wire Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
462,964	615	4,187	55,144	461	London	22,718	52,224	1,589,459	48,193
55,895	1,900	19,660	56,068	1,654	S. East	3,797	20,584	92,749	14,206
58,879	4,408	26,096	44,559	1,655	S. West	13,429	5,206	89,784	29,862
46,497	8,480	30,880	40,898	5,332	Eastern	14,222	24,365	49,775	44,671
78,475	8,567	41,416	51,686	3,203	N. Mid.	19,635	35,304	135,237	78,836
56,689	4,814	26,170	56,293	4,401	S. Mid.	12,078	14,714	110,002	83,864
51,089	5,119	28,673	45,065	1,733	S. Wales	5,213	15,756	82,605	64,955
81,642	8,338	23,435	42,474	5,521	N. Wales	11,978	31,811	154,462	46,052
128,440	1,660	17,192	46,829	2,818	S. Lancs.	12,672	61,630	333,746	32,559
77,203	6,306	29,898	42,087	2,513	N. East	8,200	30,095	170,752	25,574
52,044	3,765	23,874	36,127	2,462	N. West	8,732	29,359	100,549	24,897
39,605	2,546	15,458	23,822	2,106	North	3,210	8,456	68,081	45,093
17,999	4,781	6,074	11,619	239	Ireland N.	139	88	28,762	69
53,404	5,569	21,441	32,344	1,153	Scot. East	1,552	8,062	98,584	10,076
74,092	7,464	23,104	39,492	864	Scot. West	12,614	21,581	187,733	23,290
1,334,917	74,332	337,558	624,507	36,055	Totals.	150,189	359,235	3,292,280	572,197
1,311,214	75,807	333,539	618,370	36,782	Figures on 30th June, 1925.	148,219	341,807	3,203,448	543,363

EMPLOYMENT OF PNEUMATIC DIGGING AND ROCK BORING TOOLS ON AERIAL LINE CONSTRUCTION.

MAJOR H. CARTER, A.R.C.Sc., B.Sc., A.M.I.E.E.

INTRODUCTION.

THE application of mechanical methods of excavation to overhead construction has been considered from time to time. Trials of power-driven earth augers have been made, but these machines have been found to be uneconomical under the conditions generally met with in the Post Office Engineering Department. The chief reasons for their failure are:—

(1) Operation is only possible in very easy soil free from rock or stones of any appreciable size.

(2) Due to the fact that, under the ever increasing menace of road widening, it is now usually essential to erect poles in hedge-banks, it is almost always difficult and often impossible, on account of the existence of a ditch or a soft grass margin on the road side of the hedge-bank, to get the machine into position.

This experience led to the conclusion that if any success could be hoped for, the apparatus must be capable of operating in hard and rocky ground, and the source of power would need to be readily applicable to pole sites difficult of approach. It is obvious that any tool capable of cutting a cylindrical hole of the diameter necessary to receive a pole in ground of this nature would require power beyond that capable of provision by a readily portable aparatus, and would require too much setting up to make its employment economical for the depth of hole required. Compressed air, delivered to a small portable tool by flexible hose, seemed to be an ideal manner of fulfilling the second requirement. Years of experience in mine and quarry work have proved the efficacy of pneumatic rock drills and, of recent years, it has been proved beyond question that pneumatically operated paving-breakers are invaluable for breaking up concrete road foundations. Both these cases, however, differ essentially from the one under consideration, in that work of one type only is encountered and that work is continuous, comparatively little movement of plant being required. In pole hole work, on the other hand, it is the exception to get long stretches where every hole is in rocky ground. Due to the fact that holes are required at 50 to 60 yard intervals, adjacent excavations may vary widely in character, also the time spent in moving the plant from hole to hole compared with the time the equipment is actually working, becomes an important factor. To meet the

conditions of our work, it was obvious that a very portable outfit comprising a variety of tools capable of excavating under widely varying conditions, was required. Negotiations were accordingly opened with the Ingersoll Rand Co. Ltd., who have a world-wide reputation as manufacturers of mining machinery, and as a result it was decided to make a trial of the equipment described in detail below. The building of the Inverness-Wick trunk line presented itself as a particularly suitable field for the trial, as it was understood that a large amount of difficult and costly digging was likely to be encountered on this work.

Description of the Equipment.

Compressor. (Fig 1).—This consists of a $4\frac{1}{4}'' \times 4''$ vertical two-cylinder, single-acting air compressor driven by a four-

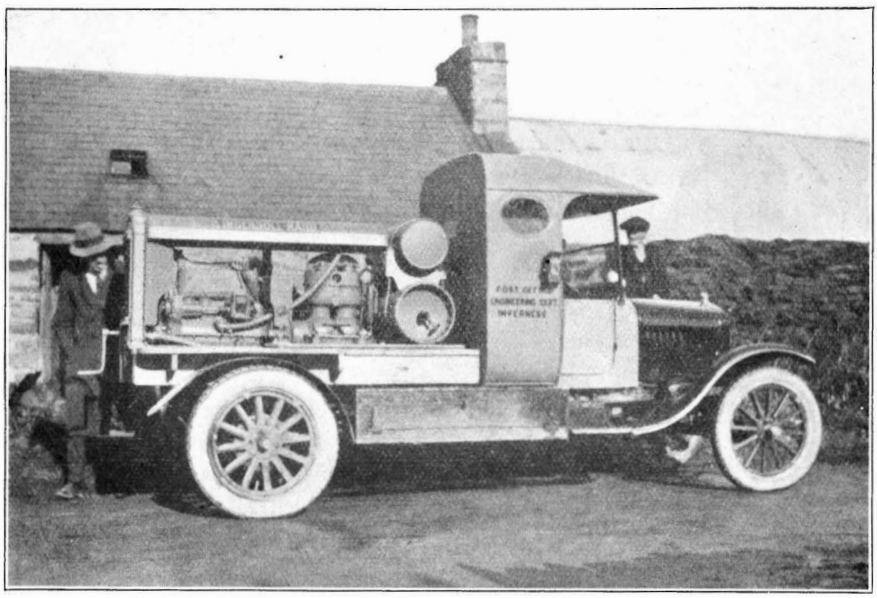


Fig. 1.—The Power Equipment.

cylinder four-cycle petrol engine of about 12 B.H.P. Both compressor and engine are water cooled. The compressor is capable of delivering 60 cub. ft. of air per minute and works at a pressure of 100 lbs. per square inch. A governor, operated by compressed air, is provided which cuts down the petrol supply to the engine during unloaded periods when the air has reached the standard pressure. The whole is mounted on a cast steel frame, which is fitted to a Ford one-ton chassis in order to secure the maximum degree of portability. Four large oak boxes are fitted to the

chassis, two on each side, in order to accommodate pneumatic tools, drill and paving breaker steels, and small tools for the engines and compressor. A strong wooden shelf is also built over the wings to form a bench for working on the tools and to protect the wings when getting out and putting away tools. Two 50-foot lengths of armoured air hose are provided for supplying compressed air to the tools.

Rock Drill.—This is the firm's Jackhammer Type B.C.R. 430 and weighs 45 lbs. It operates a hollow steel, with four point

FIG. 2.—JACKHAMMER TYPE B.C.R. 430.

cross bit, capable of drilling holes 60″ in depth. The shank of the steel is struck by the mechanism of the jackhammer and in addition the steel is rotated. A portion of the exhaust air is led through the drill to the face of the work for clearing away the cuttings from the hole. To meet unusual conditions where greater blowing capacity is required, an exhaust valve is provided which may be turned so as to divert the whole of the blast through the drill. For drilling a hole 60″ in depth three steels are used, their

lengths being 20″, 40″ and 60″, the finished diameter of the hole being $1\frac{1}{8}$″. The jackhammer in operation is illustrated in Fig. **2**.

Paving Breaker. (Fig. **3**).—This is a tool with which all town dwellers are now becoming familiar due to the operations of contractors breaking up concrete road foundations. The machine used is the firm's type C.C.25, which weighs 69 lbs. Its operation is similar to that of the jackhammer with the exception that the steel does not rotate and there is no air blast for clearing away the

Fig. **4**.

Fig. **5**.

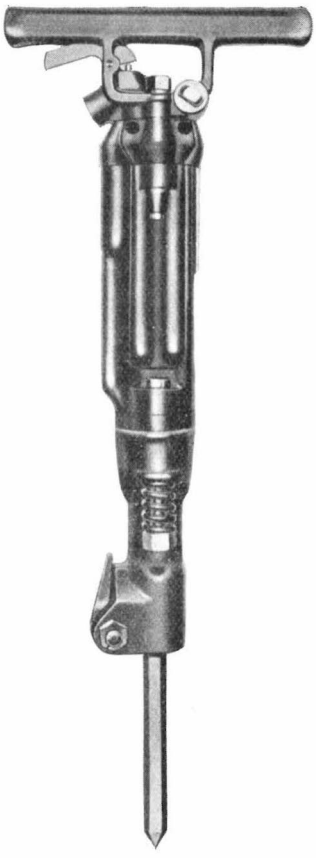


Fig. **3**.

cuttings. It is intended for breaking up rock or hard material by impact and not for drilling a hole. Solid hexagon chisel bits $1\frac{1}{4}$″ are provided, in addition to a flat chisel bit with a blade 12″ long by 3″ wide.

Trench Diggers.—Two trench digging tools, known as the 156 H and the 158, are provided. The former (Fig. **4**), which weighs 29 lbs., is for use in hard clay or where light picking is

required. It is shown in operation in Fig. **6**. The latter (Fig. **5**) weighs 45 lbs. and is for work in shale or hard material beyond the power of the 156 H digger, but not sufficiently difficult to necessitate the use of the C.C. 25 (paving-breaker).

Description of Trials.

The machine was first brought into operation on the Black Isle, near Inverness, where nine rock holes had been left by the gangs. It was found that this rock was not solid; the rock drills penetrated it at the rate of about two feet per minute and the firing of a blasting charge in the drill holes produced little result on the surface.

Fig. **6**.—Trench Digger 158 in Operation.

The paving-breaker was accordingly used and was found to be very well adapted for work in the hard shale and conglomerate which was encountered. One and a half working days completed this work.

The equipment was then despatched to Wick, in the neighbourhood of which most of the difficult excavation was expected. For many miles south of Wick, a hard blue rock known as "Caithness Flag" abounds. This is usually met with at from one to three feet below the surface, and whilst much of it is solid, in many cases it was found that holes had to be dug entirely in hard shale.

A permanent crew of two men was allotted to the machine. One of these was the driver of the Ford, who was also given care

of the compressor engine, compressor and pneumatic tools. The other man was a qualified blaster. Both men were instructed in the use of the pneumatic tools under the capable direction of Mr. J. R. Lomax, of the Ingersoll Rand Co., who spent three weeks with the equipment. The Department was particularly fortunate in securing his services and the operators, Messrs. Milne and Crawford, quickly became proficient in the use of the outfit and began to take a pride in their tools and the special nature of their work. Arrangements were made for the equipment to work five days per week, the Saturday being spent on overhaul. It was found that the best way to employ the outfit was to allow the soft surface soil to be dug by the normal working party and then to complete the holes by the pneumatic tools. In the case of holes in shale or hard clay, no further assistance was given by the gangs. The operators used the tools and cleared out the broken material by hand shoveling. In the case of rock holes two or more men, as required, were taken from the gangs to clear out the holes after blasting. Gelignite with time fuses was used for blasting, and when a succession of solid rock holes was encountered, the blaster was chiefly occupied in preparing and firing his charges, the drilling being mostly done by the driver.

The tools were all found to work very well in the types of material for which they were designed. The only difficulty experienced with the paving-breaker was that of handling it on account of its weight. Its operation is considerably more difficult in a hole than on a level road surface due to the confined space, and the fact that the tool has frequently to be lifted in and out of the hole.

A slight difficulty was occasionally experienced through the air hole of the drill steel becoming choked with gravel, which sometimes occurred in the seams between the layers of rock. The drills will not work when they are unable to clear themselves. This difficulty diminished as the operators became more experienced in the use of the exhaust valve previously referred to.

The trench diggers were found to be very convenient for shaping down the sides of the holes.

The Ford mounting was found to be a most essential factor in the success of the machine. With its tool boxes it forms a complete unit and the equipment can be transported from the garage to the work very quickly and operations commenced in from five to ten minutes after arrival. Practically no time is wasted in moving from one hole to another. Three gangs were working in the twelve miles between Wick and Lybster and the machine was sent to one or other of these gangs for a day as the state of the work required.

Record of Performance.

Over a period of several weeks, it was found that the equipment, working five days per week, was capable of getting out over 30 holes per week, and was able to do all the hard digging for the three gangs referred to. In addition to erecting the new line, these gangs were also cutting out and recovering the old telegraph line, hence their erecting operations were considerably retarded. It should also be mentioned in passing that in recovering the old poles they were finding Simplex Pole Jacks of immense value.

A good financial comparison can be obtained from a study of the work performed on October 12th, which is representative. This was as follows:—

Holes completed	6	5 by drilling and blasting. 1 by C.C. 25 and 156 H.
Employed with machine ...	2	men.
Equivalent of annual charges and running costs of equipment ...	2	men.
Assistance from gangs ...	2	men.
Total	6	men.

Time taken 8 hours.

Average man-hours per hole ...	8	(exclusive of cost of blasting materials).
Estimated man-hours per hole by manual methods	20	do. based on average of 20 similar holes in the neighbourhood.

Saving per hole 12 man-hours or 15/6, *i.e.*, a saving of £4 13s. 0d. on the day's work.

Another interesting day's work was that of October 14th, when 12 holes were completed by drilling and blasting, entailing a total drill of 60 ft. The average rate of drilling in solid rock was 4 inches per minute. It is estimated that to drill this amount by hand jumper and clearing spoon would have occupied three men for eight days.

Conclusions.

In the circumstances in which the equipment has been used so far, there is no doubt that very considerable saving can be effected. It must be admitted, however, that difficult digging is being encountered over abnormally long stretches. The possibility of keeping such an outfit employed continuously is the factor

which must determine whether its introduction generally into the Post Office service will be eventually economical. Although so far there has been no chance of comparing its performance with manual labour on less difficult excavation, there is good reason to suppose that the trench diggers will do the work more economically wherever pick work is required, though there is no doubt that the saving will be much less than in cases where the paving-breaker or the jackhammer is employed. It is no overstatement to say that there are large areas throughout the country where very few holes can be got out by means of a spade alone. The extreme portability of the machine enables it to operate as required where conditions are most suitable throughout an Engineering District, and it is probable that other work besides pole work can be found for it. Small underground schemes or small trenching works through concrete road foundations, which would ordinarily be given out to contract, present themselves as a possible field. It is probable that a pneumatic winch can be obtained which will be suitable for pulling in medium-sized cables, and work of this nature might be found to fill in periods when the equipment might otherwise be unemployed.

On the whole, it is felt that further experience will show that the supply of further sets to certain selected Districts will be amply justified.

TWO INTERNATIONAL CONFERENCES AND THE INDUCTIVE INTERFERENCE PROBLEM.

By S. C. Bartholomew, M.I.E.E.

The International Conference on Large Electric High Tension Systems held its Third Session in Paris this year, from June 16th to 25th, and I was privileged to attend as a Member of the Committee looking after the interests of Great Britain. Not quite coincident in time with this Conference, another was held in the same neighbourhood—that of the Comité Consultatif International des Communications Téléphoniques à Grande Distance (International Advisory Committee on Long Distance Telephony in Europe, usually referred to as the C.C.I.), which was in session from June 22nd to 30th, and on which I was a delegate of the British Post Office for the purpose of dealing with the subject of the "Protection of telephone lines against disturbing influences from strong currents and high tension power installations." This subject formed a connecting link between the two Conferences and considerable prominence was given to it at the Power Conference,

the matter taking up nearly the whole of one of the six days devoted to work. The Power Conference had presented to it papers dealing with various aspects of the problem, the principal contributions being that of M. Valensi, the Secretary-General of the C.C.I., which dealt with the matter very clearly and thoroughly from the telephone point of view, and that of M. Brylinski, of the Professional Syndicate of Producers and Distributors of Electrical Energy, who dealt with the matter as a power engineer. The main consideration, however, was the attitude to be adopted towards certain "Directives" (guiding principles) which had been drawn up by a Sub-Committee of the C.C.I. and which were to be submitted for the consideration of the full Telephone Conference during the following week. These "Directives" are a serious attempt to draw up rules concerning means to be adopted to protect telephone lines against disturbing influences from strong currents or high tension power installations, and they were placed before the Power Conference in their tentative form and commented upon by M. Brylinski, who was to attend the Telephone Conference on certain days as head of a delegation from the Power Conference.

Following the reading of the papers a discussion took place, which was somewhat animated. Signor Guido Semenza (Italy), Mr. Faccioli (U.S.A.) and Mr. E. B. Wedmore (British Electrical and Allied Industrial Research Association) were the principal power engineers who took part, whilst M. Milon (President of the C.C.I.) and I spoke from the telephone point of view. At the conclusion the Power Conference decided not to give a definite approval of the proposed Directives, but indicated that it concurred in the course suggested by M. Brylinski, namely, that he, as head of the power delegation attending the Telephone Conference, should press for the limitation of the proposed rules to power lines worked at 60,000 volts and over and that for lower voltages the limits laid down should be reduced.

M. Brylinski is a gentleman of strong personality and, when really "under way" and enforcing an argument, speaks so rapidly that only the very best linguists can follow him. This did not matter so much at the Power Conference, where the proceedings were conducted in both French and English and very able engineer-interpreters were employed, but at the Telephone Conference, where the proceedings were entirely in French, his arguments were frequently difficult to follow.

In addition to the engineers from the Power Conference, delegates from the International Union of Railways also attended the C.C.I. Conference to discuss the "Directives": these delegates were engineers from the French, Swiss and Italian Electric Railways.

During the course of the Conference, the "Directives" were modified in some respects and the power and railway delegates, who attended four of the sessions and were given every facility for expressing their views, regarded many of the amendments as worsening the conditions so far as their interests were concerned, and finally they presented a statement which indicated that, whilst generally in agreement with the method of tackling the problem and the limits laid down, they considered some of the conditions could not always be complied with—for instance, where the physical conditions are unfavourable, as in passes through mountainous country, it was stated that it would be economically impossible to provide the required separating distances.

The proposal to limit the "Directives" to power systems worked at pressures of 60,000 volts and over was not agreed to by the Telephone Conference.

A word now as to the scope and contents of the "Directives.' The original rapporteurs were Dr. Breisig (Germany), M. Muri (Switzerland) and Prof. Di Pirro (Italy), but undoubtedly the basis of many of the rules and the formulæ can be attributed to experience and investigations in Germany. Some of the formulæ are derived from first principles, but others, such as those dealing with interference from electric railways, have factors which have been obtained empirically. The tentative proposals drawn up in November, 1924, were modified to a certain extent as a result of criticism by the various administrations and by the work of a Sub-Committee.

The scope of the "Directives" can best be expressed in the words used in their introduction:—

> In nearly all countries with well developed telephone systems it has been found that the working of telephone circuits suffers from the disturbing influence of neighbouring power lines. On account of future developments which doubtless will take place in power distribution lines and electric traction, progressive diminution in the quality of telephonic transmission and an increase in the danger to the personnel and telephone plant is to be feared if measures are not taken immediately to prevent interference to the telephone service by power installations. These measures relate to:—
>
> (1) Telephone lines.
> (2) Power lines and installations.
> (3) The proximity (parallelism) of power lines to overhead telephone lines.
> (4) The proximity (parallelism) of power lines to underground telephone circuits.
>
> Although it is relatively simple and beyond discussion to

lay down in detail, even at the present time, the principles governing the major part of the technical regulations to be adopted, it is not generally possible to fix exactly the limits within which these regulations may be carried out. Any further contribution to the study of the phenomena of electromagnetic and electrostatic induction, as well as any progress made in the construction of telephonic and industrial material and any modification in the normal conditions of exploiting telephone lines and high power lines, would, therefore, involve a revision of the figures proposed.

Nevertheless, it appears to be useful, even at the present time—in order to fix ideas on the subject—to give certain numerical data of a precise character with regard to the limits within which the technical regulations recommended should be applied, with a view to preserving a certain degree of efficiency. It is in this spirit that the numerical conditions laid down in the text of the " Directives " have been determined.

On the other hand, the " Directives " should be regarded only as the expression of the opinion common to the technical experts who are taking part in the work of the C.C.I. Questions of an administrative or economic nature relating to the problem of the proximity of power lines are not within the competence of the Committee and have been left aside.

In particular, the Committee has abstained from entering into details of the rules of procedure which Telephone Administrations and the services engaged in the production or distribution of electricity should follow in their mutual relations. The Committee thinks, however, that it is able to make a very general recommendation.

In order to obtain the most advantage from the measures to be taken for the protection of telephone lines and in order to facilitate their practical application, it is desirable that the telephone or telegraph services concerned should evince the utmost goodwill by way of collaboration. Systematic and regular exchange of all useful information relating to the construction of existing or proposed lines and to changes in the conditions of working of installations in proximity, either at the present time or in the future, is much to be desired.

The accompanying chart shows graphically the main recommendations of the " Directives " as finally approved, but it would perhaps be well to indicate the nature of the work. The main rules are embodied under the four general headings given in the foregoing extract and, in addition, there are six appendices, some with supplements, which show how the formulæ employed are arrived at and the methods of calculating the limits fixed in the

general rules. The scope of the appendices is indicated by their headings, namely :—

Appendix I. Determination of the symmetry to earth of trunk telephone lines.

Appendix II. Examination of the conditions under which proximity may be permitted between symmetrical high tension power lines, polyphase or single-phase, not connected with earth at any point, and telephone lines.

Appendix III. Proof with reference to the margin of proximity allowable between telephone lines and three-phase or single-phase high tension alternating current lines which have an earthed neutral point.

Appendix IV. Determination of the degree of permissible proximity (parallelism) between alternating current single-phase railways and three-phase railways with earth returns, on the one hand, and telephone lines on the other hand.

Appendix V. Measurement of noise induced in telephone circuits.

Appendix VI. Determination of the unbalance of telephone circuits with reference to disturbing lines.

In the body of the "Directives," in addition to general recommendations as to the layout and working of power and traction systems, definitions are given of allowable limits of deformation for the pressure waves of alternators, harmonics in alternating current and direct current supplies, magnetising currents of transformers, etc.

The two most controversial points in the proposals related to "acoustic shock" and "permissible interfering noise," or, more shortly, "allowable noise." The former has become a matter of very serious concern in some parts of the Continent and in America, the effects being usually produced by transient faults on overhead power systems and, if of frequent occurrence, have a demoralising effect on the nerves of operators who are subjected to them.

"Acoustic shock" occurs on telephone circuits when the voltage of the wires to earth is raised to such a value that the lightning protectors should function and only one operates : when this occurs, the pressure applied to the terminals of the receiving apparatus becomes equal to the pressure between the wires and earth, which produces a great increase in the current through the receiver, causing the diaphragm to make violent contact with the pole pieces and resulting, therefore, in a violent or brutal noise. The excessive voltage on the telephone circuit may be caused either by a momentary unbalance of pressure on a neighbouring power line

or by the inductive effects of the current in such a system when it is unbalanced by the occurrence of a short circuit to earth, etc. The former is the more usual cause and is associated with power systems working with an unearthed neutral point: on such a system the occurrence of an earth fault causes a change in the electric field, a travelling wave is set up which produces a corresponding effect upon neighbouring telephone circuits, and earthing of the telephone lines through the lightning protector causes the discharge through the telephone receiver of the condenser constituted by the wires of the telephone circuit and the earth. It is agreed that the worse effects are produced by the closing of a switch on a power system when the contacts of the different phases are not made simultaneously and when, moreover, there is an earth fault on one of the lines. The effects may be only of a momentary character, but if the fault is what is known as an "arcing ground" then the trouble will persist.

In order to avoid danger from acoustic shock either the telephone wires must not be subjected to a voltage higher than the breakdown voltage of the lightning protectors, usually taken at 300 volts, or, if the wires are within a zone in which that voltage can be induced, the condenser formed by the telephone wires and earth must not during its discharge release sufficient energy to cause a dangerous shock. The danger zone, from this standpoint, can be shown to be that bounded by a telephone line and a line parallel with it at a distance $a_1 = \frac{1}{3}\sqrt{E}$, where a_1 is in metres, and E the voltage of the power line. If a power line and telephone line run parallel within this zone, the proximities should be so restricted that the electrical energy which acts in the telephone circuit due to the sum total of all proximities will not exceed 1/50th joule. In the most unfavourable case, *i.e.*, where the the telephone line is not longer than the parallelism, the whole of the energy might produce its full effect at one end of the line; but in all other cases the interference wave is divided, the two portions flowing to the ends of the circuit, where they arrive more or less attenuated according to the length of the path traversed—it is taken, therefore, that on the average only half the energy reaches the telephone receiver.

To determine whether the permissible value of the induced energy is exceeded, a "characteristic coefficient of exposure to danger" is employed, namely:—

$$f = \frac{lV^2}{Z+2}$$

in which

l = length of proximity in kilometres.

Z = number of wires in the system to which the telephone circuit belongs.

$$V = \frac{E}{400} \cdot \frac{bc}{a^2 + b^2 + c^2} pqr$$

and

E = working voltage of the high tension system (expressed in volts).

a = distance, in metres, between the two lines.

b = average height, in metres, of the high tension line above ground.

c = average height, in metres, of the telephone circuit above ground.

p, q and r are factors expressing the effect of the voltage drop (screening effect), due to neighbouring earthed bodies of the following values :—

In the case of an earth wire running the whole length of the system (lightning protector) $p = 0.75$.

In the case of a continuous row of trees in close proximity to the high tension line $q = 0.7$.

In the case of a continuous row of trees in close proximity to the telephone line $r = 0.7$.

In the two last cases the distance between the row of trees and the line is assumed not greater than 3 metres.

In the absence of earthed bodies of this kind, the corresponding factors, p, q, r, should be expressed by unity.

When the high tension lines are carried on poles more than 120 metres apart b may be taken as 12; in other cases generally $b = 8$.

The height of the telephone circuits, c, is usually taken as being equal to 6.

The characteristic coefficient of exposure to danger, f, should be determined separately for each of the sections within which the distance between the lines remains fairly constant. If p, q, r or Z varies in any one zone, the length of proximity should be suitably sub-divided and the characteristic coefficient of exposure to danger should be determined separately for each part of the line. Crossings do not enter into consideration.

The telephone circuit should be regarded as exposed to danger when the sum of the characteristic coefficients of exposure to danger exceeds 50.

When the high tension line has a voltage applied to it by means of an interrupter of low power or by means of other plant capable of eliminating transitory waves, the sum of the coefficients of exposure to danger should not exceed 100.

The bone of contention in the matter was the definition of allowable acoustic shock as that produced when an energy of 0.01 joule is applied to a telephone receiver. Many engineers question whether this figure is not too high. M. Valensi had apparatus

fixed at both the Power Conference and the Telephone Conference which appeared to bear this out. The matter is not yet settled, however, as it is down for further consideration at the next Conference, and, in the meantime, investigations are being made with the object of finding a better definition. Experiments go to show that energy ($\frac{1}{2}CV^2$) is not the proper basis, as, with the same energy, the effect is greater with a low voltage and large capacity than with a high voltage and small capacity.

The question of allowable noise produced by inductive interference was also a matter on which there was not unanimous agreement. The definition in the case of overhead lines reads:—

> "Interference to telephone working occurs when a power line develops, between the conductors of the telephone circuit, a voltage equivalent (as regards the intensity of noise in the telephone receivers) to an alternating voltage greater than 5 millivolts at a frequency of 800 periods (5000 radians per second)."

In the case of underground telephone circuits, the voltage is reduced to 2 millivolts. Here again the allowable noise appeared to many to be excessive, as demonstrated by the actual practical experiments on apparatus provided by the French Administration engineers. Noise measurements are not an easy matter to carry out, even when there is an agreed basis of comparison. Both the Standard Telephones and Cables, Ltd. (late Western Electric Co.) and Messrs. Siemens & Halske manufacture noise measuring sets, but these differ fundamentally, the former employing as a source of artificial noise a buzzer giving a complex wave form, whilst the latter uses a buzzer in which the frequency is maintained constant, *i.e.*, 5000 radians per second (frequency 800 per second). The actual methods employed for comparing the noise to be measured with that produced by the measuring set do not differ materially, the Standard set giving results in certain arbitrary noise units, whilst with the Siemens-Halske apparatus the readings are in millivolts on a potentiometer. As in the case of acoustic shock, further study is being given to this question by the various Administrations.

Another question which caused controversy and which was considered under the heading of "danger," was that of the limits to be allowed for the longitudinal voltage induced by electric traction systems (single-phase and three-phase) in telephone circuits by the normal working of the railways, *i.e.*, with maximum loads. This was finally fixed at 60 volts (effective) with an extension to 100 volts in cases where the circumstances are exceptional and normal clearance cannot be obtained owing to the presence of obstacles.

The electromagnetic inductive effect (longitudinal voltage)

produced during the short time required for the actuating of a circuit breaker of a power line normally earthed at the neutral point, or of a single-phase or three-phase electric traction line suddenly and accidentally earthed, was fixed at a maximum of 300 volts (effective). (No rule was made to cover similar happenings on traction systems working with continuous current, as it may be expected that by reason of the short duration of the faults they are not likely to cause danger to neighbouring telephone lines.) The following formula, which indicates the degree of danger, g, provides a means of verifying that the limit of 300 volts is not exceeded :—

$$4 \times 10^{-3} \frac{Ik\ l\omega}{\sqrt{a}} = g$$

where

Ik indicates the short-circuit current in amperes.
l indicates length of the proximity in km.
ω is the frequency of the currents in the high tension line × by 2π.
a is the distance between the parallel lines in metres.

The above equation is applicable only to low frequencies up to 60 p.p.s. (approximately).

It is not possible at the present time to give the formula for calculating the coefficient when the lines are further apart than 1000 metres.

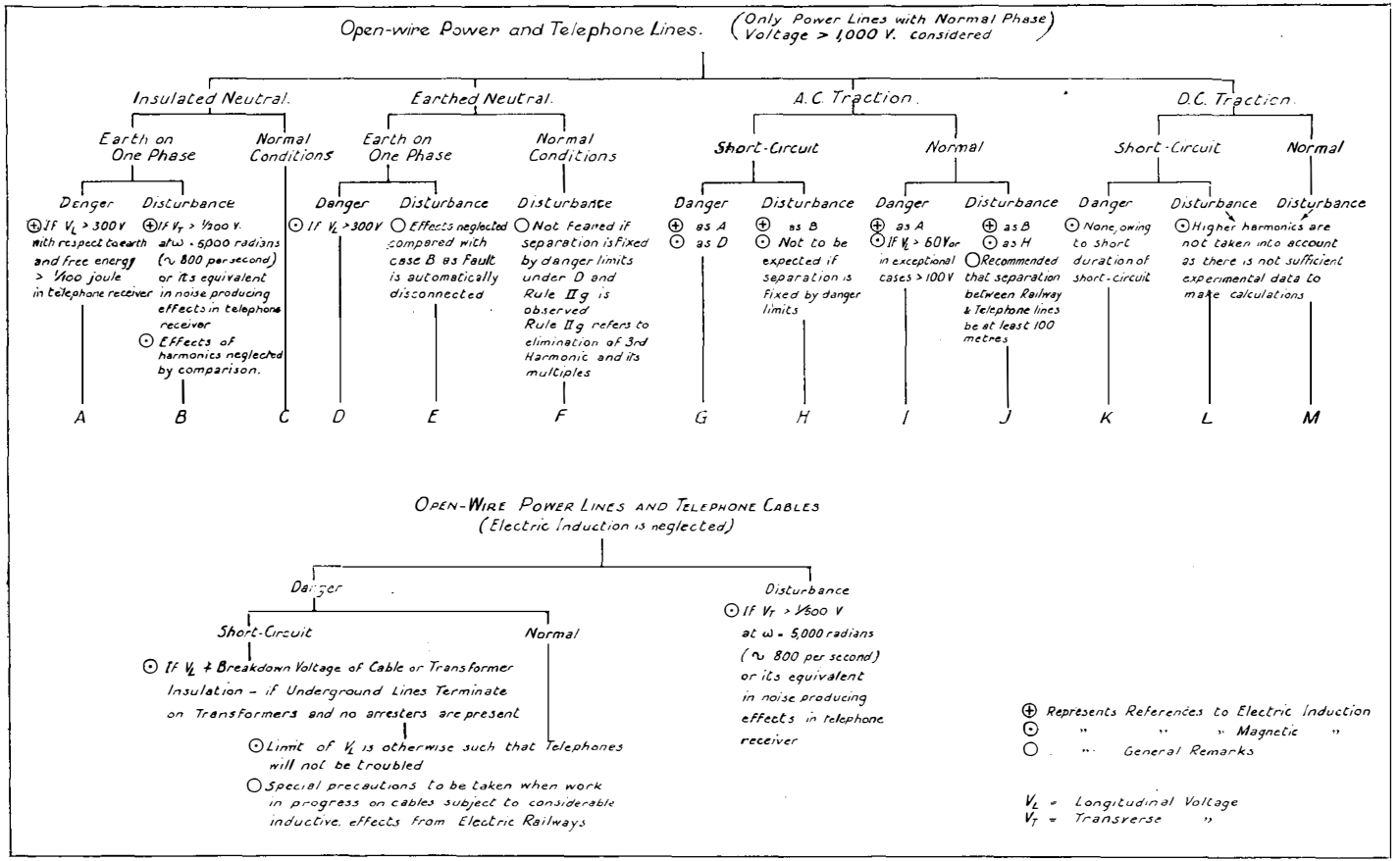
The factor Ik presents a difficulty as it is not an easy matter to arrive at the figure where the power system network is complicated.

The characteristic coefficient g of exposure to danger should be calculated separately for each section within which the distance between the lines is more or less uniform and the telephone lines should be regarded as exposed to danger if the sum total of all the characteristic coefficients of exposure to danger exceeds 300 volts. Crossings are not included in the calculation.

In a short article it is not possible to indicate all the points dealt with in the "Directives," and those interested in a closer study must await the publication of the full text; but it should be observed that the "Directives" are not concerned with telegraphs, the C.C.I. activities being limited to long-distance telephony. Further, that the British Post Office has not yet given them unqualified approval as it is considered that some of the limits are not satisfactory from a telephone point of view.

The chart printed with this article summarises the main conclusions. It follows a method of presentation used by Dr. Stanley Parker Smith, who is now engaged in preparing a report on the inductive interference problem on behalf of the British Electrical and Allied Industrial Research Association.

A few comments on the Conferences may not be out of place.



Comité Consultatif des Communication Téléphoniques à Grande Distance: Paris, June, 1925; showing chief features of the Directives (Guiding principles). Most unfavourable conditions are considered when fixing limits.

The point that impressed one most was the fact that the interference problem is not now confined to the mutilation of signals and speech, the main consideration being the question of danger to personnel. It transpired that one of the telephone administrations had at one time very serious staff difficulties owing to the effects of acoustic shock upon operators. Various devices are now provided, however, which lessen these effects. Further, two cases were mentioned of telephone linemen being killed by inductive effects due to the occurrence of faults on overhead high pressure lines where the power system and the telephone line were in close proximity. The power systems concerned were operated with unearthed neutrals and earth faults occurred simultaneously on two phases. There are very few systems in Great Britain where the unearthed neutral is employed, it being standard practice here to work with neutral earthed either directly or through a low resistance. In one of the fatality cases the lineman was killed whilst at work on a telephone line in Italy, but the actual fault on the power line was in Switzerland, the telephone route being one connecting the two countries.

As pointed out previously, the Power Conference proceedings were conducted in both English and French, interpreters being employed, when necessary, in the reading of the papers and in the discussions. Many of the engineers present could speak both languages fluently, however, and all could follow the proceedings with ease. The papers were also printed in both languages, and here one sometimes noticed in parts a little vagueness which became clearer on closer investigation. The statement that certain apparatus should be "well insulted" is near enough, but the following sentence is more than clear as it conveys, in striking language, what is likely to happen :—

"By having a finger on this hardware the operator is protected from small discharges static which might otherwise break his equilibrium when he gets in contact with the tower."

To be privileged to attend an International Conference of this character is an unique experience. 25 countries were represented and there were present over 200 of the principal power engineers of the world. The hospitality of the French Committee responsible for the arrangements was most generous and was greatly appreciated. As a Member of the British Committee, I had the honour of being one of the delegates presented to the President of the French Republic (M. Doumergue) at the Elysée Palace when representatives from the various countries were received there. There was, of course, great personal gratification in this, and I could not help feeling that my presence there, as a communication engineer, illustrated in a very practical way the broad views and spirit of co-operation of the British power engineers, in including me in the delegation.

THE THEORY OF LADDER NETWORKS.

By the Research Staff of the General Electric Co., Ltd.
Work conducted by A. C. BARTLETT.

THE theory of a ladder network such as that shown in Fig. 1 has been dealt with previously in this journal by H. P. Few* as a special case of a more general result.†

The whole theory of current and voltage distribution through the network can, however, also be put into very compact form if treated from the point of view of continued fractions and simple continuants.

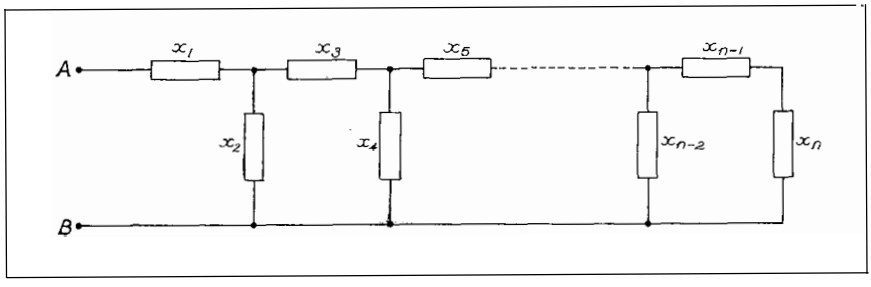


FIG. 1.—THE THEORY OF LADDER NETWORKS.

A simple continuant $K(a_1, a_2, a_3 \ldots\ldots a_n)$ may be defined by the following properties‡:—

$$K(0) = 1$$
$$K(a_r) = a_r$$
$$K(a_1, a_2 \ldots\ldots a_n) = a_1 K(a_2, a_3 \ldots\ldots a_n) + K(a_3, a_4 \ldots\ldots a_n)$$

Thus

$$K(a_1, a_2) = a_1 K(a_2) + K(0)$$
$$= a_1 a_2 + 1$$
$$K(a_1, a_2, a_3) = a_1 K(a_2, a_3) + K(a_3)$$
$$= a_1(a_2 a_3 + 1) + a_3$$
$$= a_1 a_2 a_3 + a_1 + a_3$$

Simple continuants are related to continued fraction by the relation

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \ldots\ldots + \cfrac{1}{a_n}}} = \frac{K(a_1, a_2 \ldots\ldots a_n)}{K(a_2, a_3 \ldots\ldots a_n)}$$

* H. P. Few. Vol. 15, p. 92.

† Fleming. Phil Mag., Sept., 1885.

‡ Chrystal Algebra II., Chap. XXXIV.; also Muir Treatise on Determinants, 1882, Chap. III.

Returning now to the network which is constructed of series elements x_1, x_3, etc., and shunt elements x_2, x_4, etc., let the impedances of the elements x_1, x_3, x_5, etc., be a_1, a_3, a_5, etc., and the impedances of the shunt elements x_2, x_4, etc., be $\frac{1}{a_2}$, $\frac{1}{a_4}$, etc.

Then the sending end impedance of the network will be given by the continued fraction

$$a_1 + \cfrac{1}{a_2 + \cfrac{1}{a_3 + \ldots\ldots + \cfrac{1}{a_n}}}$$

which is equal to

$$\frac{K(a_1, a_2 \ldots\ldots a_n)}{K(a_2 \ldots\ldots a_n)}$$

Consider now the current in the element x_3; current entering the network will divide between x_2 and x_3, the fraction of the current entering x_3 will be given by

$$\frac{\text{Admittance of network commencing at } x_3}{\text{Admittance of } x_2 + \text{Admittance of network commencing at } x_3}$$

$$= \frac{\dfrac{K(a_4 \ldots\ldots a_n)}{K(a_3 \ldots\ldots a_n)}}{a_2 + \dfrac{K(a_4 \ldots\ldots a_n)}{K(a_3 \ldots\ldots a_n)}}$$

$$= \frac{K(a_4 \ldots\ldots a_n)}{a_2 K(a_3 \ldots\ldots a_n) + K(a_4 \ldots\ldots a_n)}$$

$$= \frac{K(a_4 \ldots\ldots a_n)}{K(a_2 \ldots\ldots a_n)}$$

Similarly of this current a fraction

$$\frac{K(a_6 \ldots\ldots a_n)}{K(a_4 \ldots\ldots a_n)}$$

will enter x_5.

So that the fraction of the original current passing through x_5 will be

$$\frac{K(a_4 \ldots\ldots a_n)}{K(a_2 \ldots\ldots a_n)} \times \frac{K(a_6 \ldots\ldots a_n)}{K(a_4 \ldots\ldots a_n)}$$

$$= \frac{K(a_6, \ldots\ldots a_n)}{K(a_2, \ldots\ldots a_n)}$$

The process can be continued and the general result is that the current through any series member x_{2r+1} is equal to the input current multiplied by

$$\frac{\mathrm{K}\,(a_{2r+2},\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_2\ldots\ldots\ldots a_n)}$$

and that the ratio of the current through x_{2r+1} to the current through x_{2s+1}

$$= \frac{\mathrm{K}\,(a_{2r+2},\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_{2s+2}\ldots\ldots\ldots a_n)}$$

Let the current in the series member x_{2r+1} due to a voltage v impressed at the sending end AB be v/Z_{2r+1} so that Z_{2r+1} can be termed the impedance of x_{2r+1} with respect to the terminals AB; Z_{2r+1} can now be determined; the current through x_{2r+1} is $\mathrm{K}\,(a_{2r+2}\ldots\ldots\ldots a_n)/\mathrm{K}\,(a_2\ldots\ldots\ldots a_n)$ times the current through x_1 and the current through x_1 is

$$v \Big/ \frac{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_2\ldots\ldots\ldots a_n)}$$

and therefore the current through x_{2r+1} is equal to

$$v \quad \frac{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_{2r+2}\ldots\ldots\ldots a_n)}$$

$$\text{whence } \mathrm{Z}_{2r+1} = \frac{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_{2r+2}\ldots\ldots\ldots a_n)}$$

Next consider the voltages across shunt members; if a voltage is applied at AB the fraction of the voltage across x_2 will be given by

$$\frac{\text{Impedance of network commencing at } x_2}{\text{Impedance of network commencing at } x_1}$$

$$= \frac{\mathrm{K}\,(a_3\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_2\ldots\ldots\ldots a_n)} \Big/ \frac{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_2\ldots\ldots\ldots a_n)}$$

$$= \frac{\mathrm{K}\,(a_3\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}$$

Of this voltage across x_2 which is the input voltage to the network beginning at x_3 a fraction $\mathrm{K}\,(a_5\ldots\ldots\ldots a_n)/\mathrm{K}\,(a_3\ldots\ldots\ldots a_n)$ will be the across voltage of x_4.

So that, of the original applied voltage, a fraction

$$\frac{\mathrm{K}\,(a_5\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}$$

will be the voltage across x_4. Continuing in the same way, the voltage across the shunt element x_{2r} is equal to the input voltage multiplied by

$$\frac{\mathrm{K}\,(a_{2r+1}\ldots\ldots\ldots a_n)}{\mathrm{K}\,(a_1\ldots\ldots\ldots a_n)}$$

and the ratio of the voltage across x_{2r} to the voltage across x_{2s} is

$$\frac{K\,(a_{2r+1}.....a_n)}{K\,(a_{2s+1}.....a_n)}$$

If Z_{2r} is the impedance of the shunt element x_{2r} with respect to the terminals AB it follows that—

$$Z_{2r}=\frac{1}{a_{2r}}\quad\frac{K\,(a_1.....a_n)}{K\,(a_{2r+1}.....a_n)}$$

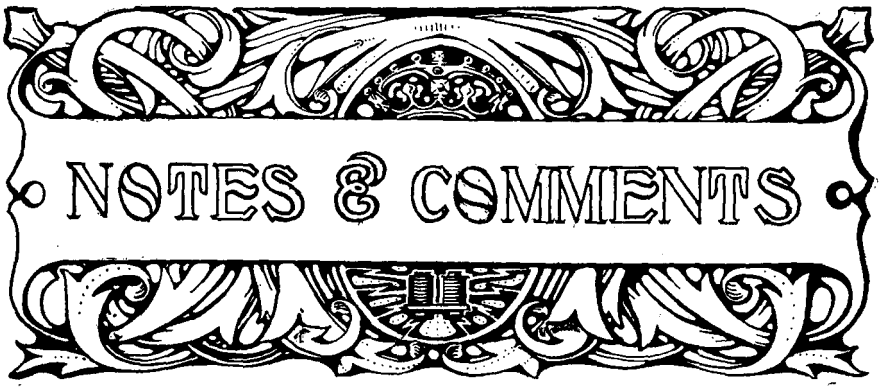
The receiving and impedance can be obtained from either the series or shunt formula (since the currents through x_{n-1} and x_n are equal) and is equal to

$$\frac{K\,(a_1.....a_n)}{a_n}$$

It has been taken throughout that the network commences with a series member; there is no loss of generality in this, for if the network commences with a shunt member it is merely necessary to put $a_1=0$ and notice that

$$K\,(0,\ a_2,\ a_3.....a_n)=K\,(a_3.....a_n)$$

A.C.B.



NOTES AND COMMENTS.

We are publishing in this issue an exhaustive summary of Colonel Purves's Institution paper on "The Post Office and Automatic Telephony," and the discussion that followed. Although rather belated—we tried to help a large number of our readers who are not supplied with the Proceedings of the Institution direct by sending them complete copies free of expense—the paper loses nothing of its value by the delay, and we are of opinion that a better appreciation of its contents will be obtained in this wise than if it had been spread in full over three or four issues of the Journal. The purely historical portion has been omitted, as our pages have contained sufficient information on this part of the subject during the past dozen years.

In our last issue we published an important article by Messrs. Jenkins and Paterson on the methods to be employed in dialling-in and -out between automatic and manual exchanges. Unfortunately quite a number of errors crept into the paper, and in order to remedy them we are sending out in this number a separate slip containing the modifications to be made to bring the article into line with the actual conditions. We are sorry for these mistakes, which were due to various circumstances not altogether under our control, and we hope the corrections now issued will enable those interested to bring the letterpress and diagrams into line.

Wheatstone Commemoration.—To mark the fiftieth anniversary of the death of Sir Charles Wheatstone, the celebrated inventor and Professor of Natural Philosophy at King's College,

London, a tablet to his memory was unveiled in Gloucester Cathedral on 19th October last.

At South Kensington, the Science Museum authorities arranged a special two weeks exhibition of Sir Charles Wheatstone's numerous inventions. The telegraph side was well represented, the well-known five-needle telegraph instrument, with its twelve sending keys, being a prominent object. There was also a double needle telegraph framed in an elaborately carved Gothic case. This instrument was used in the Houses of Parliament in 1846 and the case was designed in imitation of the architectural style of the building in which it was installed. Perhaps the most interesting electrical exhibits were the specimens of early Wheatstone automatic apparatus. The original transmitters were worked by hand, the slip being passed through the transmitter by the action of mechanism kept in motion by the operator turning a handle. A.B.C. communicators and indicators, a quaint whistling telegraph and numerous other instruments went to make up what was, perhaps, one of the most complete displays of Sir Charles's work that has ever been assembled. Among the non-electrical exhibits were a spectroscope, concertinas and many other objects which illustrated the versatility of his genius.

Altogether the exhibition was of great historical interest and was visited by many notable personages, including two of Sir Charles Wheatstone's daughters, who took the opportunity of again inspecting, after a lapse of many years, some of their father's memorable achievements.

An interesting example of the value of the Journal to Colonial Administrations has just come to hand from Lagos, Nigeria. In the July issue we published illustrations and a description of a new type of Utility Service Motor Vehicle being tried in the home service. The description has been read with great interest (says the Acting-Engineer-in-Chief of Nigeria) as they are considering the employment of motors on the lines in the "bush." He has asked for a copy of the drawings of the bodywork to be sent, so that they may benefit by the home experience.

The Relay Automatic Telephone Company has received a contract for a new 300-line automatic exchange for Fontainebleau, which will be of the same type as that supplied to the British G.P.O. The job will be engineered from Relay House.

We have received from the N.V. Electriciteits-Maatschappij Zeva, of Admiral de Ruyterweg 398, Amsterdam, a specimen of their "Zeva" electric soldering iron for telephone and telegraph

purposes. The heating element is cast under high pressure in a mass of aluminium and lies solidly locked up in the metal, being thus protected from shocks and jars and free from the effects of acid, dust and water. The bit is adjustable, being held by a lock screw which passes through the wall of the aluminium sheath. The apparatus looks a very serviceable tool; it is fitted with a stout flexible cord terminating on a 2-way plug for attachment to a wall plug and is suitable for a 220-volt circuit.

The new Tungstone Accumulator Co., Ltd., of 3, St. Bride's House, Salisbury Square, E.C.4, has sent us a copy of their pamphlet giving details of the methods employed in the construction of their Tungstone cells. The features of the type are the method of using the antimony stiffening in the plate grids and the pasting of the plates entirely by high pressure die casting machinery. It is claimed that the robust plates permit charge and discharge with safety at continuous high rates. We should recommend that the volume or weight of either pure or 1240 Sp. G. acid required for filling up any particular size of battery should be quoted, and also that a filler which does not fit the feed hole exactly should be supplied. Some difficulty was experienced on both these points in filling up a battery which the Company has kindly sent us for trial.

THE THEORY OF THE SHUNTED CONDENSER.

The Managing Editor.

Sir,—Mr. Morice's communication in your last issue on the subject of what precisely happens when $L = CR^2$, contains the following paragraph on which I should like to comment:—

"If $L = CR^2$ and also (*a*) is of the oscillatory form, then it follows that the *quantity* of electricity passing through the relay on suddenly discharging the circuit is zero. If a truly ballistic galvanometer were placed in the circuit in the position shown dotted in Fig. 1 it would not be affected. This then is the significance of the relation $L = CR^2$."

I quite agree that an interesting property of the shunted condenser circuit when $L = CR^2$ is here brought to light, and I am glad to see it placed on record.

I will confine my comments to the bearing that rapid signalling has on the property in question. It is evident that the total quantity of electricity which would pass through the supposed ballistic galvanometer would only amount to zero if the current were allowed to flow long enough for the summation to zero to take place. This is not necessarily the case. Curve A in Mr. Morice's letter admirably illustrates my point. A rapid dot signal would

be completed in less than half the time shown in this curve. Let us examine this case. The time required for the sum of the + and − quantities of electricity shown in the curve to amount to zero cannot be taken, even approximately, as less than 0.02 sec. Now we learn from Mr. Morice's article (page 15 of the April number of the Journal) that for a speed of 400 words per minute, a "dot" is completed in 0.0031 second. This is, however, a very high speed, and I will suppose that half the speed named is taken, and that a dot lasts for 0.0062 second. A reference to the curve in question will show that the transient current is very far from being completed at the end of 0.0062 second, and in practice the transient signal would be cut off with the dot and not completed although the dot would be fully registered. This is very far from being an isolated example.

So far as rapid signalling is concerned, there are one or two properties which are manifested when $L = CR^2$ which appear to me to be specially important. I showed in a general way in my previous letter that a relatively rapid rise of signals is then obtained, and I desire to take advantage of this opportunity to give precise formulæ which permit of the easy calculation of the rate of rise of the signals and other important data. All the formulæ assume that $L = CR^2$.

As shown in my former letter, the instantaneous transient current may be calculated from the equation

$$I = \frac{V}{R+R_1}\left[1 - e^{-at}\left(\cos \beta t - \frac{a}{\beta}\sin \beta t\right)\right] \quad \ldots\ldots(1)$$

R being the resistance in the shunted condenser circuit and R_1 being the resistance of the relay.

It follows that at some instant t_1 we may have a value such that

$$\cos \beta t_1 = \frac{a}{\beta} \sin \beta t_1 \text{ or}$$

$$\frac{a}{\beta} = \cot \beta t_1 \quad \ldots\ldots(2)$$

When this condition obtains the quantity in the inner brackets in (1) is zero and (1) becomes $I = \frac{E}{R+R_1}$

It is then evident that at the time t_1 the current has temporarily risen to its normal value $\frac{E}{R+R_1}$. If we know the value of $\frac{a}{\beta}$ we can find the value of βt_1 from (2), and suitable trigonomertical tables.

It can be shown that $\frac{a}{\beta}$ may be expressed in terms of the resistances R and R_1 as follows:

$$\frac{\alpha}{\beta} = \sqrt{\frac{R+R_1}{3R-R_1}} \quad \ldots\ldots(3)$$

R_1 is a known constant and therefore (3) may be solved for any value of R which we may place in the rheostat—this value of R must be known.

The values of α and β may also readily be found. It was shown in my former letter that α may be written

$$\alpha = \frac{R+R_1}{2L} \quad \ldots\ldots(4)$$

and from (3) and (4)

$$\beta = \frac{\alpha}{\sqrt{\frac{R+R_1}{3R-R_1}}} \quad \ldots\ldots(5)$$

Also since $L = CR^2$

$$C = \frac{L}{R^2} \quad \ldots\ldots(6)$$

Having found βt_1 as described, t_1 may evidently be written

$$t_1 = \frac{\beta t_1}{\beta} \quad \ldots\ldots(7)$$

Some interesting conclusions may be deduced by the aid of these simple formulæ, and to show them more clearly I have constructed the following table:—

$L = CR^2$ $\quad L = 3.5$ henry $\quad R_1 = 300$ ohms†

R ohms.	Cμf	α	β	$\frac{\alpha}{\beta}$	t_1 secs.	Maximum Reversed transient Current in terms of normal Current*
500	14	114	140	0.82	0.0063	0.018
700	7.14	143	191	0.75	0.0049	0.024
1000	3.5	186	270	0.69	0.0036	0.030
1500	1.55	257	393	0.65	0.0025	0.035
2000	0.875	329	518	0.64	0.0019	0.038
2500	0.56	400	641	0.62	0.0016	0.040

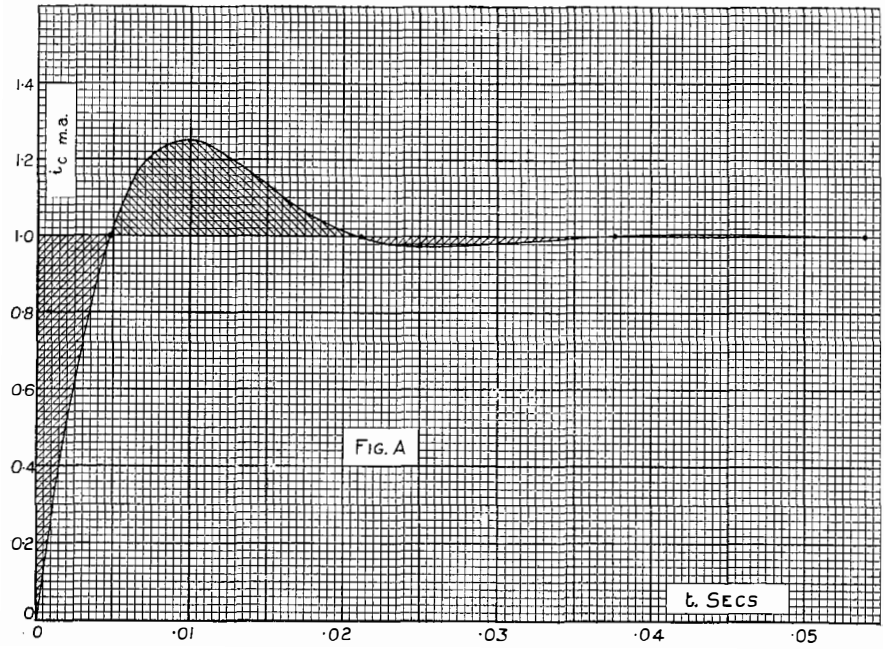
* Normal Current = 1

† In these conditions formula (1) holds good for all values of C up to 350 microfarads.

It is evident from this table that as the resistance is increased and the capacity suitably adjusted in accordance with the CR^2 rule the current rises more and more rapidly to its normal value, at the time t_1 after establishing the circuit. From an extended table of

this kind—or a curve—t_1 could readily be found appropriate to the speed of any "dot" signal. Any arbitrary manipulation of C and R would not be likely to produce such an exact result. According to our table, however, an increased rate of rise of the current has to be paid for by an increase of resistance and its consequences.

After the current has temporarily risen to the value t_1 it continues to rise, and it has a value exceeding the normal during the time that the angle βt executes a further half revolution. Mr. Morice's curve A, in his letter, affords a clear example of the characteristics of the curve and I here reproduce it, by permission, to facilitate my explanation.



CURVE A.

(*a*) The current rises *steeply* to its normal value 1.0 in the time I have called t_1, and the column headed t_1 in the table shows the variations of the time required for the current to attain the normal value.

(*b*) The current rises above its normal value for half a revolution. The maximum amplitude is attained at time $2t_1$ and it increases with the resistance R and is *large*. The excess current (that above normal) assists the signals in all cases.

It may be, and often is the case that dots are too rapid to benefit from the augmented current. Still, so long as the transient current exists it will either be in a direction which would assist or retard

signals, and the dash benefits to some extent from this limited advantage.

(*c*) After the transient current is reversed (and in the case of Curve (A) descends below the value of 1.0) the resulting transient current is very small, and this *small* value, though not constant, is a characteristic feature of the curves when $L = CR^2$. The estimated maximum values of the reversed current are shown in the last column of the preceding table, and it will be observed that in all cases the values are small. They occur at a time t_2 such that $t_2 = 2t_1 + \frac{\pi}{\beta}$

The characteristics underlined in (*a*), (*b*) and (*c*) are favourable ones and are automatically obtained when $L = CR^2$ in the range of values taken.

I showed in a general way in my former communication that the relation $L = CR^2$ ensures comparatively rapid signals as compared with some other combinations; but space does not permit of extending the comparison.

It is quite true that this study assumes a fixed value of the circuit constants for any particular case; but the amount of probable concordance between calculation and experiment was well shown in Mr. Morice's original article. In any case, theory clearly proves that the rate of rise of telegraph signals can be increased by the device of the Shunted Condenser, and an important step in the full and scientific solution of the problem is to determine and understand the factors entering into it. I have endeavoured to assist in this direction.

Yours faithfully,

J. G. HILL.

CORRESPONDENCE.

To the Editor of *The Post Office Electrical Engineers' Journal.*

Dear Sir,

Some time ago A. H. Roberts published an interesting series of articles in your Journal on the history of the electrical telegraph.* These articles contained, however, some statements about the discovery of electromagnetism, which can hardly be said to be altogether correct.† The statements I have in mind are the following :—

* The Romance and History of the Electric Telegraph. Vol. 16, p. 121, 207 and 401. Vol. 17, p. 1, 91 and 171.

† The attention of " Danmarks Naturvidenskabelige Samfund " (a Danish society for the promotion of co-operation between science and industry) was drawn to these articles by a letter from " Society of Danish Civil Engineers in Great Britain and Ireland."

"In 1802, Romagnosi, an Italian, casually announced his discovery that the magnetic needle was deflected by a galvanic current and mention is made of the fact by Aldini in his book, Essai theorique et experimental sur le Galvanisme, published in 1804, but Professor Oersted, of Copenhagen, is credited with the honour of having been the first to investigate and describe the relationship existing between magnetism and electricity."*

We Danish scientists believe that the priority for the discovery of electromagnetism belongs entirely and solely to the Dane, H. C. Oersted, and I think that by far the greatest part of all scientists agree in this view.

As, however, the name of Romagnosi now and then is mentioned in connection with this discovery it was thought worth while to investigate the question thoroughly. The original publications bearing on this subject have been collected by M. C. Harding, secretary to "Danmarks Naturvidenskabelige Samfund," and abstracts of these publications in the original language have been given in the enclosed paper by Professor K. Prytz under the headings: *Original texts*; besides, the paper contains an English translation of these abstracts and a commentary on the works of Romagnosi. This Commentary has been made by Professor K. Prytz, who has also supervised the English translation.

After this documentation I think it is perfectly clear that *the work of Romagnosi has nothing whatever to do with the discovery of electromagnetism.*

I have been asked to transmit Professor Prytz's paper to you and to beg you to be kind enough to publish it in your esteemed Journal, at least Professor K. Prytz's commentary and the English translation of the documents, but we should very much prefer also to have the original texts published, as the translation of these old memoires into modern language is somewhat difficult.

For further information about *H. C. Oersted,* his work and life, I am sending you, by separate mail, some books published in connection with the centenary of his discovery of electromagnetism. These books are:—*Kirstine Meyer*: "Scientific Life and Works of H. C. Oersted."

M. C. Harding: "Correspondence de H. C. Oersted avec divers savants."

Absalon Larsen: "The Discovery of Electromagnetism made in the year 1820 by H. C. Oersted."

I am, dear Sir,

Yours very truly,

P. O. PEDERSEN,

Professor, The Royal Technical College, Copenhagen.

* Vol. 16, p. 222.

HANS CHRISTIAN OERSTED'S DISCOVERY OF ELECTROMAGNETISM.

By PROFESSOR K. PRYTZ.

The Italian Romagnosi's experiments with the voltaic pile in combination with a compass needle have been cited against Hans Christian Oersted's priority for the discovery of electromagnetism. These experiments have been mentioned (1) in "Opere di G. D. Romagnosi riordinate ed illustrate de Alessandro de Georgi," volume I., Milan, 1841; (2) in Izarn, "Manuel du Galvanisme," Paris, 1804; (3) in Aldini. "Essai théorique et expérimental sur le Galvanisme," volume I., Paris, 1804. In the following will be set forth, using the technical expressions of the present day, what may be assumed to have really happened during the above mentioned experiments. In addition, the information concerning the experiments contained in the said works will be re-printed below and reproduced, besides, in English translation.

(1) The experiments mentioned in this report may be recapitulated as follows: Romagnosi placed a compass needle disposed in an open wooden box in the vicinity of a Volta's pile. In order to insulate the needle he placed the box on a glass insulator. One terminal of the Volta's pile was connected to a conductor, the latter being passed through a glass tube, in order that when handled by means of the glass tube the conductor might be moved about in an insulated state. The other terminal of the Volta's pile is not mentioned.

Romagnosi touched the magnetic needle with the end of the conductor, whereby the needle deviated from its position of equilibrium, and remained in its new position, after the conductor had been removed, from which fact he concluded that the needle had lost its magnetism.

Then he lifted the box carefully, with the result that the magnetic needle, while making small oscillations, *i.e.*, not suddenly, returned into its position of equilibrium during the course of a few seconds. Romagnosi concluded from this that the presumably de-magnetised needle hereby recovered its magnetism.

It is evident from the report that during this experiment no closure of current was affected, and therefore any connection between this experiment and electromagnetism is precluded. The phenomena of the experiment may presumably be explained as electrostatic action in connection with frictional resistance from the pin supporting the compass needle. Romagnosi's explanation that the magnetism of the compass needle disappeared by simple contact with an electric conductor, and that the magnetism

reappeared, because he held the box containing the needle in his hand, may hardly be accepted at present.

(2) Izarn describes another experiment, which presumably must be due to Romagnosi, in the following manner: Between the electrodes in an apparatus arranged like a Henley's discharging apparatus a magnetic needle was placed, either fixed in small pincers (petite pince) or resting on flattened extensions (petit ajoutage applati) on the free ends of the electrodes, whereafter the current from a Volta's pile was passed through the needle. Hereby a declination (déclinaison) of the needle was caused. As owing to its manner of attachment the needle could not alter its position, while the current was passing through it, the deviation here concerned must have appeared afterwards, after the needle had again been freed. For some obscure reason the position of the magnetic axis of the needle had been altered slightly. Possibly the heat generated by the current in connection with terrestrial magnetism may have been the cause.

The result of this experiment cannot possibly be considered a discovery of electromagnetism, as an electromagnet action cannot lead to a result like the one described by Izarn.

(3) Aldini makes in his report merely the statement that Romagnosi, called by him erroneously Romanési, has proved that "galvanism causes the magnetic needle to deviate." There is hardly any doubt but that he refers to the experiment mentioned under (1). One would in fact have to be very modest as to the requirements for defining a discovery, if one were to consider the discovery of electromagnetism to be involved in an isolated statement of this nature.

[*Although Professor Prytz's translations of the original texts are extremely interesting we have not the space available for reproducing them, especially since Mr. Roberts in his letter below says that the trend of his remarks has been misapprehended by our Danish friends.*—EDS., *P.O.E.E. Journal.*]

To the Editor of *The Post Office Electrical Engineers' Journal.*

Sir,

From Professor Pedersen's letter of 8th September last, I regret to find that the intention of the short summary of "Oersted's investigations," contained in Part II. of "The Romance and History of the Electric Telegraph," has been misapprehended. So far from attributing the discovery of electromagnetism to Romagnosi, the whole trend of the article acknowledges that Oersted made that great discovery, but that Romagnosi was the first to record an experiment in which a magnetic needle was deflected by the aid of a voltaic pile.

It is quite natural that in those days, before electrical units were so well defined as they now are, the terms " electric current " and " galvanic fluid " should have been used to describe the cause of observed effects which to-day would be attributed to other means. It was evidently so in Romagnosi's case.

In the paragraph quoted by Professor Pedersen, the last statement " But Professor Oersted, of Copenhagen, is credited with the honour of having been the first to investigate and describe the relationship existing between magnetism and electricity," obviously means that Professor Oersted was rightly credited with the honour, otherwise the succeeding paragraphs would be contradictory.

It has been stated by some writers that Romagnosi would have obtained a similar result if his balanced needle had been constructed of non-magnetic metal and that this being so, nothing new was disclosed by the experiment which therefore was of no importance. To discuss the matter in this strain is to ignore the central fact that Romagnosi was historically the first to use a magnetic needle and voltaic pile *in combination*.

Is it not probable that the publication of Romagnosi's experiment influenced other minds to try the same combination in a different way?

So far as I can ascertain, although he lived for many years after the publication of Professor Oersted's booklet on electromagnetism, Romagnosi never disputed Oersted's claim to that epoch-making discovery.

Oersted's reputation as a brilliant leader in several branches of science, including electricity, rests on too secure a foundation to be shaken, but, while remembering this, let us not forget the work performed by his less illustrious predecessors and contemporaries.

Yours faithfully,

A. H. ROBERTS.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed :—

Exchange.	Type.	No. of Lines.
Chapeltown	Auto	850
Headingly	,,	1220
Newport	,,	600
Paignton	,,	700

Exchange.	Type.	No. of Lines.
Roundhay	Auto	800
Stanningley	,,	680
Stockport Extension ...	,,	1200
Torquay	,,	1800
Birmingham Central Extension	Manual	1250
Caterham Valley	,,	520
Chiswick Extension ...	,,	1500
Coatbridge	,,	600
Cradley Heath	,,	400
Didsbury	,,	1660
East Ham	,,	1700
Guildford Extension ...	,,	540
Knock	,,	940
Leigh (Lancs.)	,,	680
Northam	,,	300
Porth	,,	240
Ramsgate Extension ...	,,	380
Ravensbourne Extension ...	,,	1200
St. Annes Extension ...	,,	540
Truro Extension	,,	100
Whitstable	,,	300
Worthing Extension ...	,,	660
Amalgamated Dental Co....	P.A.B.X.	50
Appleyards, Ltd.	,,	30
Bensons, Ltd.	,,	70
Balfour, Ltd.	,,	80
Birmingham Maternity Hospital	,,	20
Chad Valley Co.	,,	30
Co-Op. Wholesale ...	,,	160
Coutts & Co.	,,	50
Crosse & Blackwell ...	,,	180
Daily Express	,,	120
Delaney's	,,	30
Kendrick Jefferson ...	,,	40
Lines, Ltd.	,,	50
McNamara	,,	80
Morris Motors	,,	130
Port of London Authority (4)	,,	470
Scottish Oils	,,	60
Shanks, Ltd.	,,	40
Simons, Ltd.	,,	30
Union Cold Storage ...	,,	230
Waddington, Ltd.	,,	30

Orders have been placed for the following new Exchanges :—

Exchange.	Type.	No. of Lines.
Arkwright	Auto	1000
Sherwood	,,	1190
Wilpshire	,,	270
Dumfries	Manual	700
Popesgrove	,,	1360
Primrose Hill	,,	4500
Seven Kings	,,	1370
Wellington (Salop) ...	,,	480
Bilsland Bros.	P.A.B.X.	40
Birkenhead Corporation...	,,	100

Exchange.	Type.	No. of Lines.
Bleachers' Association ...	,,	100
British B.C. Co.	,,	30
Burndepts	,,	10
Carpet Trades	,,	50
Coopers, Ltd.	,,	20
Hall & Sons	,,	30
Harrisons	,,	30
Jarrett Rainsford	,,	40
Lancaster C.C.	,,	30
Liverpool Courier	,,	20
Mannesmann Tubes ...	,,	40
Manchester Corporation...	,,	30
Observer	,,	30
Pearson Dorman Long ...	,,	50
Sharp & Sons	,,	30
Simons, Ltd.	,,	30
Shell Mex	,,	30
Taylor's Drug Co. ...	,,	40
Treloar's Hospital ...	,,	30
Vulcan Foundry	,,	40
Zwanenbergs, Ltd. ...	,,	20

Orders have been placed for Extensions to existing equipments as follows:—

Exchange.	Type.	No. of Lines.
Blackburn	Auto	1000
York	,,	380
Royal (London)	Manual	2280

Extension Working in Automatic Exchange Areas.

In connection with subscribers' installations in automatic exchange areas, a new bell-set (No. 20) has been designed for use at the main station, where extension working in accordance with Plans Nos. 5, 5A, 7 and 7A is provided.

The bell-set in these cases includes in addition to the bell, a switch and indicator for controlling the connections to the extensions and with the switch in the "through" position (*i.e.*, exchange to extension) it is necessary for the bell to be in circuit to enable the extension to call the main station even though secrecy against the main is provided in the "through" position of the switch.

The essential feature of the new bell-set is the provision of a combined relay and indicator in place of the indicator provided in the former bell-set (No. 13) which makes it possible to avoid the tinkling of the switch bell at the main station when the dial is operated at the extension station. This is accomplished by arrang-

ing with the switch in the " through " position for the combined relay and indicator to be controlled by the loop of the extension telephone and, when operated, to disconnect the switch bell from the line.

In addition to overcoming the tinkling trouble referred to above, the new bell-set gives considerably less impulse distortion whilst dialling from the extension station and a slight improvement in transmission as compared with the old type of bell-set.

MR. A. H. ROBERTS.

MR. A. H. ROBERTS retired from the service on the 31st March last. He was appointed S.C. and T. at Exeter in 1884 and in 1898 was made Relay Clerk at Lowestoft. In 1901 Mr. Roberts was sent to Emden for two months to study German repeater working, and in 1902 he was appointed Second Class Engineer at Birmingham; he was promoted to be Estimates Engineer there in 1909. Mr. Roberts was transferred two years later to the Tele-

graph Section, Engineer-in-Chief's Office. During the war he was sent to Northern Russia and spent eight months under very trying conditions. In conjunction with Russian engineers he supervised the equipment of cable telegraph offices at Murmansk, Yukanskie and Archangel, for which he received the thanks of the Minister of Posts and Telegraphs under the Kerensky Government. He was awarded the M.B.E. on his return.

"The Romance and History of the Electric Telegraph" is not the first of Mr. Roberts' excursions into the realm of literature; in 1896-7, in collaboration with Mr. S. E. J. Burrows, he wrote a series of articles on Technical Telegraphy for the *Telegraph Chronicle*, which was later published in book form and ran through three editions. On his retirement his colleagues presented him with a silver Queen Anne tea service, which he treasures as his most cherished possession. Since his retirement Mr. Roberts has been busy at the Science Museum, where his knowledge was very useful in arranging the elaborate telegraph exhibit now being installed there.

LONDON ENGINEERING DISTRICT NOTES.

Mileage Statistics.

During the three months ended 30th September, 1925, the following changes have occurred:—

Telegraphs.—Nett decrease in open wire of 18 miles and a nett increase in underground of 172 miles.

Telephone (Exchange).—Nett decrease in open wire (including aerial cable) of 846 miles and a nett increase in underground of 35,847 miles.

Telephone (Trunks).—Nett increases in open wire and underground of 1 mile and 2,112 miles respectively.

Pole Line.—Nett increase of 52 miles, bringing the total to date to 5,190 miles.

Pipe Line.—Nett increase of 178 miles, the total to date being 6,269 miles.

The total single wire mileages at the end of the period under review were:—

Telegraphs	24,184
Telephone (Exchange)	1,645,389
Telephone (Trunks)	57,666
Spares	48,654

LONDON DISTRICT NOTES.

External Construction.

During the quarter ended 25th September, 1925, 8,517 exchange lines, 5,798 internal extensions and 1,252 external extensions were provided. In the same period, 3,055 exchange lines, 2,815 internal extensions and 505 external extensions were recovered, making nett increases of 5,462 exchange lines, 2,983 internal extensions and 747 external extensions.

Internal Construction.

New Exchanges.—A new Manual Exchange (C.B.1, 1,700 lines) was opened at Grangewood (East Ham) on December 5th, and a new C.B. 10A Exchange (850 lines) was brought into use at Pinner on December 9th. The installation of new Manual Exchanges at Primrose Hill, Bexley Heath, Walworth, Battersea and Burgh Heath will be commenced shortly.

Substantial progress is being made with the construction of the Automatic Exchanges at Holborn and Bishopsgate. The installation of the Tandem Exchange in the Holborn Automatic Exchange building has been advanced materially.

Experimental Mechanical Tandem and C.C.I.—The installation work in connection with the trial of two mechanical tandem cordless " B " positions and one C.C.I. position in the City Exchange has been completed and tested out. It is anticipated that the positions will be brought into use in January.

Exchange Extensions.—Works of this nature affecting a very large number of Exchanges in the District continue to be heavy.

P.A.B.X.'s.—The demand for P.A.B.X.'s continues and the number of Exchanges of this type in the District is increasing steadily.

Trans-Atlantic Telephone Transmission.—The terminal apparatus has been delivered at G.P.O. South, and the work of installation is proceeding.

Telegraphs.

In connection with the considerable re-building operations at the C.T.O. a large new telegraph room, on the ground floor, has had to be equipped in space hitherto used for clerical work. This space, cleared of screens, provides accommodation for six quadruple-duplex Baudots, and several Morse sets. A complete system of line cables and power mains has been installed, together with a Divisional Test Box, a type apparently special to the C.T.O.

Four $2\frac{1}{4}$" brass pneumatic tubes have been run; two to the

Central Hall, Ground Floor, and two to the Centre Third Floor, thus providing quick transit to any gallery in G.P.O. (West).

A new street-tube for the *Daily News* has been provided between C.T.O. and Bouverie Street. This makes the third tube provided for Press purposes to the C.T.O.

In connection with the re-construction of the C.T.O., the Engineering Department has been commended for the expedition and care with which the clearance of apparatus from more than half the great Centre and the diversion work in connection with the street and house tubes have been effected. The Centre is now a forest of timber supporting the fourth floor while the stanchions are being replaced, but the telegraph business appears to go forward with little disturbance.

A further advance has been made in connection with the abolition of the Intercommunication Switch. The Power Board has been dismantled and most of the new table-space has been fitted with direct circuits. An intermediate frame has also been made and fitted to accommodate the new ancillary system of switch-boards.

Battery Work.—The District battery work, the large majority of which is carried out by the C.T.O. Section, has increased considerably and the accommodation at G.P.O. (West) has been inadequate for some time. A large workshop and a stores-room have now been provided at Cornwallis Road, adjacent to the Engineering fitters' shops, with a view to facilitate the work. Moulds have been obtained experimentally by means of which standard types of lugs can be prepared for combining the several types of plates into positive and negative sections, and for combining sections into complete cells. The present conditions are more favourable for dealing with the large amount of work continually on hand.

Threadneedle Street B.O.—The reconstruction at this office has permitted the transfer, from Stock Exchange premises to the first floor of the Post Office, of the Baudot and several Hughes instruments, which form together a miniature Foreign Gallery. This is distinct from the Provincial Gallery established on the second floor. A complete tube system has also been provided so that the telegraph room can receive carriers from the Stock Exchange within a few seconds and from the Central Telegraph Office in the course of a minute or two.

The conditions, both as regards light and accommodation, show a vast improvement on the old building. The mechanical clocks have been superseded by an electrical system, three loops being worked from one Master-clock.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

PROGRAMME OF CENTRE MEETINGS: SESSION 1925-6.

LONDON CENTRE.

1925.		
3 Oct.	"The Work of the Wireless Experimental Section"	MAJOR A. G. LEE, M.C., B.SC., M.I.E.E.
4 Nov.	"The Problem of Flexibility on Cable Distribution"	HARVEY SMITH.
	"Plant in Congested Areas"	
8 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E.
1926.		
2 Jan	"Precision Testing"	N. LAYTON.
9 Feb.	"Testing of Secondary Cells" ...	CAPT. N. F. CAVE BROWNE CAVE, B.SC., M.I.E.E.
	"Torch Blowing Lamps"	
9 Mar.	"The Testing of Telephone Circuits and Apparatus with Alternating Currents"	E. S. RITTER, B.SC., A.M.I.E.E. G. P. MILTON.
1 May	"Automatic Trunking in Theory and Practice"	W. W. GIBSON. G. F. O'DELL, B.SC., A.K.C., M.I.E.E.

NORTHERN CENTRE.

1925.		
1 Oct.	"The Law of Contract in relation to P.O. Engineering Contracts" ...	F. JOHNSTON, A.C.I.S.
8 Nov.	"Balancing of Telephone Trunk Cables"	J. LOWE.
Dec.	Visit to Messrs. Hood Haggie's Rope Works at Willington Quay.	
1926.		
0 Jan.	"Telephone Repeaters"	C. ROBINSON, B.A., A.M.I.E.E. (*E.-in-C.O.*).
7 Feb.	"The Elements of Telephone Machine Switching"	F. W. LONGMORE.
7 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
7 Apr.	"Final Selection for P.B.X."	J. H. BELL, A.M.I.E.E. (*E.-in-C.O.*).

NORTH EASTERN CENTRE.

1925.		
3 Oct.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
0 Nov.	"Manufacture and Testing of Earthenware Conduit" (Lantern Lecture)...	L. TANNER and J. C. WALKER.
8 Dec.	"From Youth-in-Training to Engineer"	G. S. WALLACE, A.M.I.E.E.
1926.		
2 Jan.	"Cable Faults, Causes and Remedies" (Lantern Lecture)	W. JAMES.
9 Feb.	"Recruitment & Promotion of Staff"	W. H. THORBURN.
9 Mar.	"Slide Wire Bridge Testing" ...	A. C. MAYMAN.

NORTH WESTERN CENTRE.

1925.		
19 Oct.	"Accommodation"	A. W. FIELD, A.M.I.E.E.
30 Nov.	"Accidents on Duty"	R. A. JONES.
1926.		
18 Jan.	"Difficult Points in Cash Accounting" (Diary Pages and Time Sheets) ...	S. STOREY.
	"Difficult Points in Stores Accounting"	A. J. ROSS.

NORTH WESTERN CENTRE—*continued.*

Feb.	"Records of External Plant"... ...	H. S. TURNER and H. F. PERRY.
	"Amateur Wireless Stations"... ...	H. HORROCKS.
Mar.	"Exchange Transfer Work under Functional Organisation" ... ... (Being an elaboration of the latter portion of the paper on the same subject read during the 1924-25 Session.)	S. UPTON, A.M.I.E.E., & J. B. GLOVER, A.M.I.E.E.

SOUTH LANCS. CENTRE.

1925.		
Oct.	"Progress and Development in the Engineering Department"	W. J. MEDLYN, M.I.E.E.
Nov.	"A few Psychological and other Problems"	J. COWIE, M.I.E.E.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
1926.		
Jan.	"Staff Matters. A General Review"...	G. H. GREEN.
Feb.	"Wireless"	E. H. SHAUGHNESSY, O.B.E., M.I.E.E.
Mar.	"Notes on Cabling Work and Labour Saving Tools"	(*E.-in-C.O.*). R. C. BALCOMBE.

NORTH WALES CENTRE.

1925.		
Oct.	"The Development of the Baudot System"	R. P. COLLINS.
Nov.	"Staff Proposals based on U.M.C. Statistics"	J. H. WHITEHEAD.
Dec.	"The Work of the Engineering Testing Branch, Birmingham" ... (At Birmingham. With visit to Fordrough Lane Testing Branch and Factory).	CAPT. N. F. CAVE BROWNE CAVE, B.SC., M.I.E.E.
1926.		
Jan.	"Relay System of Auto Switching—Private Branch Exchanges" ...	A. E. STOLLARD.
Feb.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
Mar.	"Plant Records—Preparation & Use"	R. S. DACOMBE and J. T. B. DONNELLAN.

SOUTH WALES CENTRE.

1925.		
Oct.	"Notes on Cabling Balancing" ...	J. F. STEWART.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
Dec.	"The Training of an Engineering Inspector"	H. W. GIFFORD.
1926.		
Jan.	"Some Points on Trunking in Automatic Exchanges"	G. F. O'DELL, B.SC., A.K.C., M.I.E.E.
Feb.	"Inspection of Amateur Wireless Stations"	(*E.-in-C.O.*). H. B. SOMERVILLE, B.ENG. (*E.-in-C.O.*).
Mar.	"Newport Repeater Station"... ...	S. H. PENDLETON.

SOUTH WESTERN CENTRE.

1925.		
Oct.	Annual General Meeting and Chairman's Address	E. J. ELDRIDGE, M.I.E.E.
Nov.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
Dec.	"Automatic Telephony"	J. EMLYN JONES.
1926.		
Jan.	"Some Aspects of Automatic Trunking"	G. F. O'DELL, B.SC., A.K.C., M.I.E.E.
Feb.	"Some Underground Contract Difficulties"	(*E.-in-C.O.*). R. E. SOPER.
Mar.	"Fault Localisation on Loaded Cables"	A. E. HAYWARD.

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

NORTH MIDLAND CENTRE.

1925.		
12 Oct.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
16 Nov.	"Derby Repeater Station" ... ... (Paper to be read at Derby).	T. S. SKEET.
14 Dec.	"Common Estimating Mistakes" ...	J. WYATT.
	"Some Aspects of Automatic Telephones"	F. COOTE.
1926.		
18 Jan.	"Contracts"	A. W. BLOWER.
22 Feb.	"Private Automatic Branch Exchanges"	J. HYDE.
	"The Relay Automatic System"	
29 Mar.	"London-Derby Cable"	L. E. WATKINS.

SOUTH MIDLAND CENTRE.

1925.		
28 Oct.	"Telephone Repeaters in Practice"...	F. J. GIBBS.
25 Nov.	"Portsmouth and its Satellite Exchanges"	J. S. BROWN, M.I.E.E.
9 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
1926.		
27 Jan.	"New Ways of doing old Jobs with a view to Time Saving"	V. SMITH.
17 Feb.	"The training of Men for and Maintenance of Automatic Exchanges"...	J. S. BROWN, M.I.E.E.
31 Mar.	"Organisation in a Superintending Engineer's Office"	H. C. MCCORMACK.
28 Apr.	"The Duties of an Inspector" ...	F. D. TRAVISS.

EASTERN CENTRE.

1925.		
27 Oct.	"Notes from London Automatic Lectures"	H. S. NOYES
15 Dec.	"Engineering Notes"	MAJOR W. M. BATCHELOR, D.S.O., M.C.
1926.		
26 Jan.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
16 Feb.	"Coast Communications"	J. F. LAMB, M.I.E.E.
16 Mar.	"The Work of the Wireless Experimental Section"	MAJOR A. G. LEE, M.C., B.SC., M.I.E.E. (*E.-in-C.O.*).

SCOTLAND WEST CENTRE.

1925.		
4 Oct.	"Broadcasting"	J. M. CAMERON (*British Broadcasting Co.*),
2 Nov.	"Wayleaves"	G. TAYLOR.
7 Dec.	"Main Cables—Loading, Testing and Transmission"	J. D. MCLEOD.
1926.		
1 Feb.	"Main Cable Records"	M. MCKENZIE.
	"Local Cable Records"	T. HEGGIE.
1 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*)
5 Apr.	Films. (1) "Travalogue of London and the Rural Districts with special reference to Telephone and Cable Development" ... ... (2) "Creating the Instruments of Speech"	*Western Electric Co. Films.*

SCOTLAND EAST CENTRE.

1925.		
17 Nov.	"Industrial Psychology"	E. J. FRASER.
15 Dec.	"Some features of Telegraph Engineering"	J. K. MURRAY, M.I.E.E.
1926.		
19 Jan.	"Automatic Trunking Schemes" ...	H. DIPPLE, A.M.I.E.E. (*E.-in-C.O.*).
16 Feb.	*To be arranged.*	J. W. JARVIS.
16 Mar.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
20 Apr.	"Edinburgh Automatic Telephone Exchange" (with visit to Exchange) ...	J. INNES.

NORTH IRELAND CENTRE.

1925.		
16 Nov.	"Plumbing and Jointing"	W. S. KEOWN.
2 Dec.	"The Engineering Aspect of Telephone Exchange Accommodation" ...	CAPT. H. HILL, B.SC., M.I.E.E. (*E.-in-C.O.*).
1926.		
11 Jan.	"Transposition and Revolving of Aerial Circuits"	A. E. MOORE.
9 Feb.	"Main Cables, Loading, Testing and Transmission"	J. D. MCLEOD.
9 Mar	"Accidents on Duty"	J. ARDIS. (Paper loaned by R. A. JONES, N. West Centre).

LOCAL CENTRE NOTES.

NORTHERN CENTRE.

The Session opened on the 21st October, 1925, when an admirable paper on "The Law of Contract in Relation to P.O. Engineering Contracts" was read by Mr. F. Johnston, A.C.I.S., before a well attended meeting.

On the 18th of November, Mr. J. Lowe read a paper on "The Balancing of Telephone Trunk Cables," which was well received by a large attendance of members. The Chairman extended a welcome to Mr. A. Morris, of the Engineer-in-Chief's Research Section, who delighted the meeting with a lucid and fluent description of the methods of balancing in vogue.

In connection with the discussions of the papers read before the Centre, the Committee has found it necessary to limit opening speakers to 10 minutes and subsequent speakers to 5 minutes in ordinary circumstances and at the discretion of the Chairman.

The Centre will visit Hood Haggie's Rope Works, at Willington Quay, on Wednesday afternoon, the 2nd of December.

The promotions of Messrs. Kitchen and Bellwood to the ranks of Assistant Staff Engineer and Executive Engineer respectively have given general satisfaction to the members, as both these gentlemen have taken a keen interest in the activities of the local Centre. Mr. Kitchen has served on the Local Committee and has also had the honour of representing his class on the Council. In addition, he has read several papers before the local Centre. Mr.

Bellwood has represented the Assistant Engineers' class on the Local Committee and has read no less than six papers before the Centre. One of his papers was printed by the Council.

SOUTH LANCS. CENTRE.

In accordance with the custom of the past few years the first meeting of the Session, held on the 19th October, was devoted to an address by the Chairman, Mr. W. J. Medlyn, on "Progress and Development in the Post Office Engineering Department." In this annual review of the previous year's work, the lecturer not only summarises the work accomplished by Post Office Engineers in such a manner as to require a minimum of effort on the part of the audience for its assimilation, but also draws many useful comparisons with other engineering works, and quotes largely from authoritative statements made by other Engineers of high standing, both in this and other counties. The address has a definite educational value and by focussing the attention of individual members on the work of the Post Office Engineering Department as a whole it enables each one better to appreciate his own relation to the larger design and is thus an incentive to carry out the work assigned to him in the most efficient manner possible. The large attendance and sustained attention throughout the address was an indication of the interest taken in the subject.

The second meeting of the Session was held on November 9th, when Mr. J. Cowie read a paper on "A few Psychological and other Problems." The novelty of the title undoubtedly stimulated the curiosity of the members, and there was a record attendance. At first sight the connection between the subject and practical engineering might appear to be somewhat remote, but the lecturer succeeded in showing that psychology in its application to administration, in the broadest sense, had a direct and important bearing upon engineering practice. Although made palatable by a characteristically humorous clothing the lecture gave much food for thought, and emphasised the importance of some knowledge of psychology, more especially by Engineers occupying administrative positions.

On November 30th, Captain H. Hill, of the Equipment Section of the Engineer-in-Chief's Office, visited this Centre, and read his instructive paper on "The Engineering Aspect of Telephone Exchange Accommodation." The pending introduction of automatic working into the Manchester Area has given rise to a large number of accommodation cases which are at present under consideration or contemplated, and a paper on the subject was, therefore, particularly opportune. The valuable information and data contained in the paper supplemented by other useful matter

obtained as a result of the discussion will undoubtedly enable members of this Centre to facilitate the handling of such cases in future. There was a lengthy discussion in which numerous speakers participated, and it was obvious that the subject appealed very strongly to the audience.

The members of the Centre are indebted to Capt. Hill both for the excellent paper on a very live subject and also the full and lucid replies he gave to all the questions raised in the discussion.

SCOTLAND WEST CENTRE.

The opening lecture for the current Session took place on 5th October, when Mr. J. M. A. Cameron, Superintending Engineer for the Northern Area of the British Broadcasting Company, delivered a lecture on "Broadcasting." In the absence of Capt. Crompton, on leave, the Vice-Chairman of the Centre, Mr. Hardie, presided. A good attendance of members was augmented by visitors from kindred societies and from the District Manager's and Telegraph Staffs. The Chairman read a letter from Capt. Crompton expressing regret at his inability to be present and hoping for a pleasant meeting.

The lecturer outlined the system for broadcasting from Main Stations and dwelt at some length on the arrangements for modulation at the Station and Studio ends, and the methods of control of modulation. Relay stations were then described. As the lecturer had to catch a train for a Belfast connection within forty minutes of the conclusion of his lecture, discussion was necessarily curtailed.

The lecturer was accorded a very hearty vote of thanks.

Capt. Cooper, Contract Manager, thanked the local Centre Executive for the courtesy of the invitation, and expressed the hope that it would be repeated when suitable papers were being delivered.

The second meeting of the Centre was held on the 2nd November, Captain Crompton presiding over a good attendance of members.

The paper for the day was on the subject of "Wayleaves," contributed by Mr. G. Taylor, Higher Clerical Officer.

Mr. Taylor outlined the position of the Postmaster-General under the Telegraph Acts, 1863 to 1916, and thereafter dealt with the procedure to be followed by the Department's officers in dealing with wayleave consents affecting private property, and applications and notices in respect of the placing of telegraphs on public roads and streets. The general interest taken in the subject of the paper was manifested by the fact that over an hour was taken up by questions and discussion. Very interesting remarks were made by the Chairman and by Mr. Hardie, A.S.E.

On completion of the ordinary business, Mr. Hardie, in proposing a vote of thanks to the Chairman, mentioned that this would be the last occasion on which Capt. Crompton would be with us, owing to his approaching retirement. Mr. Hardie spoke in happy terms of our association with Capt. Crompton, and pointed to the increased membership of the local Centre, and to the improved attendance at meetings, as evidence of the good spirit inspired in the Centre under Capt. Crompton's Chairmanship. The vote of thanks was heartily responded to, and Capt. Crompton replied.

Captain Charles Crompton, O.B.E., R.E., M.I.E.E.

Captain Crompton was born on the 2nd November, 1864. He entered the Post Office Service at Liverpool as Telegraphist in April, 1885; was transferred to the Engineering Department at Liverpool, December, 1886; was promoted Engineer in Scotland West, June, 1894, and stationed at Oban.

Early in the following year the submarine cable connecting Oban with the islands of Mull, Coll and Tiree was broken and Captain Crompton established Wireless communication between Morvern on the Mainland and Craignure in Mull. The system used was that devised by the late Sir W. H. Preece, then Engineer-in-Chief of the Post Office, and a considerable number of public telegrams were satisfactorily dealt with during a period of ten days until the cable ship arrived and restored normal conditions by repairing the submarine cable. It should be noted that the foregoing constituted the first occasion on which Wireless Telegraphy was used commercially in Great Britain, if not in the world. Senator Marconi arrived in London later the same year and, with the assistance of the British Post Office, conducted experiments which resulted in the Wireless system as known to-day in all parts of the world.

In 1896 Capt. Crompton was transferred to Warrington in connection with the transfer of the Trunk Telephone lines from the late National Telephone Co. to the Post Office.

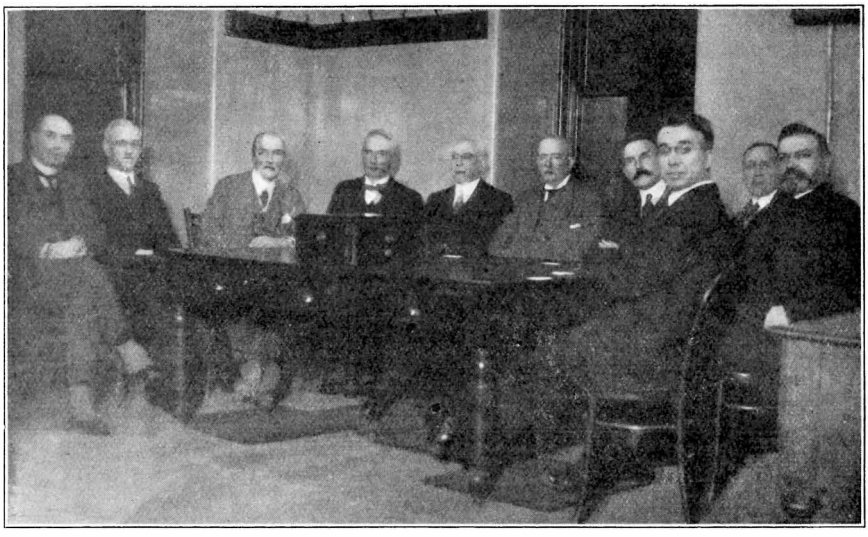
During the latter part of the South African War, viz., from March, 1900, to November, 1901, Capt. Crompton was loaned to the Royal Engineers (Telegraph Battalion) Southern District, and acted as Superintending Engineer of a Sub-division with Headquarters at Basingstoke.

After this Capt. Crompton was given charge of a section of underground cabling of London for the then extensive Post Office scheme of telephoning the Metropolis.

In 1904 Capt. Crompton went as Executive Engineer to Bradford in charge of the Section, but two years later was recalled to London as an Assistant Staff Officer in the Engineer-in-Chief's Office.

In 1908 Capt. Crompton went to Edinburgh as Assistant Superintending Engineer.

When the late War broke out he was appointed adviser on Telegraph and Telephone communications in all Scotland to the General Officer Commanding, Scottish Command, and, later, to the Commander-in-Chief, Coast of Scotland, Rosyth, with the rank of Captain and dealt with the communications of the premier Services as well as many others which sprang up; R.A.F. Anti-Aircraft, Ministry of Munitions, etc., etc., until some time after the end of the war. He was awarded the O.B.E. in 1921 for his services.



From left to right: W. E. Gauntlett, District Manager, Scot. W.; R. Aitken, Superintending Engineer, Scot. W.; Capt. Crompton; J. D. Taylor, S.E., Scot. E.; S. G. Forsythe, C.B.E., Postmaster, Glasgow; R. Cunningham, Sectional Engineer; D. Dunlop, Surveyor, Scot. W.; W. E. Coombs, District Manager, Glasgow; A. B. Gilbert, A.S.E., Scot. E.; J. Hardie, A.S.E., Scot. W.

In August, 1921, Capt. Crompton was promoted to be Superintending Engineer in charge of the South Wales Engineering District.

In 1924 he was transferred to the charge of the Scotland (West) Engineering District with Headquarters at Glasgow.

Having completed 40 years' service he retired under the age limit on November 30th, thus ending his Engineering career as head of the same District in which he started as a junior engineer 31 years ago.

At a meeting of the Engineering Staff, under the Chairmanship of Mr. R. Cunningham, Executive Engineer, at the Head Post Office, Glasgow, on Monday, 30th November, he

was presented with a handsome canteen of cutlery from his colleagues in the Service. The presentation was made by Mr. John Hardie, A.S.E., and among those present were Messrs. S. G. Forsythe, C.B.E., Postmaster-Surveyor, Glasgow; D. Dunlop, Surveyor, Scot. W.; J. D. Taylor, S.E. Edinburgh, and members of the various departments with which Captain Crompton had dealings. The speakers were representative of all grades and all spoke in appreciatory terms of their relationship with Capt. Crompton. The accompanying photo is the best that could be obtained of a memorable gathering.

EASTERN CENTRE.

A four-valve wireless set has just been installed at the Chelmsford Hospital by voluntary effort on the part of the Chelmsford Post Office engineering and general staffs, who, with the hearty co-operation of the Postmaster (Mr. W. Hawkins) and others, collected the necessary money. Other assistance was willingly rendered.

The scheme was brought into being by Mr. O. D. Robinson, the senior engineering inspector of the Chelmsford area Post Office engineers. Mr. Hawkins acted as treasurer, and postmen in particular did splendid service in collecting. The construction of the set was done by Mr. L. G. Hazell, of the Marconi Co., while the installation work was carried out by the Post Office engineering staff. About a mile of lead and copper wire was used. All this work was voluntary, and occupied 560 hours of the workers' spare time. There are 59 head-phones at present in use, but the installation consists of 90 points all over the institution—so that 90 phones could be used. A 40ft. mast was presented by Messrs. Brown & Son.

The opening ceremony took place on the 13th October, Major N. A. C. de H. Tufnell, D.L., J.P. (chairman of the Hospital Committee), presiding, supported by the Mayor (who handed over the set to the Hospital), Mr. W. Hawkins, and Mr. H. S. Tuke (hon. treasurer).

SOUTH MIDLAND CENTRE.

It was known that there was an encouraging increase of interest in the work of the Institution in this centre and the record attendance of 72 at the opening meeting of the 1925-26 session confirmed the optimism of the Local Officers. At this first meeting, held on the 28th October, the Chairman had the pleasure of welcoming 25 new members who had been enrolled since the end of the preceding session. The Chairman made the formal presentation to Mr. F. J. Gibbs of the certificate granted by the Council of the Institution to record his securing the first place in the 1924 Essay Competition for Workmen. In congratulating Mr. Gibbs, the Chairman re-

ferred to the record of the South Midland District staff in the first two competitions and expressed the hope that the enviable positions obtained by the men in the District would be repeated during the current year. The cheque also awarded by the Council had been posted to Mr. Gibbs in the spring.

Mr. F. J. Gibbs then read a paper entitled, "Telephone Repeaters in practice," which was based on his essay for which the certificate presented earlier in the meeting and the cheque had been given.

Mr. Gibbs at the outset was bold enough to prophesy the imminence of the day when the last trunk pole line was uprooted and the thermionic valves glowed triumphantly in circuits hidden from the eye of the æsthetic wayfarer.

The developments which led to the introduction of repeater stations were described, the desiderata affecting the choice of site and design of the stations explained and the saving in the cost of external conductors quoted.

The apparatus used in a repeated circuit from the point of emergence from the duct was detailed and the importance of the special precautions in the station necessary to secure efficiency stressed.

The paths of the currents in a 2-wire, 2-valve, 1 stage repeated circuit were traced and some details of apparatus testing given. Interesting notes were read about the system adopted for the production of power at stations where energy from an electricity supply undertaking is not available and the capacity of the secondary cell installations was mentioned.

The closing sentences of Mr. Gibbs' paper pictured a halcyon day when the occasions of trunk calls made by subscribers normally of irascible temperament would, under the sweetening influence of the repeaters, be three minutes' oases of amiability in lifetimes' deserts of acerbity.

Encouraging tributes of appreciation of Mr. Gibbs' first paper were made by Mr. J. S. Brown, Capt. Horton, Messrs. Gravill and Traviss, and replies were given to the questions asked by these members.

The Chairman added his mead of praise and expressed the hope that further papers would be read by Mr. Gibbs in future sessions. The audience enthusiastically endorsed these sentiments.

At the second meeting of the session, which took place on the 25th November, the announcement of the gift by Major Comport to the S. Mid. Centre Library of a book, "Building Specifications in Detail," by F. W. Macey, was received with applause.

Mr. J. S. Brown delivered a lecture entitled, "Portsmouth and its Satellite Exchanges."

He described the unique situation, on an island, of the centre

of the system, gave some details of the history of the Portsmouth Automatic Exchange, which was opened in 1916, and of the Ex. N.T. and Ex-Corporation Exchanges it superseded, and passed on to a description of the present system at the centre exchange.

The lecturer explained the uses of repeaters and selector repeaters in automatic exchanges and continued by giving details of the equipment at Hayling Island—one of the satellite exchanges—and the method of passing various classes of calls by and to subscribers in that town.

After stating that the Cosham Satellite Exchange will be almost identical with that at Hayling Island, a description of the apparatus at Gosport was given.

The passing of nine classes of calls within the boundaries of the constellation was described with the aid of a series of conventional diagrams. These helpful drawings were remarkably clear although every detail not absolutely essential to the exposition had been eliminated.

The Chairman opened the discussion by thanking Mr. Brown for the great trouble he was taking during the last session in which he would be on the active list of the Department, Mr. Halton followed with congratulations and a string of questions, Mr. Atkins pleaded for a paper on the *principles* of automatic working and Mr. Lockwood asked about the results of a fault in the submarine cables. Mr. Robb concluded the discussion by a tribute to Mr. Brown and his staff for the splendid work done in the substitution of automatic working at Portsmouth for the obsolete systems inherited from the late N.T. Co., and the Corporation.

The Chairman closed the meeting by stating, amidst applause, that the audience had shown by demonstration of their interest that a vote of thanks to Mr. Brown would be superfluous.

Capt. H. Hill, of the Engineer-in-Chief's Office, was the lecturer on the 9th December, his subject being "The Engineering Aspect of Telephone Exchange Accommodation." The first part of the lecture was concerned with principles and procedure and consideration was given in the latter section to standards.

The question of the period for which the site for a proposed Exchange would suffice was first dealt with and the preparation of the schedule of accommodation and the "area of search" maps explained. Capt. Hill gave some details of the considerations which affected the decision when alternative sites were available.

At the consultation stage, between the Engineer-in-Chief and the Architect, only main issues are considered, leaving details to be settled by the Engineer-in-Chief and Superintending Engineer at the plan stage, after which the final sketch plans and heating plans are prepared.

Accommodation details relating to certain fittings were outlined and a description of small standard buildings given.

In part II. leading-in schemes appropriate to Exchanges of different capacities and housed in various types of buildings were discussed and data about the strength, area and surfaces of floors were quoted. The importance of dust exclusion and the resulting ventilation problems was stressed and the heating system favoured described.

The 23 slides passed through the lantern aided the audience in appreciating the points of the discourse.

Opening the discussion, Major Comport thanked the lecturer and heartily supported the policy of holding conferences to settle differences of opinion. Mr. Atkins asked two or three questions and pointed out the urgency of accommodation cases. Mr. Lewis stated that Contractors do not always measure from the inside of the brickwork, Mr. Traviss enquired about a portable battery hut and the Chairman emphasized the importance of distinctive nomenclature.

Capt. Hill replied to the questions and the Chairman's expression of thanks was endorsed with applause.

A.W.L.

NORTH WALES CENTRE.

The first meeting of the present Session was held on the 6th October, 1925, when Mr. R. P. Collins read a paper on "The Development of the Baudot System."

He explained the principles of the system, dealt with the methods of drive and correction—mechanical and electrical—and described the various types of apparatus used. Forty slides were utilised for the purposes of illustration, in addition to the items of apparatus brought for inspection.

Mr. Collins expressed the view that type printing telegraph will in the near future replace Morse circuits—except perhaps the Wheatstone for news distribution, race meetings and special events—and that for this class of work the Baudot may be less suitable because less portable, and because of the longer time required to instal it.

He also referred to the efforts which have been made in America to increase the amount of traffic carried on a single line by the application of wired wireless, a system of connecting a number of Baudot circuits to one line, giving each a different wave length, and providing the necessary filter and receiving apparatus.

At the second meeting on the 3rd of November, Mr. J. H. Whitehead dealt with the question of the Department's costing system and its relation to the distribution of staff under the title of

"Staff proposals based on Unit Maintenance Cost Statistics." The subject was approached by an analysis of the Sectional U.M.C. and plant statistics, which indicated that there were apparently adequate reasons for costs in any Section being regarded as peculiar to that Section and not claimable by other Sections.

It was intimated that the average rates may not be applicable in the case of a single Lineman's load, and that it was now the practice to consider the plant and staff in each Inspector's area as a unit; also that the allowance of full average rates in every instance would probably result in the average rates being increased.

The U.M.C. was not an index of the quality of maintenance, that consideration was met by the Faults Records, etc. The U.M.C. showed what was involved in doing whatever was necessary. Where a steady figure was obtained over separate periods of six months the figure should be recognised and accepted.

From a comparison of Expenditure for 1922-3 and 1924-5 it was shown that the total manhours on certain sub-divisions had appreciably increased even if it were thought that the number of staff authorised had not increased. An explanation of this may be that less internal construction work is being done by the maintenance staff than heretofore.

The results of errors due to units as stated in the Returns differing from those in existence were pointed out. It was also emphasised that the important requirement was to obtain credit for all units claimable, and to ensure this there should be no delay in the closing of Works Orders, etc.

Birmingham was the venue of the third meeting held on the 3rd of December, 1925, when by the courtesy of the Stores Department a room at the Fordrough Lane Depot was used and an inspection of the Factory made. Captain N. F. Cave-Browne-Cave, B.Sc., M.I.E.E., who was to deliver the lecture had also arranged that members should see the Engineering Testing Branch.

Mr. T. Plummer, M.I.E.E., Chairman of the Centre, presided, and Captain Cave read a paper on "The work of the P.O. Engineering Testing Branch at Birmingham."

The lecturer introduced his subject by giving particulars of the branches of the Stores Department and the Engineering Department located at Birmingham, their functions, and the work done.

Some interesting comparisons of the staff and grades employed in these branches were given, together with the yearly value of the stores handled.

It was explained that the Engineer-in-Chief decides the specification and drawing for stores, approves the pattern and the sample

with tender, and the general technical principles to be followed in seeking supplies. The Testing Branch carries out the specified tests, approves all such stores before they go to stock, and attempts to arbitrate impartially in any disputes on technical matters between buyer and seller. The Controller of the Stores Department arranges contracts, controls supplies, carries out visual examinations of deliveries, repairs vast quantities of stores, maintains depot stocks, and distributes supplies.

Under the heading of Testing Branch Organisation, reference was made to the functions of the Test Section of the Engineer-in-Chief's Office and the Studd Street Testing Branch. Test report routine, factory test reports, examinations at contractors' works, re-issues examinations, patterns and gauges, volume of rejections, and the accounting arrangements were also outlined.

Finally, the Testing Branch equipment was described with details of the most important tests.

Advantage was taken of the occasion to present a certificate to Mr. S. H. Johnson, who was successful last Session in gaining one of the prizes in the essay competition for workmen arranged by the Intitution.

A.J.W.D.

BOOK REVIEWS.

"Electrical Engineering." By L. A. Hazeltine, M.E. (New York; The Macmillan Co). Pp. 623; 364 figures. Price 30s.

In this work the author has attempted to present in a single volume the essential elements of electrical science and its application to electrical engineering. To attain such a result without superficiality, a concise treatment has been necessary so that the book is less suited for self-study than as a college text book where it will be supplemented by the elaborations of a teacher. On the other hand, by very reason of this conciseness, the volume is admirably suited as a book of reference for the electrical engineer.

The first chapter is devoted to the basic ideas of physics which underlie the electrical branches. The author favours the conception of energy as a fundamental dimension (in common with length and time) and mass as a derivative of these quantities, in preference to the conception of mass as a fundamental dimension and energy a derivative. Modern ideas are thus introduced at a very early stage.

The next three chapters deal with the fundamental branches of electrical physics—electrical conduction, electrostatics and electromagnetism. The earlier method of basing electrical theory on the hypothetical distributions and reactions of point charges and point magnetic poles has been abandoned, the author following the

methods employed by Steinmetz and others whereby the basic experimental facts are first of all described and these facts then expressed in concise laws which are applied to specific cases.

In Chapters V. and VI. alternating and transient currents and electrical waves are introduced by the employment of complex quantities and vectors.

The succeeding chapter is devoted to conduction in gases and electrolytes. In this chapter various types of rectifiers are described, and the employment of thermionic valves for this purpose and as oscillators is briefly outlined.

Chapters VIII. and IX. deal with electrical measuring instruments and electrical measurements respectively, while the five succeeding chapters are devoted to heavy electrical engineering under the heading of Direct Current Machines, Synchronous Machines, Induction Machines, Transformers and Transmission and Distribution.

A short final chapter of 42 pages outlines the principles of electrical communication. This section of electrical engineering has been summarized rather than described. The telegraph practice referred to is, of course, American.

As the author is so well known as an authority on Radio Telegraphy (his name will be familiar to many readers as the inventor of the Neutrodyne circuit) it is surprising and disappointing to discover that only seven pages have been allocated to Radio Communication. It is a matter for regret that the author has found so little to say on this branch of electrical engineering, which has undergone such rapid development both in research and construction during the last few years.

There are other omissions in the volume as, for example, the subjects of A.C. Commutator Motors, Switchgear and Control Gear. The latter subjects are particularly important and no work on electrical engineering can be considered complete without some reference to them. It is generally more important for an electrical engineer to be able to design a switchboard than to be able to design a machine, as in the one case he has to specify the particular design in full detail while in the other he usually accepts a standard design of the manufacturer. The engineering student (judging from many text books on electrical engineering) appears to be expected to arrive at his knowledge of this intricate and complicated subject by some process of intuition. The present work appears to be free from errors and the author is to be congratulated on the excellent way in which the subject matter is presented. The book is clearly printed and the diagrams are well reproduced, while a comprehensive index is provided.

One of the most satisfactory features of the book for teaching purposes is the inclusion in the text of a large number of numerical

examples, many of which are fully worked out, while in the case of the remainder the answers are given.

The method of treatment conforms throughout with modern practice and the book will constitute a useful work of reference to the teacher, student and engineer.

A. J. GILL.

The first three volumes of Messrs. Ernest Benn's "Electrical Engineers' Data Books" are published. This ambitious undertaking has been planned by Mr. E. B. Wedmore, known throughout the Electrical industry as the Director of the British Electrical and Allied Trades Research Association, and a start has been made with three volumes dealing respectively with "Lighting, Traction and Power Distribution," "Manufacture, Design and Laboratory Work," and "Radio Engineering."

The Radio Engineering volume is being published by Messrs. Ernest Benn in conjunction with the Radio Press, Limited.

The object of the series, as seen by Mr. Wedmore, is to fill the gap between the scientist or research worker and the practical engineer for whom the different volumes are primarily intended. The expert work of compilation has occupied more than eighteen months, and every effort has been made to ensure that each volume is absolutely up-to-date.

A special feature is the cheapness of the series, the volumes being published at the uniform price of 15/- each.

"Nogle Statistiske Meddelelser vedrorende Telefonselskaber i Danmark." Statistics of Danish Telephone Companies: 1924-1925.

The report is published by a Government Committee which supervises the concessions to private telephone companies.

During 1924 the telephone receipts, excluding Government telephones in Sonderjylland, amounted to approximately £1,900,000. £670,000 was used in new construction. The capital value of telephone plant and property, allowing for no depreciation, is 197 million kronor. There are 1,700 exchanges, of which 106 are in towns. Mileage of single wire is 1,100,000 km: number of poles, 800,000 (approx. 25 kronor = £1 in 1924).

Some comparative figures of the three largest Companies are as follows:—

	Copenhagen Telephone Company.	*Jydsk Telephone Company.*	*Fyns Communal Telephone Company.*
Population of district	1,324,800	1,362,400	339,400
Subscribers	134,900	78,520	21,460
Town exchanges	41	37	13
Country ,, ...	311	1,139	85
New subscribers: 1924	10,773	5,469	1,790
Ceased subscribers	3,682	2,518	328
Dividend on shares	8%	8%	—
,, ,, loans	5.2%	7.6%	5%

Calls: total: millions	264	110	34.4
,, per sub. local	1,840	1,068	1,251
,, ,, ,, trunk	171	362	408
Staff: Administrative	601	225	55
Operators	2,490	1,925	334
Linemen, etc.	1,024	390	177
Costs: (£1 = 20 to 25 kronor).	Kronor *per sub.*		
Income	195	169	159
Expenses: Wages, salaries ...	70	68	56
Maintenance ...	20	26	37
Depreciation ...	30	29	25
Miscellaneous ...	31	27	33
Total	151	150	151
Average rental: per sub. ...	135	105	133
Income from calls, per sub. ...	26	58	18
Other receipts, per sub.	34	6	8
		Kronor.	
Income per call	0.10	0.12	0.10
Oper. cost per call	0.023	0.037	0.029
Mtce. per km. aerial wire ...	9.07	5.74	3.33
,, ,, undergd. wire ...	0.48	0.33	0.34

Yearly Rentals, etc.	*Kronor.*
Copenhagen: to main Exchange: installation Fee	300
,, to other Exchange in country: installation fee	200
,, 2 party line: anywhere: installation fee	160
To main Exchange: including 8,000 calls	380
,, ,, ,, ,, 5,500 ,, ...	290
To local ,, ,, 1,200 ,, ...	146
,, ,, ,, 2 party line 2,000 ,, ...	126
In the country: Exchange over 100 subs.	90
,, ,, ,, ,, under 100 ,, ...	85
Fees for 3 minutes' conversation:	
From Copenhagen to surrounding zones	0.20
To Copenhagen from ,, ,, ...	0.12
Inside a country zone	0.06
Between zones 1 and 2	0.30
,, ,, 1 and 3, or 2 and 3	0.40

THE SCIENCE LIBRARY.

Science Museum, South Kensington, London, S.W.7.

The Science Library is the National Reference Library especially devoted to Pure and Applied Science, and forms part of the Science Museum. The Library is open free to the Public, practically without restriction, daily from 10 a.m. to 6 p.m., or until 8 p.m. on Thursdays and Saturdays. Admission is by ticket, to be obtained by application addressed to "The Director, The Science Museum, South Kensington, S.W.7." A single admission may be granted by the Librarian. The Library contains a very large collection of works on Science, both English and foreign, from the earliest times, including an exceptionally fine set of Periodical Literature, such as the Transactions of Societies, and the Bulletins, Monographs, Reports and other publications of Government Departments, Experiment Stations, Observatories, Research Laboratories, Universities and Scientific Institutions of

all kinds, as well as independent Journals. The total number of volumes, bound or for binding, in the Library is 158,000; the number of current Periodicals, 75 per cent. of which are presented, is over 4,700.

The new books received are exhibited for inspection on counters in the Reading-Room for about six months. Similarly, the current parts of some of the more important Periodicals are shown in 500 pigeon-holes along the East side of the Reading-Room. The Author and Subject Catalogues are on cards: the latter, classified minutely on the Decimal System, together with the published bibliographies, provides an Index to the resources of the Library. Special efforts are being made to gather together as complete as possible a collection of the Scientific Literature of the World, so as to make the Library a Central Institution for study and research available to any *bona fide* student.

"Photo-Electricity." By Prof. H. Stanley Allen, M.A., D.Sc., F.Inst.P., F.R.S.E. Published by Longmans, Green & C., 1925. 18*s*. net.

This book is one of a series, entitled "Monographs on Physics," edited by Sir J. J. Thomson and Dr. Frank Horton. The first edition was issued in 1913 and the present volume is a second edition. The aim of the author has been to give a connected view of the subject of the liberation of electrons by ordinary and ultra-violet light, showing how the experimental facts have led up to, and may be expressed in terms of, modern theories of radiation and matter. The introductory chapter gives an outline of the whole subject and is followed by sixteen chapters dealing with photo-electric phenomena, their measurement and practical applications.

The book is well printed and suitably illustrated and a useful bibliography of scientific papers relating to photo-electricity, published in the years 1913-1924, has been incorporated.

A.B.M.

The following prints, published by the International Advisory Committee for Long Distance Telephonic Communications, are on sale at the Offices of the General Secretary to the Committee, 22, Avenue de Messine, Paris, 8C:—

(1) *Report of the work done by the Preliminary Technical Committee for Long Distance Telephony in Europe. (March,* 1923).

Pamphlet in 8 Vo. of 50 pages, 2 illustrations. Price 5 frs. (Add 20% for postage).

This pamphlet contains the exact text of the various proposals made by the Preliminary Technical Committee and also the minutes of the plenary sittings.

(2) *Report of the work done by the first plenary sitting of the International Advisory Committee for Long Distance Telephonic Communications. (Paris 28th April—3rd May,* 1924).

Pamphlet in 8 Vo. of 68 pages. Price 5 frs. (Add 20% for postage).

The International Advisory Committee for Long Distance Telephonic Communications composed by the official representatives of the Telephone Administrations of Germany, Austria, Belgium, Denmark, Spain, Finland, Great Britain, Hungary, Italy, Lettland, Luxemburg, Norway, Holland, Poland, Serbia Croatia and Slavia, Sweden, Switzerland, Czecho-Slavia, France, after considering as the basis for discussion the proposals made by the Preliminary Technical Committee has arranged effectively the organisation of the International Telephony in Europe by adopting unanimously the recommendations contained in this pamphlet.

(3) *Report of the work done by the second plenary meeting of the International Advisory Committee for Long Distance Telephone Communications. (Paris, 22nd—29th June,* 1925).

Pamphlet in 8 Vo. of 200 pages under print.

Standard specifications for the supply of international cables and their accessories are appended to the proposals relating to the specification for cables, instruments and methods of measurements for maintaining the international circuits.

The disposition relating to the measures required for the protection of the telephonic lines against interference by power systems at high current or potential, have been set out after a discussion between the official delegates of the Telephones Administrations of Europe, the official delegates of the International Union of Railway lines, and the official delegates of the International Conference for the great systems of electric power at high tension.

These documents are of the utmost importance to those interested in the modern technique of telephonic communications.

(4) *Nomenclature of the International Telephonic Circuits existing in Europe on the 1st January,* 1925.

Pamphlet in 8 Vo. of 80 pages, of which 73 pages are tables. Price 12 frs. (Add 20% for postage).

(5) *Statistics of the International European Telephonic Traffic.* (1924-1925).

Pamphlet in 8 Vo. of 44 pages, of which 19 pages are tables. Price 7 frs. (Add 20% for postage).

The data contained therein has been assembled by the various Telephone Administrations during the second half of the year 1924 and the first half of the year 1925.

(6) *Schematic map of the International Telephonic Cables in Europe.*

The map to scale 4,000,000°, in two colours on strong paper, is sold for 10 frs. (Add 20% for postage).

It shows the approximate route for all the existing or proposed telephone cables, the number of pair/conductors and spacing of the various telephone repeater stations.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to.	Date.
Aitken, R.	Asst. Staff Engineer, E.-in-C. Office.	Superintending Engr., Scot. West District.	1-12-25
Comport, Major G. H., M.C.	Asst. Suptg. Engr., S. Mid. District.	Asst. Superintending Engineer, In charge of Ireland N. District.	To be fixed later.
Kitchen, H.	Executive Engineer, N. District.	Asst. Staff Engineer, E.-in-C. Office.	1-12-25
Richardson, J. ...	Executive Engineer, Scot. W. District.	Asst. Superintending Engineer, S. East District.	1-11-25
Mercer, C. J.	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer, E.-in-C. Office.	22-10-25
Hines, Capt. J. G. ...	Executive Engineer, London District.	Asst. Superintending Engineer, London District.	24-10-25
Anson, B. O.	Executive Engineer, E.-in-C. Office.	Asst. Staff Engineer, E.-in-C. Office.	23-10-25
Roach, C. G.	Executive Engineer, S. West District.	Asst. Superintending Engineer, S. Mid. District.	To be fixed later.
Bellwood, G. F. ...	Assistant Engineer, N. District.	Executive Engineer, N. District.	1-12-25
Leigh, C.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	13-11-25
Turner, J. W. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	27-10-25
Johnson, A. S. A. ...	Assistant Engineer, E.-in-C. Office.	Executive Engineer, E.-in-C. Office.	10-11-25
Faulkner, H.	Assistant Engineer, E.-in-C. Office.	Executive Engineer, In charge Rugby Wireless Station.	7-11-25
Mathew, K. R. ...	Skilled Workman, Class I.	Inspector, Scot. East. District.	5-1-25
Lambert, J. G. ...	,,	,,	5-1-25
Reid, W. A.	,,	,,	4-4-25
Middlemiss, W. A. ...	,,	,,	5-1-25
Douglas, J. H. ...	,,	,,	5-1-25
Robertson, J.	,,	,,	27-4-25
Abbotts, G. E. ...	S.C. & T.	Repeater Officer, Cl. II., Eastern Dist.	10-6-25
Stone, T. H.	Skilled Workman, Class I.	Inspector, London District.	10-5-25
Griffiths, C. E. ...	,,	,,	26-7-25
Boys, W. E.	,,	,,	9-9-25
Pullan, J. G. W. ...	,,	Inspector, Testing Branch.	22-6-25
Repton, G.	,,	Inspector, N. East District.	17-6-25
Akester, G. B. ...	,,	,,	3-6-25
Terry, H. E.	,,	,,	10-9-25
Harper, J. P.	,,	,,	4-10-25
Lally, J.	,,	,,	4-8-25
Garrard, A. W. O. ...	,,	Inspector, N. Mid. District.	13-10-25
Strong, H. A.	,,	,,	7-5-25
Hemington, H. ...	,,	,,	22-7-25
Brown, A. H.	,,	,,	17-5-25
Taylor, C. H.	,,	Inspector, S. Mid. District.	23-2-25
Green, F. R.	,,	,,	5-1-25

STAFF CHANGES.

APPOINTMENTS.

Name.	Grade.	Appointed.	Date.
Somerville, H. B. ...	Probationary Assistant Engineer. E.-in-C. Office.	Assistant Engineer, E.-in-C. Office.	1-11-25
Jolley, E. H.	,,	,,	,,
Pidgeon, J. E. ...	,,	,,	,,
Taylor, T. A.	,,	,,	,,
Jackson, J. M. ...	,,	,,	,,
Williams, L. E. ...	,,	,,	,,
Wallcroft, F. E. ...	,,	,,	,,
Farnes, G. H.	,,	,,	,,
Hines, R. J.	,,	,,	,,
Dixon, E. J. C. ...	,,	,,	,,
Gray, W. D.	,,	,,	,,
Gray, G.	Chief Inspector, N. Wales District.	Assistant Engineer, Egyptian Government (Seconded).	5-11-25
Jarvis, J, W.	Inspector, Scot. East. District.	Egyptian Tele. Department.	13-11-25
Cross, W. H.	Probationary Inspector.	South Lancs.	7-6-25
Balcombe, F. G. ...	,,		7-6-25
Britton, G. A. C. R....	,,	Testing Branch.	8-6-25
Gilby, F. W.	,,	,,	8-6-25
Helman, S. L.... ...	,,	,,	14-6-25
Summers, F.	,,	,,	23-6-25
Hawkins, N. A. ...	,,	,,	29-6-25
Sanders, A. E. ...	,,	,,	30-6-25
Anderson, E. W. ...	,,	,,	1-7-25
Couch, P. R.	,,	,,	21-7-25
Robinson, A. K. ...	,,	,,	15-9-25

TRANSFERS.

Name	Grade.	Transferred. From	Transferred. To	Date.
Smart, E. V. ...	Exec. Engineer.	E.-in-C. Office.	London Dist.	13-11-25
Horn, C. O. ...	Asst. Engineer	E.-in-C. Office.	Rugby Wireless Station.	7-11-25
Davies, T. A. ...	Pro. Asst. Engr.	Testing Branch.	E.-in-C. Office.	
Bewick, W. ...	,,	,,	,,	1-9-25
Barker, P. L. ...	,,	,,	,,	
Towers, R. ...	Chief Inspector.	E.-in-C. Office.	Grimsby-Skegness Wireless Station.	4-10-25
Roberts, F. R. ...	Second Officer.	H.M.T.S. "Alert."	H.M.T.S. "Monarch."	1-11-25
Dunk, W. G. ...	Inspector.	Testing Branch.	E.-in-C. Office.	21-6-25
Sturgess, H. E. ...	,,	E.-in-C. Office.	Rugby Wireless Station.	31-9-25

RETIREMENTS.

Name	Grade.	District.	Date.
Crompton, Capt. C. O.B.E.	Superintending Engineer.	Scotland West.	30-11-25
Evans, Lt.-Col. Wm.. O.B.E., M.C. ..	Asst. Superintending Engineer.	N. Ireland.	9-11-25
Callender, R. W. ...	Executive Engineer.	London.	31-12-25
W. G. Webb	Inspector.	,,	13-8-25
J. H. Walker	,,	,,	16-11-25
F. Limb	,,	E.-in-C. Office.	28-11-25

STAFF CHANGES.

DEATHS.

Name.	Grade.	District.	Date.
A. A. Kent	Inspector,	S. Mid. District.	7-8-25

CLERICAL ESTABLISHMENT.

PROMOTION.

Name.	Grade.	Promoted to	Date.
Barrett, C. H. ...	Clerical Officer, E.-in-C. Office.	Executive Officer, E.-in-C. Office.	28-10-25
Elsworth, C.	Clerical Officer, S.E. District.	Higher Clerical Officer, S. Lancs. District.	1-10-25
Norman, R. D. S. ...	Clerical Officer, N. District.	Higher Clerical Officer, N. District.	1-10-25
Hansford, W.	Clerical Officer, S. Wales District.	Higher Clerical Officer, N. Wales District.	20-9-25

APPOINTMENTS AS CLERICAL OFFICER.

Name.	District.	Date.
Stepney, H.	S. Lancs.	23-8-25
Roper, T. W.	S. East.	23-8-25
Hill, T. J.	S. West.	23-8-25
Martin, E.	London.	6-9-25
Nash, J. A.	E.-in-C. Office.	17-9-25
Fyfe, A. Y.	N.	20-9-25
Fear, G. H. L.	N. West.	11-10-25
Gray, M.	London.	25-10-25
Laird, W. W.	do.	1-11-25
Mickleburgh, G. B. ...	E.	8-11-25

TRANSFERS.

Name.	Rank.	Transferred. From.	Transferred. To.	Date.
Warren, P. J. ...	Clerical Officer.	Land Regy. N. Ireland.	S. Lancs. Dist.	1-9-25
Hughes, P. ...	,,	Stores Dept.	S.W. Dist.	20-9-25
Postlethwaite, R. R.	,,	N.W. Dist.	S.E. Dist.	111-10-25
Thorpe, F. E. ...	,,	A.G.D.	Ireland, N. Dist.	18-10-25
Moses, H. W. ...	,,	S. Lancs. Dist.	N. Dist.	1-11-25
Thorne, C. ...	,,	E. Dist.	Sec.'s Office.	8-11-25
Durham, E. C. ...	,,	Secy.'s Regy.	L'd'n Eng. Dist.	8-11-25
Spink, S. T. ...	,,	S.M. Dist.	S. East. Dist.	15-11-25
Martin, E. ...	,,	L'd'n Eng. Dist.	Scot. E. Dist.	15-11-25
Whelton, M. ...	,,	London Eng. Dist.	London Postal Service.	15-11-25
Other Changes.				
Kennedy, W. E. H.	Exec. Officer.	E.-in-C. Office.	Appointed Asst. Inspector Min. of Health.	28-9-25
McCandless, L. I.	Clerical Officer.	Ireland, N.	,,	5-10-25
McGann, R. H. ...	,,	N. Dist.	Appointed Asst. Supt of Traffic.	18-10-25
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R. V. HANSFORD,
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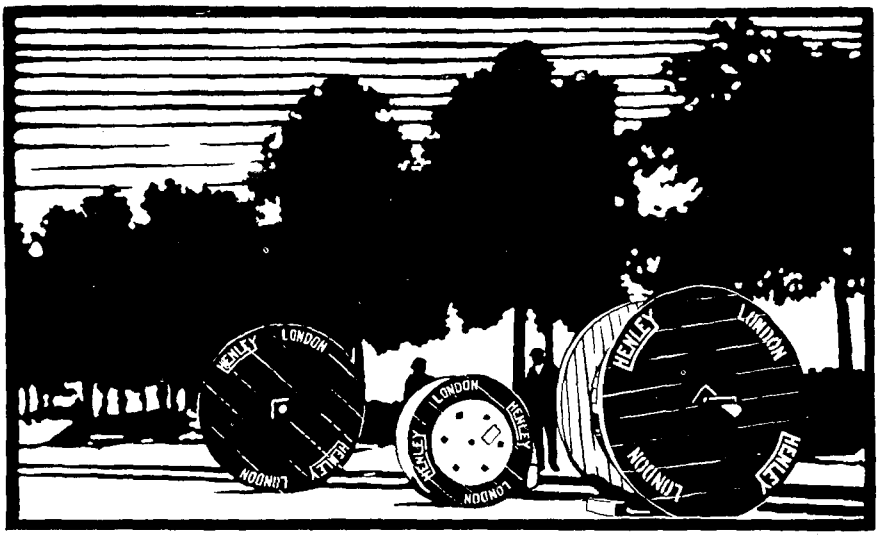

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Errors in Part 3, Vol. XVIII., October, 1925, issue.

We regret that a number of errors crept into our last issue. Readers interested will perhaps amend their copies as follows :—

Corrections to article on

"Junctions working between Automatic and Manual Exchanges."

Page 231 GB should read GG.

Fig. 13 Relays (from left to right) should be labelled C, D and S.

,, 14 Relays (from left to right) should be labelled S, H, CO and A.

Page 238 Sixth line from bottom—LA should read LB.

,, 239 Number and title of Fig. 17 should be placed under second diagram on page 240.

,, 240 Number and title of Fig. 19 should be placed under diagram on page 239.

,, 241 First diagram should be labelled Fig. 22—"Magneto and C.B.S. No. 1 Exs. Dial Key per Junction."

,, 241 Second diagram should be labelled Fig. 23—"C.B.S. No. 1 Exs. Outgoing; Loop or battery dialling or outgoing portion of bothway, battery dialling."

,, 242 First diagram should be labelled Fig. 20—"Non Mult. Magneto Exs., Outgoing loop or battery dialling or outgoing portion of bothway, battery dialling."

,, 242 Second diagram should be labelled Fig. 21—"Non Mult. Magneto Exs., outgoing portion of Bothway—Loop dialling."

,, 242-3 Delete references to C.B.S. No. 3 Exchanges.

,, 243 Fig. 25. Relay marked E should be D; Relay A should be L; Relay C should be CO.

,, 244 Fig. 26. Relay D should be S,
Top Jack and lamp should be No. 2.
Bottom ,, ,, ,, ,, ,, No. 1.

,, 245 Fig. 27. Relay C.L. should be F.
,, D.D. ,, ,, M.
,, D ,, ,, S.

,, 246 Fig. 29. Relay D ,, ,, S.
,, D.D. ,, ,, M.

,, 246 Last line, springs 11 and 9 should read 10 and 9.

,, ,, Third last line, comma after D.M.