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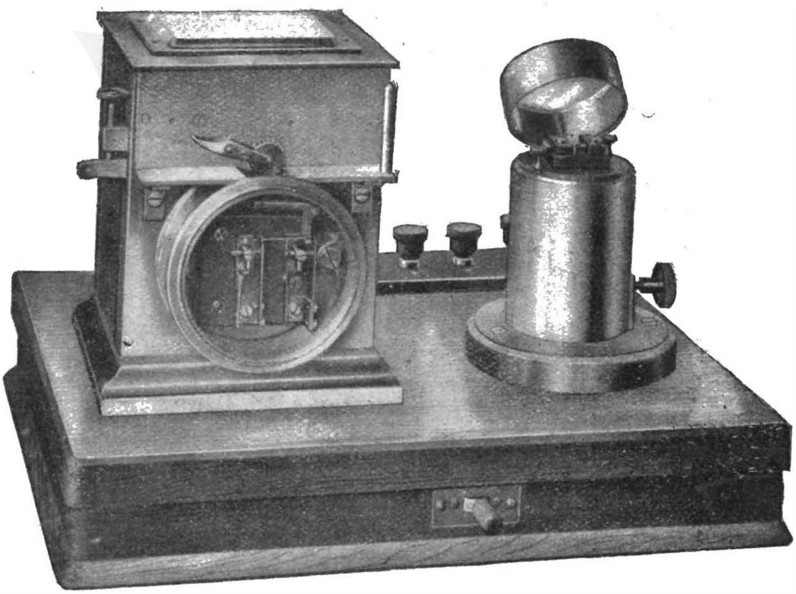

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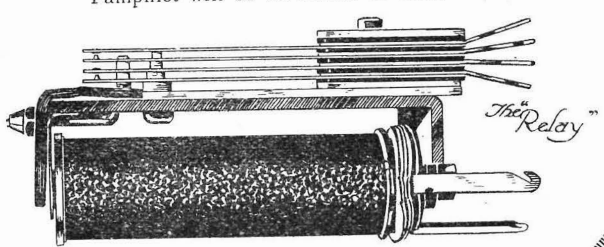

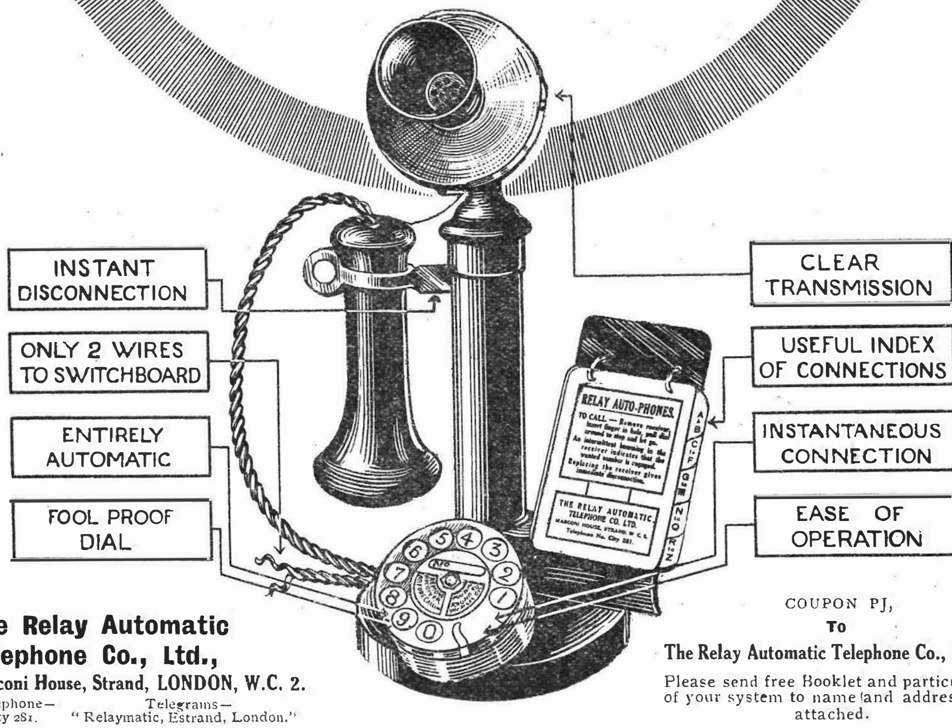

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SOME NOTES ON THE TELEPHONE SYSTEMS OF THE UNITED STATES OF AMERICA.

By W. Noble.

One of the most impressive sights I have ever seen is the view of New York from the sea on a clear morning such as that of October 27th last, when the representatives of the Engineering Department of the British Post Office arrived on their visit to study the telephone conditions of America. We had been led to think that the huge buildings of New York would be, by their very size, outside the appeal of architectural charm, but this did not prove to be the case; the skyline of that great city viewed under favourable conditions is so striking and so pleasing that one is not likely to forget it. Nevertheless, reflecting upon our visit after the lapse of four months, I am bound to say that the telephone system of America, a subject of quite a different order, is to the telephone engineer more impressive than the New York skyline. When one realises that the United States has over twelve million telephone stations—one telephone to every ten inhabitants—and if one recollects at the same time that the United Kingdom possesses fewer than one million telephone stations, an analogy between the development of architecture and of the telephone in America is not altogether fanciful.

Fig. 1 shows the telephone development of the United States compared with that of this country over a period of twenty-eight years, and lest it should be thought that the disparity is due to the great difference in population, Fig. 2 has been prepared to show the corresponding conditions in the two countries, considered in regard to the number of telephones per 1000 inhabitants.

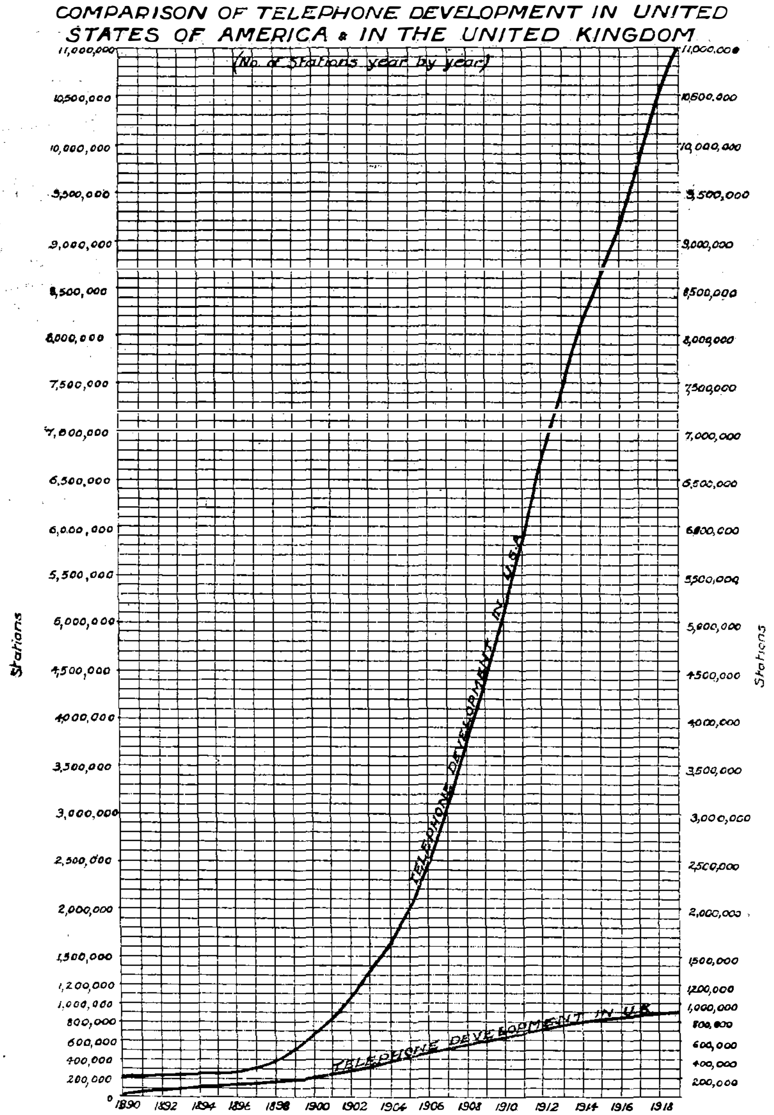


FIG. I.—TOTAL NO. OF STATIONS IN U.S.A., DECEMBER, 1918.

BELL OWNED	. . . .	7,201,757
INDEPENDENT: ON BELL TOLL SYSTEM	.	3,790,568
,, NOT ON ,, ,,	.	1,012,000
TOTAL	. . . .	12,004,325

Of course, owing to the war, this country has failed to realise a great deal of its natural development during the last five years.

This loss must be overtaken under conditions that will impose in the

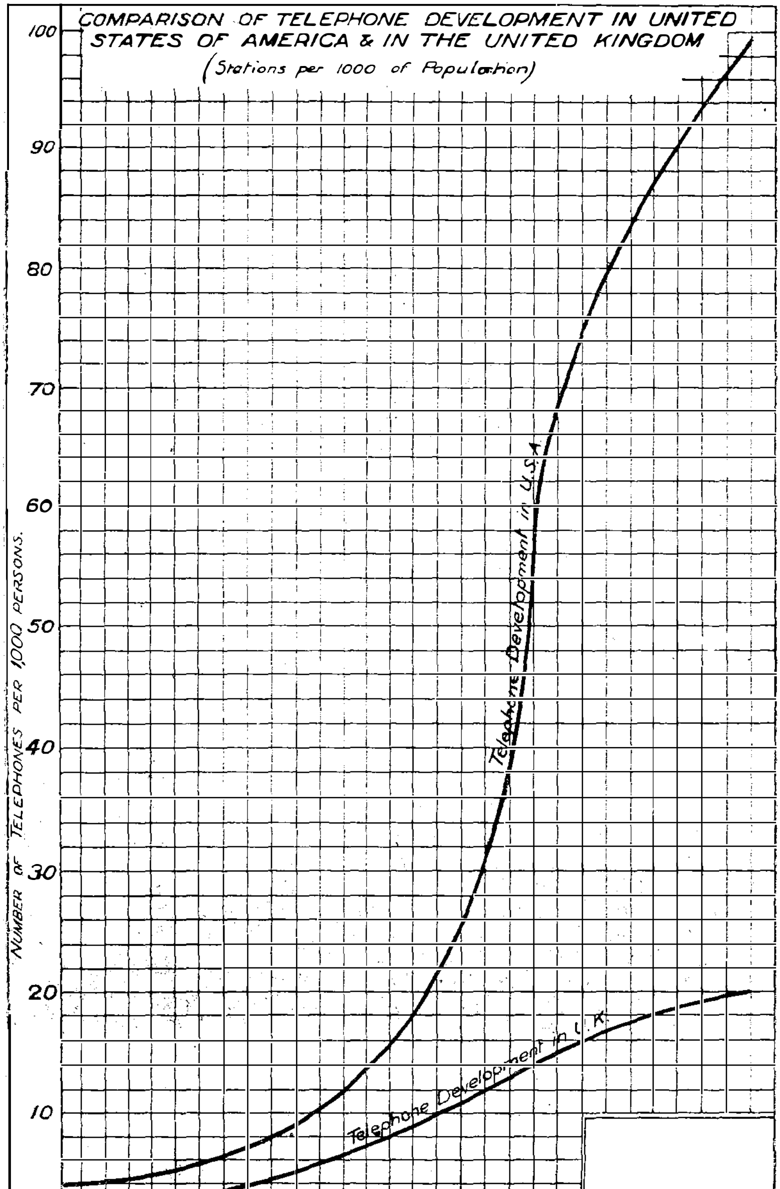


FIG. 2.—STATIONS PER 1000 OF POPULATION.

immediate future a great strain upon our telephone engineering resources. Our telephone development, as will be seen from Fig. 2, represents at the present time 20 telephones per 1000 of population. It is perhaps not too optimistic to say that, given ample plant, the telephone development during the next five years could reach 40 telephones per 1000 of population. The shape that would then be assumed by the lower curve of Fig. 2 can be mentally projected, and

FIG. 3.—WALKER-LISPENARD TELEPHONE BUILDING, NEW YORK.

it is clear at once that this would represent a period of supreme effort for the construction branches of the Engineering Department.

The main obstacle in the way of achieving such development is probably the competition for telephone materials that is arising on the continent of Europe, but in any case one cannot imagine that this country will be content to lag permanently so far behind America in the use of the telephone, and the development will, I venture to prophesy, be very great.

What such development would mean can readily be imagined if one considers London alone, and appreciates the fact that it would involve practically the duplication of the London telephone system within the short period of five years. The contemplation of the great network of conduits and cables, the telephone sites and buildings, the Exchange equipment, and the enormous increase of *personnel* that would be required should be sufficient to enable any telephone engineer to visualise what is involved, and after all that had been achieved we should have reached only 40 per cent. of the present

FIG. 4.—MAIN TELEPHONE BUILDING, KANSAS CITY.

American development. The question of buildings and sites alone opens up a great problem ; the way in which similar problems have been faced in the United States with the huge telephone development existing there is evident from Figs. 3 and 4. Fig. 3 is a 25-storey building known as the Walker-Lispenard Telephone Building in New York. Fig. 4 is the main telephone building of Kansas City. Conditions in America have reached the stage when it is considered that in large cities it will be necessary to connect 30,000 lines, and even in exceptional cases as many as 40,000 lines, to switching plant located in one exchange building.

We found in America evidence of extraordinary enthusiasm and zeal on the part of the engineering staff, and I am confident that this is not unconnected with the fact that the telephone companies are in normal times prosperous, profit-making concerns. Of course circumstances are now altering in this respect, and therefore general increases in tariff are necessary owing to the changing conditions of the country. The same is the case in Europe, and in this country it would be well to follow the American lead and fix tariffs on a commercial basis. The psychological effect on employees produced by the knowledge and pride that they are part of a successful commercial concern is of considerable value.

In New York we had the privilege of inspecting a novel semi-automatic tandem junction equipment that was nearing completion. There are important engineering advantages in tandem junction working, but the system has been objectionable in the past owing to the fact that manual tandem operating is relatively slow and inaccurate. The semi-automatic tandem junction scheme for New York has been designed to overcome these defects. The calls are received by order-wire at the tandem junction exchange in the ordinary way; the operator at the latter point sits at a position of the "desk" type, without multiple, and on receiving the call sets it up on a keyboard of the well-known semi-automatic type. This operation automatically finds an idle junction from the tandem operator to the distant "B" operator. The latter has her attention drawn to the call by the glowing of an assignment lamp associated with a cord on her position. She depresses an assignment key, and the number which has been set up by the tandem operator now appears on a "call indicator," which consists of a set of numbered lamp indicators. The "B" operator, seeing the number displayed on the call indicator, tests the wanted line in the multiple and makes the connection in the usual way. It will be seen that the call has but one oral transmission, namely, that from the "A" to the tandem operator; the remainder of the operation is visual and mechanical. It is anticipated that semi-mechanical tandem junction working will be very rapid and accurate, and it is important to note that the existence of an exchange of this type in a large city will at a future date materially facilitate the conversion of the city to automatic working.

In response to an invitation from the International Western Electric Company, a member of our party attended a demonstration of the trans-continental telephone service. The demonstration was very successful, and was accompanied by a motion picture film illustrating various stretches of the trans-continental line passing through typical American scenery. Interesting methods of telephone line construction were also pictured. Altogether about 100 guests listened to the conversation passing between New York and San

Francisco. The New York–San Francisco service involves the use of six repeaters, covers a distance of 3400 miles, and is undoubtedly a remarkable engineering achievement.

On another occasion we were afforded an opportunity to see a series of motion picture films designed by the Western Electric Company for educational and telephone propaganda purposes. One remarkable film illustrated the assembly of the numerous parts making up a subscriber's telephone. The picture opened with all the parts laid on a table, and the progress of the film illustrated the various parts moving towards a central point and becoming assembled in a perfectly natural order. Another film showed the complete process of manufacturing a multi-core telephone cable. Films of this kind are obviously of great utility in interesting the public and in educating apprentices and others in the construction of plant and apparatus.

We found evidence that telephony in America has advanced to a stage where in a large measure the replacement of the operator by the machine is about to take place. The difficulties of obtaining, training and keeping operators are now great, and consequently the quality of service is unstable. In a manual system, particularly in a big network, it should be noted that the opening of each new exchange unit entails the opening of "B" positions at many of the other exchanges of the area. With machines this traffic is more easily cared for. Additional junction circuits for each unit are of course necessary, and equipment to accommodate them has to be provided, but that equipment is more easily installed and cheaper than "B" positions, and the absence of *personnel* in connection with the opening of additional units renders the problem of the continuity of good service more simple. Further, it should be noted that the introduction of machine switching is influenced by the question of development. With a small development, traffic is likely to consist of relatively small volumes, and to be peaky—effects which reflect unfavourably upon the finances of the concern. The ratio of the day traffic to that of the busy hour in New York is 10, whereas in London it is 7. This means that a larger amount of plant would have to be provided in London than in New York for a given volume of daily traffic, and consequently the cost of providing automatic plant for London would be more expensive per unit volume of daily traffic than in New York. This discrepancy would probably be reduced with an increased development in London, particularly in "residence" telephones, but it is partly due to the existence of different time zones on the broad American continent.

We found the telephone repeater extensively developed in America, and the tendency is in the direction of placing all long-distance circuits in light gauge cables with repeater stations suitably located. In this country telephone cables have been widely developed in the past but have been of relatively high gauge, and, in general, placed underground. The Americans propose to use aërial cable on routes where the requirement for the next eight years is not expected to exceed two cables. Figs. 5 and 6 illustrate a typical repeater station and an aërial cable route respectively.

The method of constructing aërial cable routes is interesting. For heavy trunk cables poles are spaced 100 to 110 ft. apart on straight runs, with closer spacing on gradients, and are of sufficient

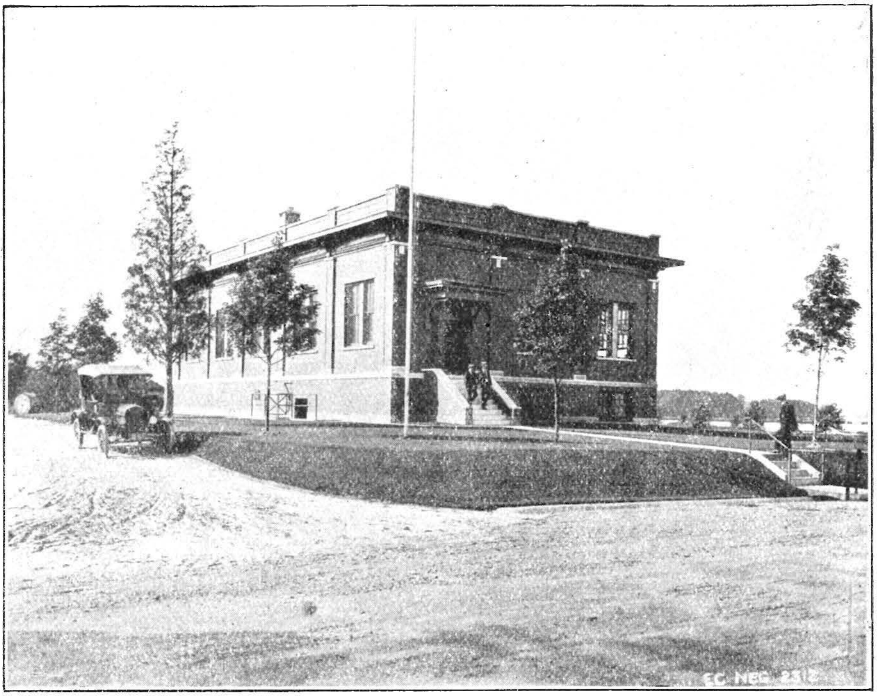


FIG. 5.—A TYPICAL REPEATER STATION.

height to give a clearance of 18 ft. above road level. The poles are well stayed. The suspension wire is high-tensile steel strand varying in size according to the weight of the cable. The suspension is drawn up to a strain which gives an initial sag, when the cable is placed, of about 14 in. at a temperature of 60° F. for a 200-pair, 20-lb. cable.

The strain on the suspension strand is determined by an oscillation test which is applied as follows: A span is selected where there is no joint in the suspension and a hand line is thrown over the centre of the span. The hand line is pumped up and down, and after it has been pulled clear the oscillations of the stranded wire are counted over a period of 15 seconds. The strain on the suspension is then adjusted until the correct frequency of oscillation, shown by tables provided for the purpose, is obtained. This method has been proved to give perfectly reliable results in practice and is now standardised.

Cables are slung from the suspension strand by steel cable rings, spaced 16 inches apart for heavy toll cables. These cable rings are

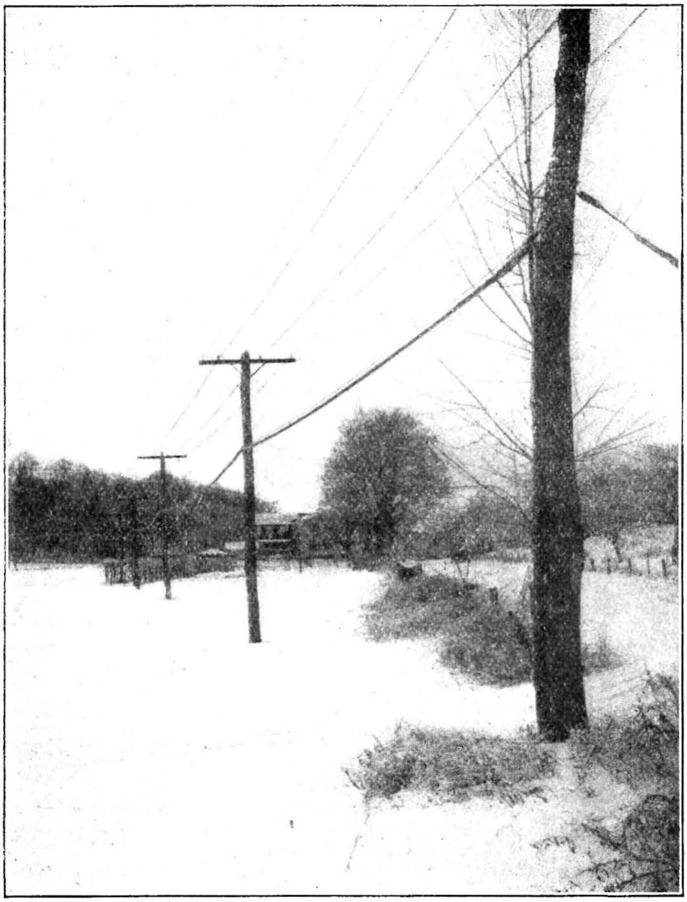


FIG. 6.—A TYPICAL AËRIAL CABLE ROUTE.

of round section steel and grip the suspension strand tightly. They are clamped in position after the strand has been finally strained up. Cable is drawn through the rings as through a continuous conduit. It is lubricated by being passed through a trough containing grease. When the cable is finally in position it is tied to the suspension strand by a marline splicing on each side of every pole. These splicings, which are spaced 10 in. from the pole, are made sufficiently tight to raise the cable slightly from the steel rings, the object being to prevent chafing of the cable sheath by the steel rings near the poles.

Forged steel plate clamps with lead bushings are provided in each span on grades of 10 per cent. or more; these clamps fasten the cable and its suspension rigidly together, and prevent creeping.

Aërial cables are jointed in the same manner as underground cables.

The experience with aërial toll cables has been such that the engineers of the American Telephone and Telegraph Company are satisfied that communication between such important centres as New York and Chicago will be as safe with an aërial as with an underground cable; conditions in the United States are such that the former can be kept well clear of danger from falling trees, and is more economical in annual charges and less subject to long interruptions than the latter. In this country there are smaller differences between the first costs of aërial and underground cable routes, and on maintenance charges the balance is heavily in favour of the underground system.

We found the long-distance telephone system of America very efficient. This is mainly due to the lavish provision of circuits. In consequence the Americans have much less delay in completing a long distance call than we have in this country, but it follows that they do not obtain so much paid time per circuit. The trunk charges are, however, higher than ours, and as practically every long distance circuit carries superposed private renter's telegraph circuits a considerable amount of revenue is derived from that source.

We were impressed by the extent to which motor vehicles are used in telephone construction and maintenance. Practically all stores are despatched by automobile, including the delivery of telephones to subscribers' offices prior to installation. Trunk maintenance centres and testing points are well equipped with automobiles, and immediately an advice of a fault is received a maintenance man is despatched by motor car. In many parts of America we found that the maintenance staff owned their own cars, the use of which, for official purposes, was paid for by the telephone company. Incidentally it may be mentioned that the development of the ownership and use of motor vehicles per head of population in America is even more strikingly ahead of the corresponding figures for Great Britain than in the case of telephones, and I would recommend this fact to the consideration of those who suppose that our backwardness in telephony is due to shortcomings on the part of the Government technical service.

Further, the home of every lineman maintaining a section of main route is connected by telephone, so that after hours he may be called out in case of emergency.

Another interesting feature of the long-distance system is the introduction of high-frequency transmission, which has been frequently mentioned in various technical papers during the past year.

The Annual Report of the American Telephone and Telegraph Company for 1918 made special mention of high-frequency telephone and telegraph multiplex systems as follows:

"Special mention should be made of the multiplex telephone and telegraph system. By our multiplex telephone system four telephone conversations over one pair of wires are simultaneously carried on in addition to the telephone conversation made possible by the ordinary methods of working. Thus over a single pair of wires a total of five telephone conversations are simultaneously operated, each giving service as good as that provided by the circuit working in the ordinary way.

"In telegraphy, as well as in telephony, sensational results have been attained by the new system. By combining two telegraph wires into a metallic circuit of the type used for telephone working, and by applying our new apparatus and methods to this metallic circuit, we have enormously increased the capacity of the wires for telegraph messages. As applied to high-speed printer systems we can do eight times as much as is now done, and as compared with the ordinary duplex telegraph circuit in general use we can do ten times as much. These increased results are attained without in any way impairing the quality of telegraph working.

"It is not too much to characterise this new system as marking an epoch in the development of long-distance telephony and telegraphy.

"Our new multiplex telephone system has already been applied to a pair of wires between Baltimore and Pittsburg and has been in service for a number of months, furnishing facilities greatly needed to take care of war business. Further applications of this system are under way in locations where additional long circuits are required."

We were interested therefore during our visit to Baltimore in seeing the working of the Baltimore-Pittsburg circuit, inspecting the apparatus, and comparing the results with those obtained on similar but less extensive experiments that had been carried out in this country. We found the high-frequency circuits very "silent" and the articulation remarkably good. The route distance between the terminals is about 250 miles. The cost of the equipment and its wide range of interference at present militate against the prospects of its utility on the relatively short and heavily-loaded aërial lines of this country. The whole system is, however, in the experimental stage, and much may be done to make it more economical and to remedy the limitations which at present exist.

As regards the high-frequency multiplex telegraph system, the problem is nearer solution, on practical lines of utility, and the prospects are distinctly promising, but it is a good illustration of the irony of life that in telephony a multiplex is badly needed and is difficult of attainment, whereas in telegraphy, with several reliable types of mechanical high-speed multiplex systems already available, the present development, though so very remarkable, will merely advance the art a stage ; it will not revolutionise it.

One of the most important features of the American telephone system is the large amount of research work that is carried on by the Western Electric Company on behalf of the Bell telephone organisation. A huge staff of approximately 1500 engineers and engineering assistants is employed in improving telephone devices and investigating the possibilities of utilising current scientific discoveries. It will be readily understood that an organisation of this kind is easily practicable with an enormous development, but it will be comparatively expensive to do justice to similar work where the development is small. One naturally assesses the cost of research work upon a per station basis, but it should be borne in mind that the cost per station will necessarily be greater the smaller the system.

Of necessity this article must be brief and other matters of interest to telegraph engineers cannot here be given. The utility of many of these, however, for adoption in this country is receiving attention, and information with regard to some of them will be made known late. I should, however, like on behalf of myself and my colleagues (Messrs. Hart, Hedley and Anson) to put on record here our appreciation of the way in which we were received in the United States. We saw engineers and other officials of the A. T. & T. Co., the Western Electric Co., the Automatic Electric Co., the North Electric Co., the New York Telephone Co., the Lima Telegraph and Telephone Co., the Western Union Telegraph Co., and a number of other important telegraph companies, as well as Post Office officials at Washington. Everywhere we were received most cordially, and given every assistance to obtain information on the various subjects in which we were interested. During our short visit two public holidays occurred, but even on these and on Saturday afternoons and Sundays the American telephone and telegraph engineers willingly placed their time and services at our disposal.

THE RELAY AUTOMATIC TELEPHONE SYSTEM.

THIS article is intended to give readers some idea of the principles upon which the relay automatic system of telephony works, as it is expected that a public exchange of this type will be working in this country in 1921. The article does not give the circuit operations in detail.

The relay system differs from the other automatic systems in having no rotating selectors or connectors. In the Strowger, Siemens, and Western Electric Company's systems, connection is made between the calling subscriber and the wanted subscriber *viâ* various "selectors." The subscribers' lines are multipled (in 100's or 200's) on semicircular banks of contacts, in front of which the final selectors or connectors, carrying the wipers or brushes to touch any set of contacts, can rotate. The dialling of the calling subscriber determines to which particular line the final selector will rotate. In the relay automatic system there is no such selection in front of a multiple; the subscribers' lines terminate in only one place, and *the selection* of the wanted subscriber is carried out by the recorder and marker in such a way that the *wanted subscriber's line relay is energised* by the calling subscriber, and the called line picks up links and trunks which join the called subscriber through to the calling subscriber. The connection between subscribers' lines is made entirely by relays, links and trunks (Figs. 1 and 2). A typical relay is shown in Fig. 3. The calling subscriber's line can be joined to links, the links to out-trunks; the wanted subscriber can be joined to links; these links to in-trunks; then the in-and-out trunks can be connected either (1) directly from one to the other (if the exchange is small), (2) indirectly from out-trunk to "trunk links" and from in-trunk to "trunk links," and the trunk links directly to one another. We have finally a circuit made thus: Subscriber's line—subscriber's link—out-trunk—trunk link (out)*—trunk link (in)*—in-trunk—subscriber's link—subscriber's line.

The groups of apparatus used in the system may be subdivided thus:

(*a*) Apparatus particular to each subscriber's line, consisting of the termination of the line on the main frame and I.D.F., along with a line (*LE*) relay, a cut-off (*CO*) relay, and meter in parallel if a meter is used, a fault (*F*) relay and link-connecting (*LC*) relays, one associated with each subscriber's link (see Fig. 2).

(*b*) Subscriber's links, each consisting of a pair of wires, which can be connected to any one of the subscriber's lines *viâ* the *LC* relay contacts, and can again be connected to an out-trunk *viâ* the

* These disappear in small exchanges.

contacts of an *OTC* relay, or to an in-trunk *viâ* the contacts of an *ITC* relay. Associated with each link is a link-busy (*LB*) relay and a link-marking (*LM*) relay. The *LM* relay chooses one of the idle links when a subscriber calls up and cuts off the other links from being marked. This prevents a subscriber's line being joined to two links in parallel at the same time.

(*c*) Out-trunks, which take the place of the " A " cord circuit in manual exchanges, containing about eighteen relays ; the out-trunks control the battery supply to the subscriber's talking circuits, connect the subscribers temporarily to the recorder during the dialling period, and control the release of the call.

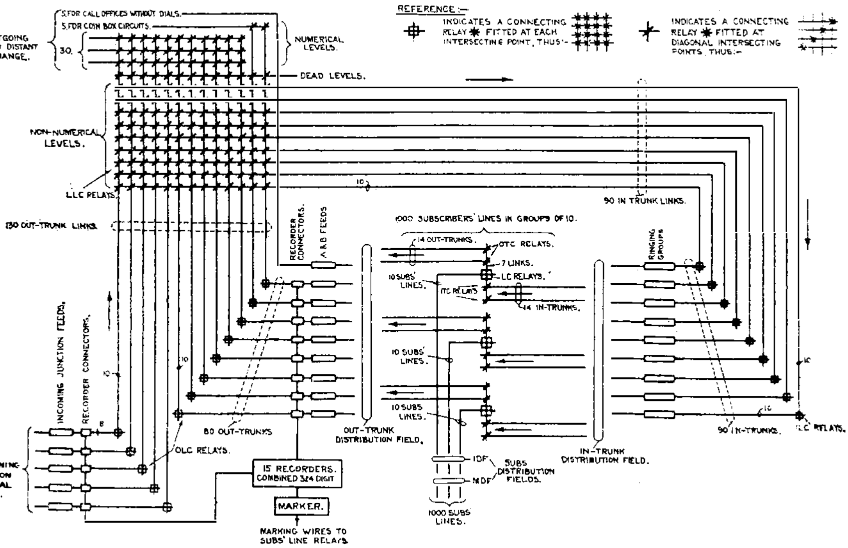


FIG. I.—TYPICAL TRUNKING SCHEME FOR A 1000-LINE RELAY AUTOMATIC EXCHANGE.

The group of relays (see Fig. 5) which connect the out- and in-trunks together are dealt with in (*e*) below.

Reverting to the subscriber's apparatus, a subscriber's unit contains the apparatus for ten subscribers and their links (see Fig. 2), viz. *LE*, *CO*, *F*, and six or seven *LC* relays, depending on how many links are required to carry the incoming and outgoing traffic to the ten subscribers ; two *ITC* and two *OTC* relays per link, which connect the out- and in-trunks to the links ; one *OTT* and one *ITT* relay, which test the in- and out-trunks to see which are idle. There is only one of each of these relays per subscriber's unit. Fig. 4 shows a subscriber's unit.

(*d*) In-trunks, which contain four relays for controlling the ringing of the wanted subscriber. The relays (*ITC*) joining the in-trunk to a subscriber's link have been included in the apparatus associated with the link.

(*e*) Trunk connecting group, which contains the *OT/IT* relays (see Fig. **5**) for joining the out- and in-trunks together. If there were thirty of each the number of relays in the group would be 900. To avoid such a multiplication of relays "trunk links" are used (see Fig. **1**); then out-trunk, out-link (*OLC*), out-link, in-link (*LLC*), and in-link, in-trunk relays (*ILC*) would be required; in this case each out-trunk still has access to every in-trunk.

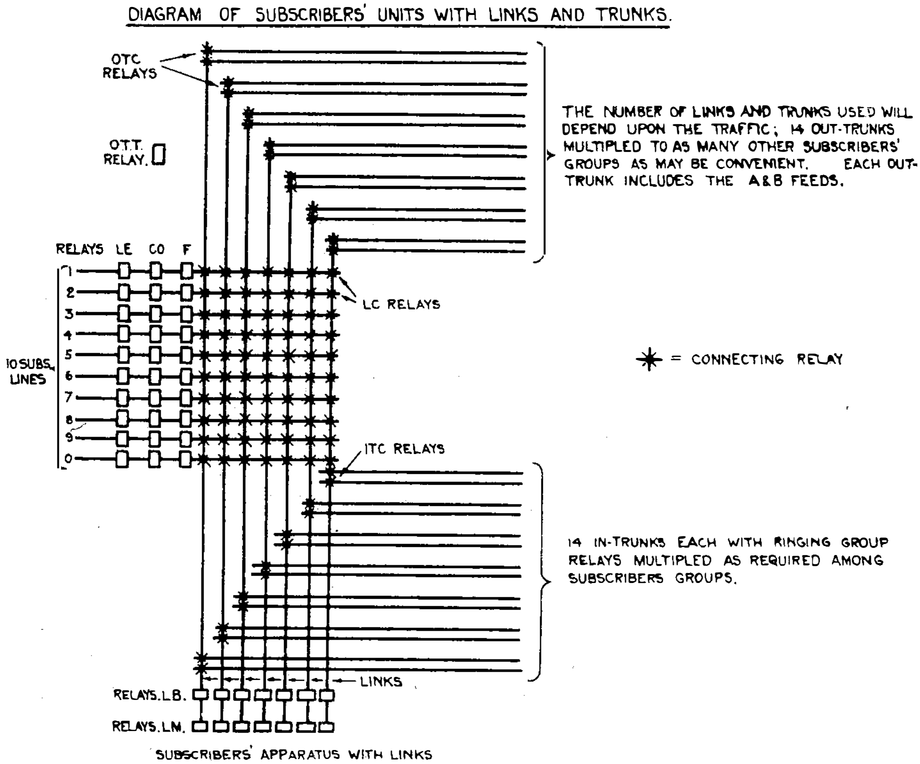


FIG. **2**.—DIAGRAM OF SUBSCRIBERS' UNITS WITH LINKS AND TRUNKS.

(*f*) The recorder. This contains "counting relays," "storing or memory" relays and controlling relays. When a subscriber dials a number, say, 347, the 3 and the 4 are stored in the storing relays until after the completion of the dialling of the units, when the "marker" is energised. A three-digit recorder has about fifty relays.

(*g*) The "marker" (Fig. **6**), which for a 500-line exchange would have fifty-five relays, at the conclusion of the dialling chooses or "marks" the wanted subscriber in about one-fifth of a second; the recorder and marker perform the function which the register performs in the Western Electric system.

The method by which the calling subscriber (called the "A" subscriber) picks up the wanted subscriber (called the "B" subscriber) is as follows:

Subscribers are wired up in groups of ten; the subscribers' lines are run across a series of links and can be connected by means of relays (*LC*) to any of these links, only one subscriber being connected at one time to a link (see Figs. 1 and 2). The links are run across two out-trunks and two in-trunks, and can be connected to any of these by the trunk-connecting relays (*OTC* and *ITC*). The *out-trunks* are picked up by the calling subscriber, and contain the *battery feeds* to both subscribers and the *relays controlling* the call. The *in-trunks* contain the ringing relay. In joining subscribers' lines and links to in- and out-trunks, the process is the same for calling and called subscribers—that is, in both cases the subscriber's link picks

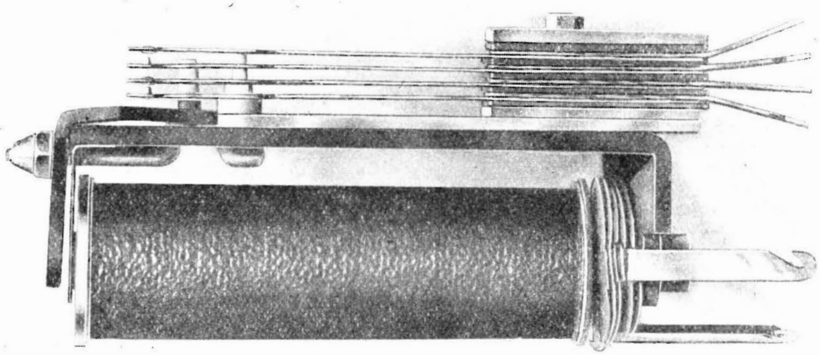


FIG. 3.—A TYPICAL RELAY.

up a free trunk. For example, if subscriber 281 calls 347, 281 picks up a link and an out-trunk, and after dialling, the recorder sends an impulse through the marker to the line relay of the wanted subscriber 347, so that his line relay is actuated and he picks up a link and an in-trunk. All the out-trunks (provided no trunk links are used, as in big exchanges) run across all the in-trunks. Connection is now made between the energised out-trunk and energised in-trunk by an *OT/IT* relay, and subscriber 281 can talk to subscriber 347. This point may be emphasised: the *wanted or called subscriber's line is chosen* by energising its marking wire and operating the line relay through its second winding; this marking wire is taken to the line relay *viâ* contacts on the cut-off (*CO*) relay and fault (*F*) relay. If the line is faulty, the fault relay is operated and the incoming marking wire is connected to a line to the test desk or to a high "fault" tone, instead of to the line relay; the marking impulse from a calling subscriber can then be made to give any desired signal or tone to the calling subscriber to acquaint him with the fact that the line to the wanted subscriber is out of order.

The use of a fault relay prevents faulty lines engaging common apparatus.

Consider the connection of trunks in detail as seen in Fig. 5.

At the point where each out-trunk crosses an in-trunk there is

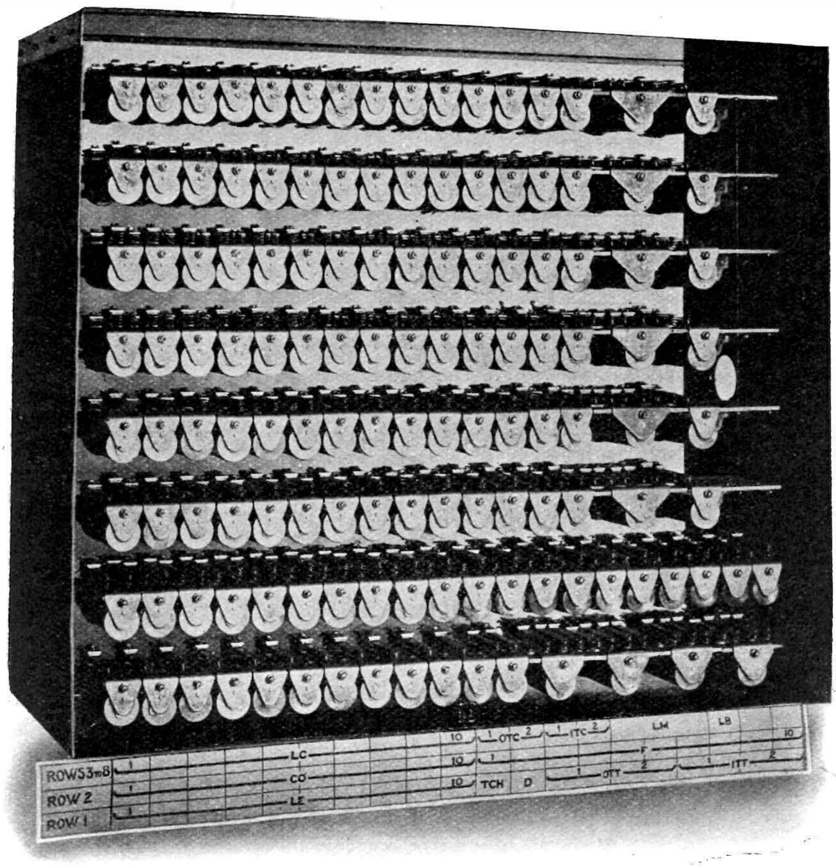


FIG. 4.—A SUBSCRIBERS' UNIT: 10 LINES.

an *OT/IT* relay which ordinarily is entirely disconnected. When subscriber 281 picks up an out-trunk, say No. 1, a relay (*OTM*) puts battery on one side of the marking winding of all the *OT/IT* relays associated with this out-trunk. When subscriber 347 took up the in-trunk—say No. 6—the earth was put on the other side of all the marking windings of the *OT/IT* relays associated with in-trunk No. 6; the only relay which gets both battery and earth is the one represented by *OT*1/*IT*6. This relay is energised, and thereby closes its holding circuit and connects the two energised trunks, thus forming the channel for the conversation. As soon as the connection is fully made and the holding circuits completed, battery is removed from all the out-trunk *OT/IT* relays and earth from the in-trunk *OT/IT* relays, so that no double connections can be made. Owing to the method of operation in the marker, only one subscriber can be selected at one moment, so it is impossible for two in-trunks to be energised simultaneously and make connection on the same out-trunk.

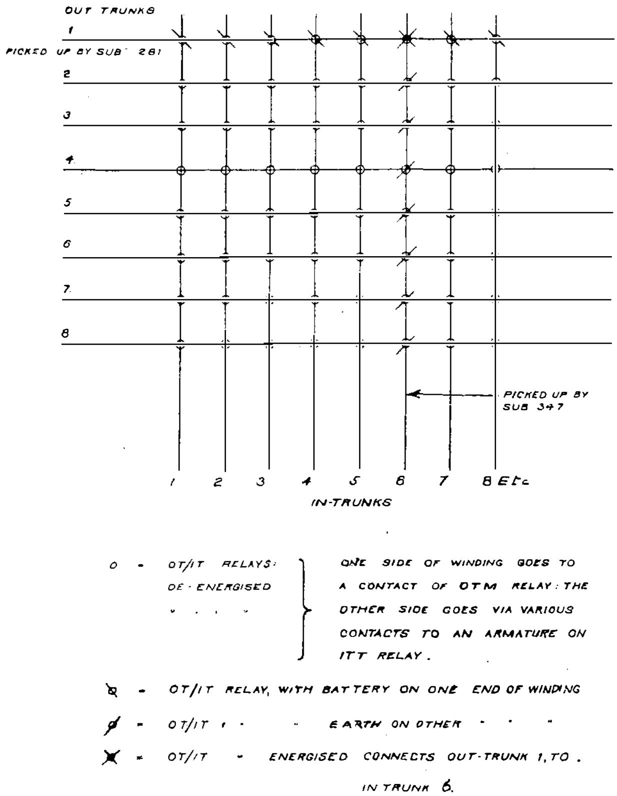


FIG. 5.—METHOD OF CONNECTING IN-TRUNK AND OUT-TRUNK TOGETHER.

The selection of a *particular subscriber*, due to the impulses dialled by the calling subscriber, is done by means of (1) a *recorder*, through which the dialled impulses travel in order to actuate storing relays for the 100's, 10's and units, and (2) by means of the *marker*, which joins up the subscriber's marking wires belonging to the chosen 100's and 10's group to the recorder; the final impulse travels along from the recorder down one particular marking wire of the group of 10 to the line relay of the wanted subscriber.

Operation of recorder.—The apparatus which receives the impulses dialled by the subscriber is called a "recorder." The impulses pass *viâ* a train of counting relays (the *MK*, make, and *BK*, break, relays), and are stored in 100's and 10's storing relays, so that when the final unit impulse is received the proper subscriber will be rung. Three operations occur after the unit digit is dialled: first, an impulse comes from the 100's storing relay and energises a 100's marking relay, say *HDM*3; second, an impulse comes from a 10's storing relay and energises a 10's marking relay, say *TNM*34; the 10's marking wires are only joined through the *TNM* relays of a particular 100 group *viâ* the contacts of the *HDM* relay; third, the unit marking impulse travels from a particular *BK* counting relay (in our example No. 7), along the units marking wire to the contact of *TNM*34 and through it to the line relay of the subscriber 347. The line relay has two windings. When the subscriber calls he uses one winding; when the subscriber is called the other winding is energised by the impulse coming down the marking wire from the recorder. The energisation of the line relay in the latter case results in the subscriber's line being joined to an idle link, and then to an idle in-trunk, and thus finding a circuit to the trunk connecting group and there being joined to the calling subscriber. The recorder is only prepared, ready to receive impulses, by the subscriber when he lifts his receiver, but is not held until he dials; when the dialling commences and the subscriber's loop is broken, one recorder is connected definitely to the out-trunk, and its busy relay cuts off battery from the supply to the *RC* relays which might connect it to other out-trunk connection circuits.

The recorder is released when the in- and out-trunks are connected together, and is thus only in use during the dialling period and while the connecting relays operate—the total period should not exceed three to seven seconds. The number of recorders required for an exchange will depend upon the number of subscribers who may be dialling simultaneously; eight or ten are sufficient for a 500-line exchange; a three-digit recorder comprises about fifty relays with four lamps, several resistance spools and wiring.

The "*marker*," of which one per 1000-line exchange is sufficient, is associated with the group of recorders; it is operated momentarily—say, for 0·2 second—between the completion o the units dialling and the commencement of the ringing of the subscriber. If four simultaneous calls were being received and each subscriber was dialling and storing his call in the recorders 1 to 4, the marker would make the connections one after the other; even if the four subscribers completed dialling (which is a practical impossibility)

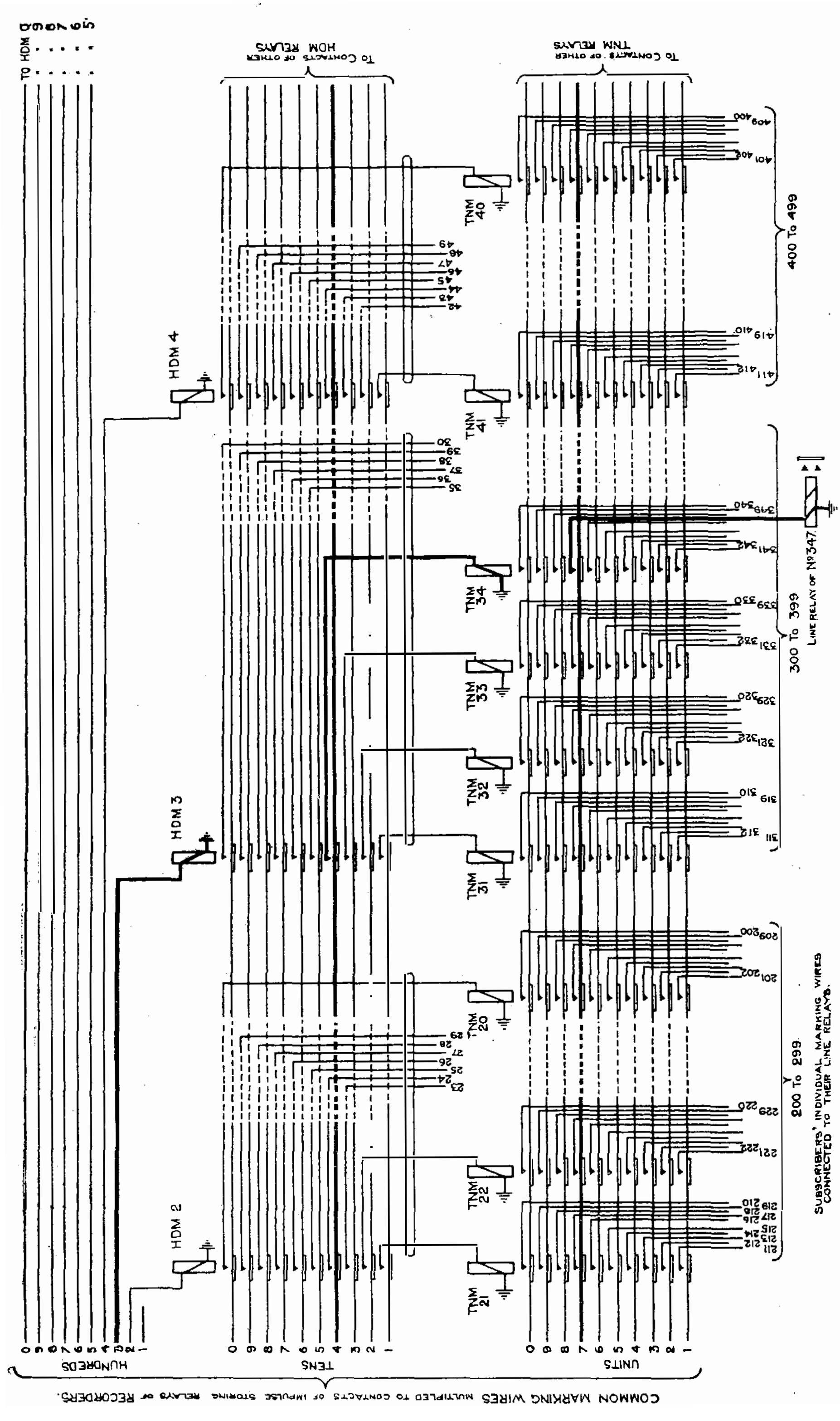


FIG. 6.—EXPLANATORY DIAGRAM OF THREE-DIGIT MARKER.

at the same moment, the connections would be made in succession by the marker *viâ* the *MC* relay during the next second.

The marker (see Fig. 6) comprises (1) the "units" marking wires coming from the back contacts of ten counting *BK* relays, and multipled to every *TNM* relay, of which there is one per each group of ten subscribers; (2) the "10's" marking wires from the contacts of the "10's" storing relays, multipled to each *HDM* relay, and taken to the winding of each *TNM* relay; (3) the "100's" marking wires from the contacts of the "100's" storing relays to the winding of each *HDM* relay. The "storing" relays and counting relays are in the recorder.

The author would like to express his thanks to the Relay Automatic Telephone Company, Marconi House, Strand, W.C. 2, for the loan of blocks and tracings, and for the courtesy in supplying information about the system. A description of the arrangement appeared also in 'Electricity,' vol. 32, 1918, p. 473.

A. B. EASON.

THE STANDARD G RELAY.

By A. H. ROBERTS, A.M.I.E.E.

A DESCRIPTION of the Post Office form of vibrating relay, used for telegraph purposes, appeared in Part I, vol. x, of this Journal.

Previous experience with the Gulstad relay had clearly established the utility of a vibrating relay to increase the working margin on long-distance fast-speed Wheatstone circuits. On some of the lengthy underground and submarine cables the average rate of transmission was improved by 50 per cent., but as the Gulstad relay could only be applied to Bridge and not to Differential duplex sets its sphere of action in the Post Office service was limited.

The relay, standard G, was therefore designed to meet the requirements of both methods of duplexing.

Since its introduction in 1915 this instrument has been used to replace the ordinary standard B relay on circuits required to work at a rate approaching the maximum transmission value of the line. In every case a marked increase in the speed and improvement in the quality of the signals was secured.

A few typical examples may, perhaps, be of interest. When Baudot quadruple duplex working was first introduced between London and Hull on the underground cable, which follows a route through Birmingham, Warrington, Manchester, and Leeds to Hull, it was decided to equip both ends of the circuit with G relays. The result was so satisfactory that arrangements were made to conduct experiments on a still longer circuit. The London–Newcastle-on-Tyne quadruple duplex Baudot following the same route to Leeds was selected for the purpose. This circuit was already working with a repeater at Warrington.

When G relays had been fitted at London and Newcastle the repeater at Warrington was withdrawn from the circuit. After a long day's trial direct working was proved to be practicable, and the repeater was permanently released. The length of the loop between London and Newcastle is 357·8 miles and the K.R. value amounts to 103,704.

For Wheatstone duplex purposes the G relay has proved invaluable on many circuits. On the London–Middlesbrough loop, with a line K.R. of 109,767 and with a key duplex installation superposed on the loop, a practical Wheatstone duplex working speed of 75 to 80 words a minute is obtained.

On certain other Wheatstone duplex circuits it has been possible to convert the system from Bridge duplex to Differential duplex without loss of efficiency by using G relays at the terminal offices. In some cases this is a distinct advantage, as the balancing conditions of the differential duplex do not require such expert treatment as the bridge duplex.

In the case of a Birmingham–Glasgow Wheatstone duplex the introduction of G relays at the terminal offices rendered the use of a repeater which had been previously employed unnecessary.

During the course of a series of Wheatstone duplex experiments undertaken in April and May last, it was found that when the steady current in the line was kept below 10 m.a. there was a tendency for the ordinary vibration of an instrument table to cause the delicately adjusted tongue of the G relay to register false signals.

This difficulty was overcome by supporting the relays on spring trays similar to those used for supporting the relays used on Baudot sets.

The use of G relays is not entirely confined to this country, as the North Russia submarine cable connecting Murmansk and Yukanskie with Archangel is equipped at all stations with this form of instrument.

From experiments conducted when the cable was first laid, it was proved that over the Murmansk–Yukanskie portion, a length of 201 knots, the G relay gave an increase of 55 per cent. in speed as compared with a P.O. standard B relay for Wheatstone duplex working.

Following is a list of the circuits in the United Kingdom on which G relays are at present working:

Circuit.	Repeater at—	G relays at—	Remarks.
T.S.–Jersey . . .	Exeter	Exeter and Jersey	—
T.S.–Jersey Reserve .	,,	,, ,, ,,	—
T.S.–Guernsey . .	,,	Exeter	Gulstad at Guernsey.
T.S.–Exeter . .	—	T.S. and Exeter	—
T.S.–Newcastle . .	—	T.S. and Newcastle	Baudot, quad. duplex.
T.S.–Hull . . .	—	T.S. and Hull	,, ,, ,,
T.S.–Leeds . . .	—	T.S. and Leeds	,, ,, ,,
T.S.–Middlesbrough .	—	T.S. and Middlesbrough	—
T.S.–Aberdeen . .	Preston and Edinburgh	T.S.	—
T.S.–Edinburgh . .	Preston	Preston	Baudot, quad. duplex.
Birmingham–Glasgow.	—	Birmingham and Glasgow	—
Glasgow–Dublin . .	Llanfair	Glasgow and Llanfair	—
Liverpool–Edinburgh .	—	Liverpool and Edinburgh	—
Manchester–Edinburgh	—	Manchester and Edinburgh	—

Trials are in progress on a few other circuits, principally with the object of releasing repeaters at intermediate offices.

DIFFERENT SYSTEMS OF HIGH-SPEED TELEGRAPHY.

At a conference of the French Society of Electricians held on June 4th, 1919, a contribution on the above subject was given by M. Montoriol, Inspecteur des Postes et Télégraphes. The paper is given in full in the 'Annales des Postes, Télégraphes et Téléphones' for September, 1919, occupying 58 pages. In it he deals with Wheatstone, Creed, Murray automatic, Siemens automatic, Buckingham-Barclay and Pollak-Virag, representing the automatic systems, while the multiplex systems include the Baudot, Delany, Rowland, Baudot-Dubreuil, Murray duplex multiplex, Western Electric duplex multiplex, Western Union duplex multiplex and the Mercardier systems.

The study of this highly important and complex subject has been well carried out, as one would expect from this well-known authority on French telegraph matters, and his conclusions are very interesting, as they represent the French view of the advantages and disadvantages of the various systems so far as they apply to the French Telegraph Service, and to a less extent, perhaps, to other services.

The author states that he has endeavoured to deal with the matter from a purely technical standpoint, quite apart from any commercial, national or other consideration that might lead to a false conclusion. In this respect it can be said that he has succeeded very well indeed.

There are one or two minor points that need correction, viz.:

(1) The speed of the Creed receiving perforator is given as 120 to 130 words per minute, and although this is the usual working speed when it is used in conjunction with Creed printers, it is very far from being the maximum, which is in the neighbourhood of 220 words per minute.

(2) The Creed printer is given a speed of 125 *letters* per minute. This is no doubt a printer's error, as the machine works well at 125 *words* per minute and has frequently done 140 words per minute.

(3) The Siemens automatic is given a speed of 500 to 600 revolutions per minute or 100 words, whereas the set purchased in 1913 for the British service regularly works at 1000 revolutions or 166 words per minute.

After considering the systems the author gives his provisional conclusions as follows:

Preference should be given to—

(1) Systems having multiple transmission.
(2) Systems employing the Baudot code.

He then proceeds to compare these, viz. the Baudot, Murray duplex multiplex, Western Electric duplex multiplex and Western Union duplex multiplex. He says: "The Murray multiplex is a Baudot arranged to work exclusively at duplex," and then refers to the striking resemblance of the Western Union and Western Electric to the Murray, thus giving all three similar advantages and disadvantages. He states that the two latter also are practically Baudots. On this account he groups all three and refers to them as the Anglo-American Baudots to distinguish them from the French Baudot.

It is considered that he should have included with the Anglo-American Baudot the British arrangement of duplex Baudot, because it was due to the remarkably successful results that were obtained by this arrangement, and which were published in this JOURNAL, that the Americans were led to try it and subsequently to develop it into their present system.

As a matter of fact the first American experiments were made with two Baudot distributors purchased in England from the representative of the French manufacturer M. Carpentier. Further, the completed sets have followed exactly the earlier British arrangement, viz. permanent duplex, no matter whether the apparatus is used on aërial or underground lines.

M. Montoriol considers this to be a disadvantage and gives his reasons, but the fact remains that the British and American services have many sets working on aërial lines and have not found the disadvantages sufficient to warrant a departure from the arrangement, although on long and difficult lines a switch has been provided for utilising two lines on a duplex set, one line for receiving and the other for sending, without otherwise disturbing the set or the positions and working of the operators. So satisfactory has this arrangement proved that it is unlikely that the purely simplex French Baudot installations with transmission in both directions on one wire will be utilised other than to France. In fact it would be an all-round advantage if all the sets to France were changed to double duplex in those cases where there is not sufficient margin for triple duplex.

In regard to duplexing systems, the author states that it is not the apparatus but the line that is duplexed. This is, of course, as far as it goes, technically correct, but it does not go far enough, for in every case the duplexing of a system means considerable modifications and addition of apparatus to the terminal sets, while the line itself remains absolutely unaltered. It is the arrangement of connections and disposition of the apparatus, switches, etc., that determine whether the duplex installation will be successful or not under the usual working conditions. Further, the use of the Baudot system (*i. e.* the French simplex Baudot) was limited and the spread of its use was quite a slow matter; but following the publication of the British results of duplexing the Baudot its extension became very rapid. The first British Baudot duplex circuit (named by the British Committee on High-Speed Telegraphy the "Booth-Baudot duplex") was established in June, 1910, and since that date, *i. e.* in less than ten years, the number of Baudot duplex sets introduced, including the Anglo-American type, is some three or four times greater than the number of Baudot simplex sets that have been installed during a period five times as long. This fact speaks for itself, and plainly indicates that there is a considerable difference between the purely French Baudot and the Anglo-American Baudot.

The British Post Office arrangement for duplexing the Baudot has been adopted, among many other services, by the French Telegraph Service, and there is now very little difficulty in obtaining good double and triple duplex working on several lines between London and Paris.

In a previous issue of the 'Annales,' M. Montoriol explained that it was because of the need for standardisation and unification of material that the French Administration ceased to use the one double duplex that was in use in 1900, replacing it by quadruple simplex, which met the traffic requirements equally well. It was not until 1914 that the duplex was re-started in France, and it has now proved so very useful that it is hardly likely to be put aside again. We may even yet see the duplex Baudot as the standard for the French service.

We will now give fully the author's final conclusions:

"The Baudot equipped with automatic transmission, and as an accessory the phonic wheel drive, will keep the premier position that it has held up to the present because of its irreproachable working and the robustness and simplicity of its various parts, which allow it to be placed in the care of officers who are the least specialised; also because of its incomparable flexibility to meet all requirements and all circumstances. It will be worked duplex if the need arises on all the lines where its rivals are able to do so. It will keep the first place as long as no other system based on a new principle challenges it; this principle may perhaps be that of the Rowland, of which the first utilisation seems to have been incomplete; or it may be the Pollak-Virag, of which the extraordinary rapidity is unhappily counter-balanced by most serious defects. It would without any doubt be rash to prophesy in this respect, for a third system may arise at any moment to reverse completely our actual conception of rapid telegraphy. When that time arrives the Baudot will have to give place to a newcomer, as it has itself displaced its predecessors, and our national pride will not be injured thereby, since the Baudot will have held a glorious place in the annals of telegraphy. The importance of this position is confirmed by the efforts of inventors, whose merits it would be unjust to decry, but who in the impossibility of discovering this new and better principle find no other use for their ingenuity than in modifying the Baudot system, sometimes with advantage, sometimes indifferently, and sometimes inopportunely. That is certainly the purest homage that the clever French inventor could desire.

"It will undoubtedly be recognised that the author of this study, in order to keep quite impartial, has banished sytematically all sentimental considerations; the words 'National Industry,' which have their value, have not once been mentioned, and it is solely from the technical and experimental point of view that the matter has been discussed.

"The conclusion therefore acquires only greater weight, and in the eventuality of its adoption by the administration it will only result in some purely commercial inconvenience to our English and American friends, who are technically too good to be surprised thereby."

We heartily congratulate the author on his excellent paper, and would have published it in full had space permitted.

THE AMERICAN MULTIPLEX TELEGRAPH.

IN the 'Annales des Postes, Télégraphes et Téléphones,' December, 1919, a description of the above, which is known in this country as the Western Electric duplex multiplex, is given by M. Mercy. He commences the article by the generally accepted statement that this system is a modification of that devised by Baudot some forty years ago, and then follows detailed information of the various parts, including a description of the printer by Kleinschmidt in which type-bars are used in place of a type-wheel.

Finally, he gives his conclusions, in which he compares the advantages and disadvantages of the system so far as it appeals to him from a French standpoint. It is somewhat difficult to reduce these conclusions to a few lines as they occupy some five and a-half pages, but put briefly, he is not in favour of adopting the Western Electric duplex multiplex. He considers that the better way is to utilise the undoubted improvements in details by adapting them to the Baudot system, and mentions that there may be advantages in utilising—

(1) Automatic transmission.

(2) Phonic motor drive for the distributor with electric correction.

(3) Receiver without a continually rotating axle or type-wheel.

The question of the value of duplexing is not discussed, but its disadvantages when lines are not in sufficiently good condition for duplex are mentioned.

The Western Electric duplex multiplex working as triple duplex on a line between London and Paris is compared with a Baudot triple duplex working on a similar line. The relative speeds, *i. e.* rotation of the distributors, is given as 155 and 180 respectively. It is well known that the former will work at a very much higher rate than that given and has reached something over 300 revolutions per minute. There is, therefore, some reason not apparent why its speed is so slow. It may be that the system meets traffic requirements at that speed, and its slowness is not due to any technical difficulties. If that be the case, we see no relation between the two results.

In this country we work both the Baudot and the Western Electric with Post Office standard relays, so that on similar lines or cables there should be no difference in the rate of sending or receiving signals.

M. FÉRY'S NEW PRIMARY BATTERY: AN AIR DEPOLARISER.

THE following extract from the December, 1919, issue of the French Administration's publication, 'Annales des Postes, Télégraphes et Téléphones,' may be of interest in view of the novel method of dispensing with the use of the dioxide of manganese depolariser in the Leclanché type of primary cell.

The new cell was designed by M. Féry, Doctor of Science, Professor to the Municipal School of Physics and Industrial Chemistry of the City of Paris.

The characteristics of the cell had already been indicated in a previous issue. The positive electrode is a vertical cylinder of carbon of a somewhat porous nature. The negative electrode consists of a zinc plate placed horizontally at the bottom of the cell, and the exciting liquid is a solution of sal ammoniac.

The porous carbon plays the *rôle* of a catalytic agent between the oxygen of the air and the hydrogen issuing from the electrolyte. The atmosphere is, therefore, utilised as a depolarising agent in the action of the battery. This depolarising operation is facilitated by the remoteness of the zinc plate from the top of the cell, at which point the air contact occurs. Zinc, being a metal very easily oxidisable, would tend to combine with oxygen, and it would therefore be detrimental, both to the constancy of the battery and to the zinc plate, were the latter not placed at the bottom of the cell.

Arrangements were made by the French technical authorities to put the Féry cell under trial on telegraph and telephone circuits. In the latter case the cells were used as a local battery. The telegraph offices at St. Cyr-l'Ecole (Morse apparatus) and St. Denis-sur-Seine (Hughes apparatus) were equipped with the Féry cell in September, 1918, since which date the batteries at these two offices have rigorously remained constant.

At St. Cyr, after 250 days of service, each of the zinc plates had only lost 8 grm. weight, notwithstanding that the Morse apparatus sets at this office had heavy traffic loads in consequence of the importance acquired by the aeronautic centre of St. Cyr due to the war conditions.

The constancy of the Féry cell is an extremely important feature —a quality which it has been found is not obtainable with the use of the ordinary sac type of Leclanché battery. As the cell does not deteriorate when idle, it certainly is in this respect superior to the dry cell type of Leclanché battery.

In subscribers' telephone installations comprising calling batteries the new cell has given equally good results with those already referred to.

The Féry cell costs less than a cell in which dioxide of manganese is used, and when the zinc has been absorbed by the chemical action a new zinc plate and a renewal of the sal ammoniac are all that need be provided in order to obtain the equivalent of a new cell. Both as regards prime costs and annual maintenance charges, therefore, the new cell is less expensive than the manganese sac type of Leclanché battery, which requires to be renewed entirely.

The French technical authorities have been impressed with the results of these experiments, and have in consequence expressed the opinion that, in consideration of the importance of the results obtained and having regard to the economies which the general use of the Féry cell will make possible, the cell should be employed in both the telegraph and the telephone services. J. L. T.

COMBINED TELEPHONE AND TELEGRAPH CABLES: IMPORTANT TRIALS.

By A. H. Roberts, A.M.I.E.E., and W. J. Hilyer, B.Sc.(Eng.), A.M.I.E.E.

From the time of the introduction of paper-core cables for telephone circuits, it has been recognised that great economy would result from the use of combined cables, that is, cables containing within one lead sheath both telephone and telegraph conductors. The earliest attempt in this direction was the designing of a cable which consisted of pairs of wires for telephone use, and single conductor lapped over the paper insulation with a copper screening tape for the telegraphs. The screen conductors were in the outer layers of the cables, and the screening tape was earthed by contact with the lead sheath. The copper tape greatly reduced the interference on the telephones from the telegraphs, and between the telegraph circuits themselves. The induction from the telegraphs on the telephones, however, continued to give a good deal of trouble on the longer circuits, and it was deemed desirable to revert to the practice of carrying the wires for the two services in separate cables for the main trunk routes.

In late years rapid strides have been made in the method of balancing telephone cables. The process has been described in previous numbers of the Post Office Electrical Engineers' Journal. The resulting reduction in the amount of interference between the different pairs of conductors, together with improvements in certain of the apparatus used for telephones and for telegraphs gave rise to the promise that most, if not all, the trouble previously experienced could be overcome. It was hoped that it would not only be possible to work fast-speed telegraphs in long-distance cables containing also telephone circuits, but the gauge of the conductors for the telegraphs could be very much smaller than that previously used for similar lines.

A proposal was made to provide a composite cable between London and Manchester. To ascertain the practicability of this a series of tests was made on a 76-pair 40-lb. balanced telephone cable between Birmingham and Coventry. This cable contains a number of loaded lines, used for telephones, and a number of unloaded lines

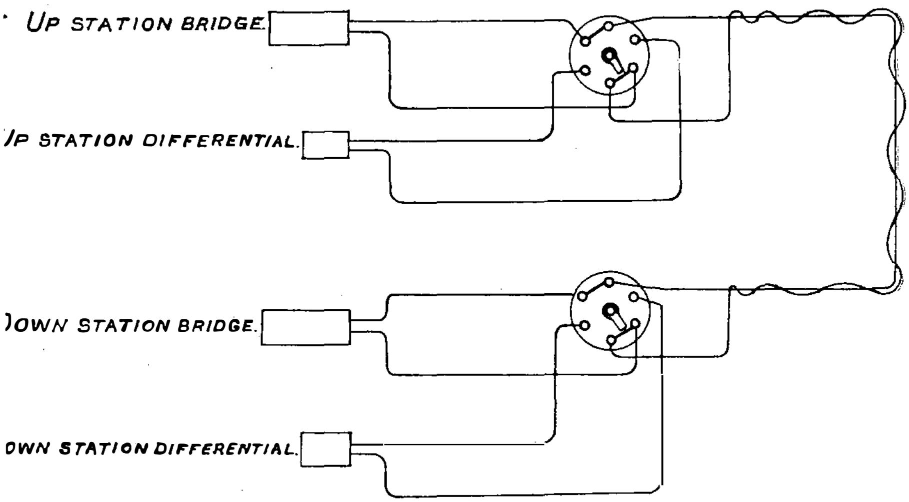


FIG. 1.

which were used for the telegraphs in most of the experiments detailed below. In a number of the trials a telegraph circuit 186 miles long, the approximate length of the proposed London–Manchester cable, was made up.

In all the experiments it was necessary to connect pairs together at Birmingham and Coventry. To get the working conditions as nearly as possible resembling a straight-through line, care was taken that the pairs were so joined together that any one pair was not looped back on the other in the same 4-wire core. The duplex sets were fitted with the standard G-vibrating relays. The listening tests were made in a building separate from that in which the telegraph apparatus was fitted.

The objects of the tests, and their results, are given seriatim; a summary of the results is included at the end of the article.

Test 1.—To determine the minimum voltage at which differential and bridge Wheatstone duplexes can respectively be worked at a speed not less than 150 words per minute on a loop circuit 186 miles in length.

The differential duplex was wired to Diagram TG 254 and the bridge duplex to TG 253 (standard diagrams for loop working). Fig. 1 shows the switches for changing-over. The minimum voltages with which the differential and bridge sets could be worked at a speed of 150 words per minute were found to be 40 and 60 respectively. Particulars of the steady line current strength, battery surge current strength, resistance of lines, etc. are given in Table I.

TABLE I.

Set.	Main voltage.	Steady current in line.	Battery surge current.	Speed duplex.	Conductor resistance.		Insulation resistance.
	Volts.	M.a.	M.a.	W.p.m.	Ohms. A wire.	B wire.	Meghoms.
Differential . .	40	8·6	38	156	3890	3892	9
Bridge . . .	60	6·5	63	150	3890	3890	10

The speed on the differential duplex set was later increased to 167 words per minute.

Test 2.—To ascertain the induction on loaded telephone circuits in the cable caused by one duplex Wheatstone (differential or bridge), working with the minimum voltages at 150 words per minute over an unloaded loop 186 miles in length.

The same line was used for both the telegraph sets and by switching it over from one set to the other a direct comparison of the induction caused by the differential duplex and of that caused by the bridge duplex was obtained.

In Table II are shown the results of the listening tests.

TABLE II.

Set running.	Voltage.	Listening at— Birmingham.	Coventry.
Differential "up" station . .	40	Very slight	Negligible
Differential "down" station . .	40	" "	"
Differential full duplex station .	40	" "	"
Bridge "up" station . . .	60	Considerably more than similar cases with differential sets.	Very slight
Bridge "down" station . . .	60		"
Bridge full duplex station . .	60		"

The "listening" telephones were connected first at the ends of loaded pairs 1 and 30, and then at Birmingham at the ends and at

Coventry in the middle of a composite loaded loop made up of pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 (148 miles long). The same results were obtained in each case. Reversals and slip gave about the same induction.

Test 3.—To ascertain the variation of the induction from one Wheatstone set caused by altering the line steady current without altering the battery surge current.

For this test three simplex sets were joined up in accordance with Fig. 2.

The length of loop of each of the three telegraph circuits was 74 miles. The strength of the steady line current was changed by means of R_1: values of from 3·5 to 10 milliampères were used. The

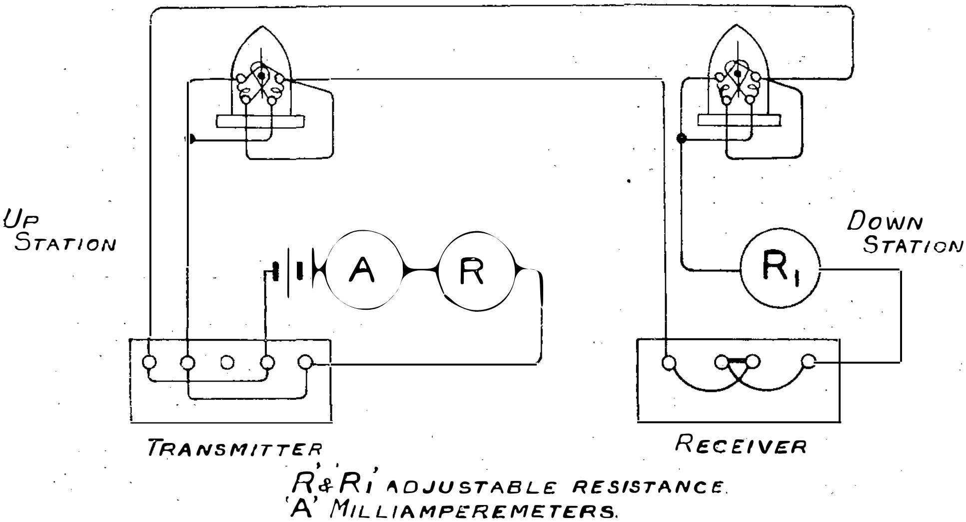


FIG. 2.

battery surge current remained approximately constant and was 24, 27 and 27·5 milliampères on the three sets which were run respectively with main battery voltages of 35, 42 and 44 volts, and at 200 words per minute (reversals).

"Listening" telephones were connected to the ends of loaded pairs 24, 26, 28 and 30, and there was no appreciable difference in the overhearing, as the steady line current was altered without changing the battery surge current at the sending station.

Test 4.—To ascertain the variation of induction caused by altering the battery surge current either by variation of the main voltage or by the speed of working.

For this experiment the set wired to Fig. 3 was used and worked over a loop 222 miles in length. R and R_1 were kept at constant values throughout the trials. The listening telephones were connected at Birmingham at the end, and at Coventry in the middle of a loaded loop consisting of pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 (148 miles long). The results are shown in Tables III and IV below.

TABLE III.—*Variation of Main Voltage.*

Telegraph set.	Length of telegraph loop.	Speed.	Main battery.	Steady current to line.	Battery surge current.	Listening at— Birmingham.	Listening at— Coventry.
	Miles.	W.p.m.	Volts.	M.a.	M.a.		
Wired to Fig. 2.	222	150	40	4	21·5	Very slight	*Nil.*
			60	6·25	31	"	"
			80	8·5	43·5	Slight*	"
			100	10·25	55	" †	"
			120	12·25	64	" ‡	"

* Rather more than at 60 volts. † Small increase. ‡ Small increase again.

TABLE IV.—*Variation of Speed.*

Telegraph set.	Length of telegraph loop.	Speed.	Main battery.	Steady current to line.	Battery surge current.	Listening at— Birmingham.	Listening at— Coventry.
	Miles.	W.p.m.	Volts.	M.a.	M.a.		
Wired to Fig. 2.	222	50	60	6·25	19	Very slight indeed*	*Nil.*
		110	60	6·25	28·5	" " " *	"
		150	60	6·25	31	Very slight†	"
		200	60	6·25	33·5	" " ‡	"

* About same induction. † Increase above induction at 110 w.p.m.
‡ Increase above induction at 150 w.p.m.

From the tests it appears that generally the induction increases with the main voltage and with the speed of running within the limits of these trials.

To determine the effect of the variation of the steady line current, voltage, and speed on the magnitude of the battery surge current tests, particulars relating to which are shown in Table V were made. The Wheatstone set was connected up to Fig. **2** and reversals only were run.

Test 5.—To ascertain the effect on the loaded telephone lines when the number of Wheatstone workings was two, three, four, and so on.

For this test all the Wheatstone apparatus available was employed, and twelve circuits were made up of unloaded pairs.

This arrangement gave a maximum of fourteen transmitters, which could be run together.

The transmitters were all run at 150 w.p.m. The main voltages steady current in line and battery surge current for the various circuits were as shown in Table VI.

TABLE V.

Telegraph set.	Length of telegraph loop.	Speed.	Value of R.	Value of R_1.	Main battery.	Steady current to line.	Battery surge current	Remarks.
	Miles.	W.p.m.	Ohms.	Ohms.	Volts.	M.a.		
			Variation of R or R_1					
Wired to Fig. 2.	74	200	0	920	43·5	10	28	See Curve 1 (Fig. 3).
		200	1120	920	43·5	8	15	
		200	4320	920	43·5	5	6	
		200	8400	920	43·5	3·25	3·5	
		200	920	0	43·5	10	17	
		200	920	1120	43·5	8	16·5	
		200	920	4320	43·5	5	16·25	
		200	920	8400	43·5	3·25	16·25	
			Variation of Voltage.					
Ditto	74	200	0	0	43·5	12·5	28	See Curve 2 (Fig. 3).
			0	0	34·5	10	22	
			0	0	27·5	8	17	
			0	0	17	5	10·75	
			0	0	11·25	3·25	7	
,,	74	150	0	0	43·5	12·5	22·5	See Curve 3 (Fig. 4).
			0	0	34·5	10	18	
			0	0	27·5	8	14	
			0	0	17	5	9	
			0	0	11·25	3·25	6	
,,	222	150	0	0	120	12·5	65	See Curve 4 (Fig. 4).
			0	0	96	10	52	
			0	0	76·5	8	40	
			0	0	49·5	5	27·5	
			0	0	31	3·25	17	
			Variation of Speed.					
,,	222	200	0	0	60	6·25	33·5	See Curve 6 (Fig. 5).
		150	0	0	60	6·25	31	
		110	0	0	60	6·25	28·5	
		50	0	0	60	6·25	19	

TABLE VI.

Circuit No.	Set.	Main voltage.	Steady current in line.	Battery surge current.
		Volts.	M.a.	M.a.
1	Bdge.	59 up station	—	46 up station
	Dx.	58 down station	—	50·5 down station
2	Diff.	40 up station	9·5 up station	39 up station
	Dx.	40 down station	9·5 down station	37 down station
3	Sx.	40	10	21·5
4	,,	41	10	28
5	,,	40	10	21
6	,,	40	10	23·5
7	,,	40	10	19
8	,,	40	10	19·5
9	,,	39	10	17·5
10	,,	39	10	15
11	,,	39	10	15·5
12	,,	40	10	15

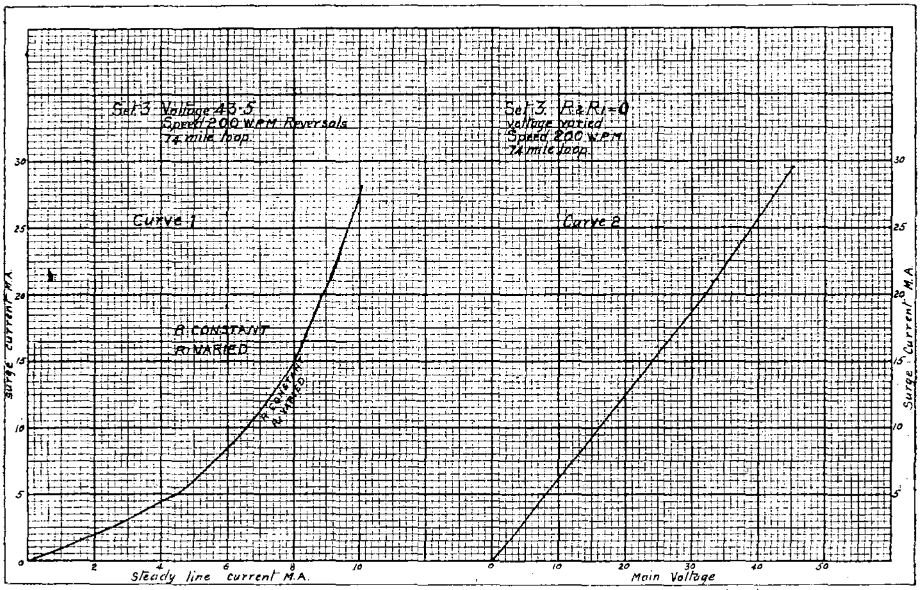


FIG. 3.

In the simplex circuits adjustable resistances were placed in series with the lines at the receiving end, and were regulated to give

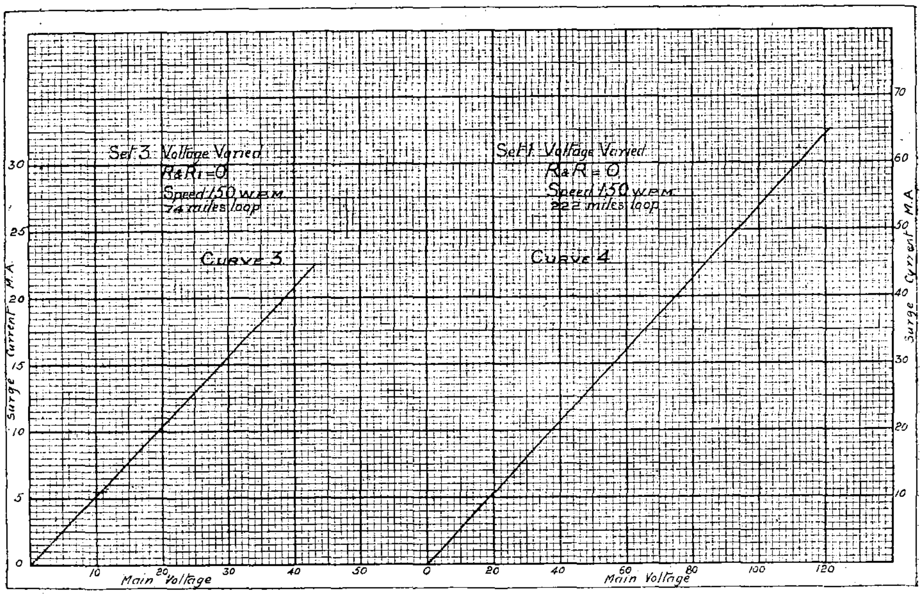


FIG. 4.

10 m.a. line current. All fourteen transmitters were started together and were then cut off one at a time. While this was done listening tests were made at Birmingham and Coventry on—

(*a*) Loaded pair No. 30 (18·5 miles).

(*b*) A loaded circuit 166·5 miles long made up of pairs—
$1 + 5 + 9 + 12 + 16 + 20 + 25 + 28$.

It was found that with fourteen transmitters running in case (*a*)

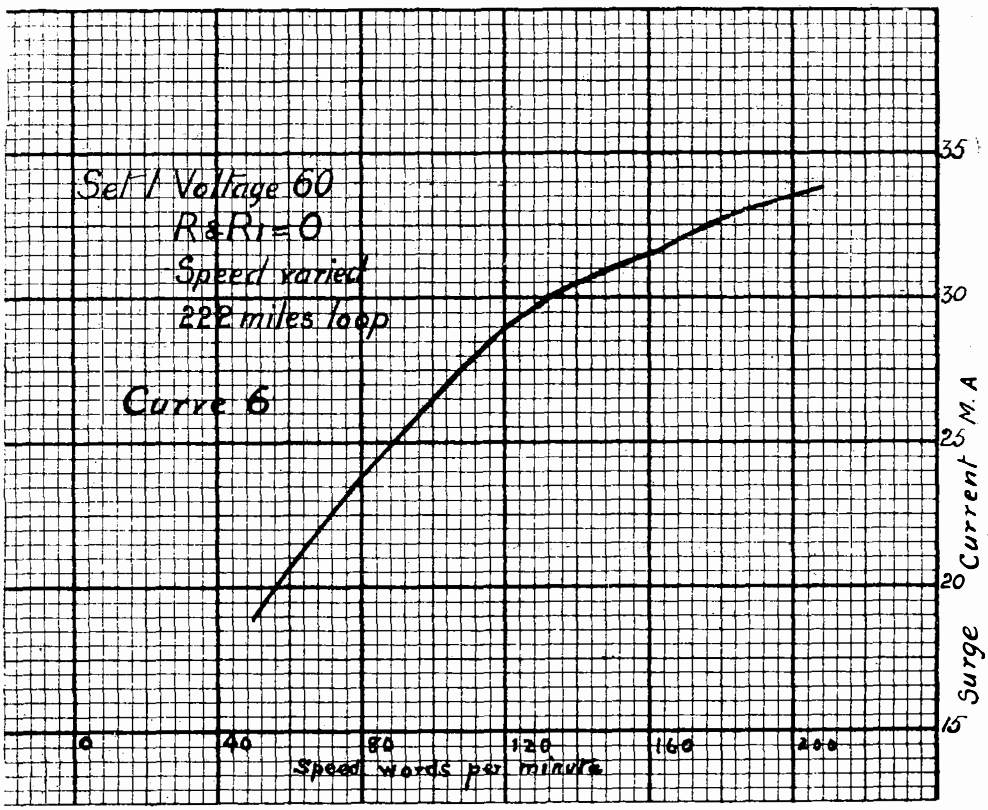


FIG. 5.

the overhearing was slight and in (*b*) was rather heavier than in (*a*); the test was made with the transmitters of the "listening" telephones cut out.

When the transmitters of the telephones were in circuit—as in conversation—the overhearing was quite negligible, and it made no difference whatever to conversation. Speech was conducted over the 166·5-mile circuit with and without the telegraphs running. No difference could be detected in the case of conversation. It was found when the telegraphs were cut off or switched on, one at a time, that the more telegraphs there were running the greater was the overhearing in the telephones, although the overhearing was not in direct proportion to the number of telegraphs running (the overhearing did not increase as quickly as the number of telegraphs run).

It appears, however, that it will be necessary to place a limit on the number of fast-speed telegraphs permitted in a cable ; it would be necessary to determine this number by actual experiment on the particular cable. Much depends on the electrostatic balance and insulation of the cable.

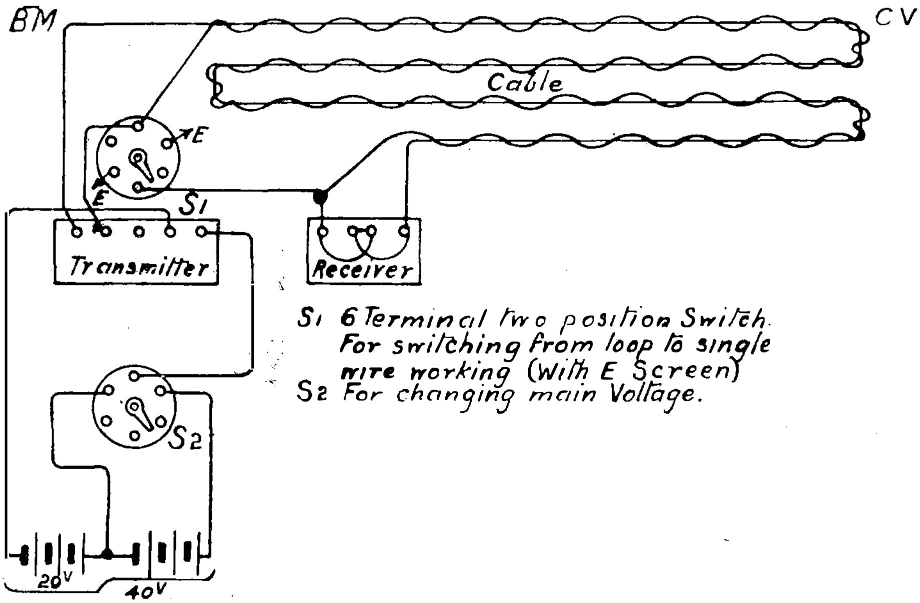


FIG. 6.

Test 6 (A).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-wire circuit with the other wire of the pair (*i. e.* that twisted with the line wire) used as a screen ; each end of the latter wire earthed.

(*Note.*—In the test below the numbers of the sets correspond to the circuit numbers in Table VI.)

The connections for this test are shown in Fig. 6.

Tests were made with the following voltages, etc., in the circuits. In all cases the speed was 150 w.p.m.

It was possible to run the single 186-mile wire earth circuit at 150 w.p.m. duplex with a main voltage of 20. The speed obtained from the loop circuit with 40 volts was 167 w.p.m. The difference in results of (*d*) and (*e*) is probably due to the fact that the pairs nearest

TABLE VII.

Set No.	Loop circuit.			Earth circuit.			Conditions.
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current in line.	Battery surge.	When circuit listened on consisted of the 166·5 - mile loaded telephone loop already referred to.
		M.a.	M.a.		M.a.	M.a.	
5 Sx. (74 miles cct.)	40·75	9	20	40·75	13·7	35	Single-wire circuit more noisy than loop.
Ditto	40·75	9	20	40·75 with 750^{ω} inserted in battery lead	10·75	21	Single-wire circuit less noisy than loop.
Ditto	40	8·5	21	28	9·25	25	Single-wire circuit more noisy than loop.
2 diffl. Dx. (186 miles cct.)							
Up station running	40 up station	3	21·5	20	2	17·5	Single-wire circuit slightly less noisy than loop.
Down station running	40 down station	3	21	20	2	17·5	Single-wire circuit more noisy than loop.
2 diffl. dx. (186 miles cct.)							
Up station running	40·5	2·0	23	20	1·3	19	Single-wire circuit slightly more noisy than loop.
Down station running	40	2·0	22	19·5	1·3	17	Ditto
Up station running	40·5	2·0	23	25	2·25	21·5	Single-wire circuit more noisy than loop.
Down station running	40	2·0	22	24	2·25	21	Ditto

the up station were not so well balanced as those near the down station.

The general results of the whole series of tests is to show that there is not much difference in the overhearing between the loop working with voltage 40 and single-wire circuit (screened) working with voltage of 20.

Test 6 (B).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-wire circuit with the other wire of the pair (*i. e.* that twisted with the line wire) insulated.

The connections were as shown in Fig. 7.

TABLE VIII.

Set No.	Loop circuit. Main volts.	Loop circuit. Steady current in line.	Loop circuit. Battery surge.	Earth return circuit. Main volts.	Earth return circuit. Steady current in line.	Earth return circuit. Battery surge.
		M.a.	M.a.		M.a.	M.a.
5 (74 miles Sx.)	40	8·5	20·5	28	9·25	21·75

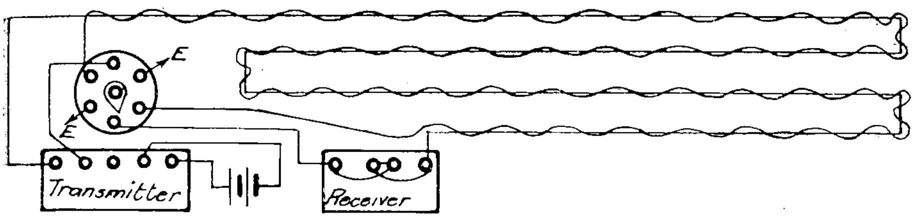


FIG. 7.

Single-wire working (not screened) gives much louder induction than loop working. Listening was carried out on 166·5-mile loaded circuit. The induction from single-wire working unscreened is prohibitive at 40 volts.

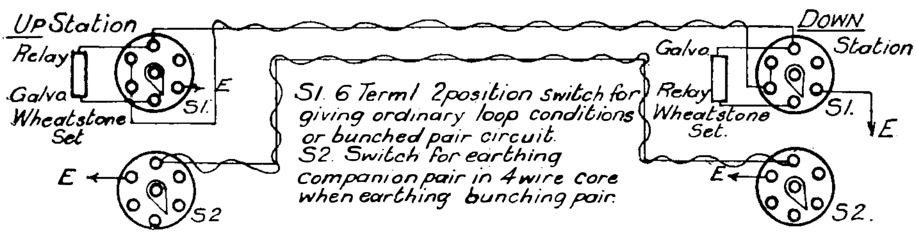


FIG. 8.

Test 6 (c).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-line circuit consisting of the two wires of the pair bunched; the other pair in the same 4-wire core being used as a screen, earthed at each end.

The connections for the test were as shown in Fig. 8.

The values of the voltage, steady current to line and battery surge current were as follows:

TABLE IX.

Set No.	Loop circuit.			Earth return circuit.			Conditions.
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current k in line.	Battery surge.	
2 (186 miles differential set worked dx.)		M.a.	M.a.		M.a.	M.a.	
Up station	40	3·25	22·5	20	3	30	(*a*)
Down station	40	3	22	20	3	28	(*b*)

Under both (*a*) and (*b*) the earthed circuit was much louder in induction than the loop-circuit.

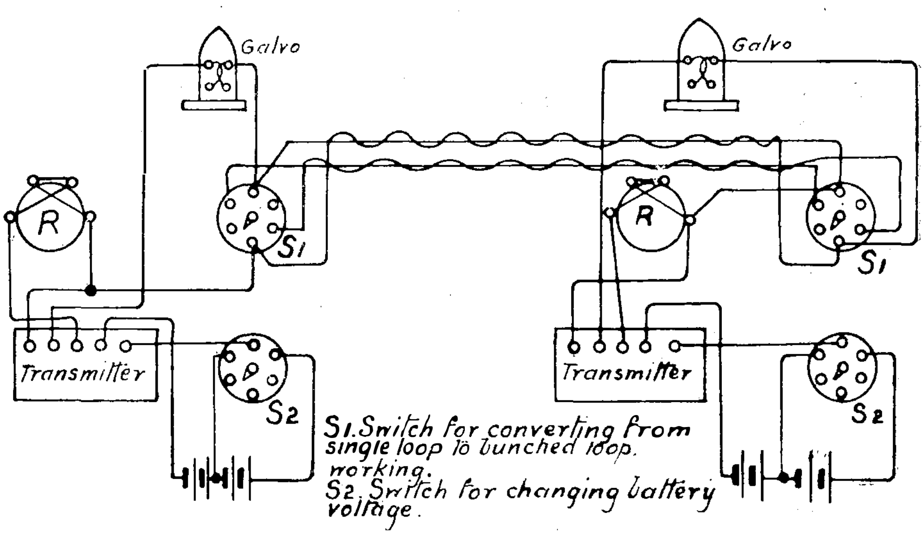


FIG. 9.

Test 6 (D).—The above test was repeated, except that the switches S_2 were left so that the companion-pair in the 4-wire core was always insulated. The interference from the earthed circuit was much greater than from the loop. It was also greater than with the second pair used as screen.

Test 6 (E).—To compare the overhearing from Wheatstone working on (i) an ordinary loop, (ii) a loop circuit, each line consisting of the two wires of a pair bunched; the two pairs forming the lines being in the same 4-wire core.

The connections were as shown in Fig. 9.

Particulars of the working conditions and the results of the tests are given in Table X.

TABLE X.

Set. No.	Length of Wheatstone circuit.	Main voltage.	Steady current to line.	Battery surge.	Listening in pairs.	Result and remarks.
			M.a.	M.a.		
2 Diffl. Dx. Up station	186 miles (Ordinary loop)	40	4½	19	1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 + 28	Bunched loop gives louder induction than ordinary loop. (No res. in rheostats.)
	(Bunched loop)	40	8½	39	Ditto	Ditto.
Down station	(Ordinary loop)	40	5	20·25	"	"
	(Bunched loop)	40	9	33·5	"	
Up station	(Ordinary loop)	40	4	25	"	Bunched loop gives louder induction than ordinary loop (4000ω in rheostats).
	(Bunched loop)	40	6	39·5	"	Ditto.
Down station	(Ordinary loop)	40	3·25	21	"	"
	(Bunched loop)	40	5	34	"	

The above tests were repeated, using the second pair in the 4-wire core as the "ordinary" loop. The same results were obtained as above.

2 Diffl. Dx. Up station	37 miles (Ordinary loop)	40	19	14·75	1	The induction from the ordinary loop is *nil*; from the bunched loop slight.
	(Bunched loop)	25	22	18·75		
Down station	(Ordinary loop)	36	19	15	1	No induction from bunched loop; very faint from ordinary loop.
	(Bunched loop)	25	22·25	16		

The tests in the 37-mile Wheatstone circuit were repeated with the other pair of the 4-mile core as "ordinary" loop. The results were as follows:

2 Diffl. Dx. Up station	37 miles (Ordinary loop)	40	19	14·75	1	The induction from the bunched loop was the louder.
	(Bunched loop)	25	22	18·75		
(Down station	(Ordinary loop)	36	19	15	1	The induction from the ordinary loop was the louder.
	(Bunched loop)	25	22·25	16		
2 Diffl. Up station	74 miles (Ordinary loop)	40	11·25	22·5	1	Bunched loop gives much greater induction.
	(Bunched loop)	40	20	36		

TABLE X (*continued*).

Set. No.	Length of Wheatstone circuit.	Main voltage.	Steady current to line.	Battery surge.	Listening in pairs.	Result and remarks.
Down station	(Ordinary loop)	40	11·25	22	1	Bunched loop gives much greater induction.
	(Bunched loop)	40	19·5	37		
Up station	(Ordinary loop)	40	11·5	22·5	1	Induction from ordinary loop very faint; from bunch loop louder.
	(Bunched loop)	40	13·25	26·25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from bunched loop faint; from ordinary loop louder.
	(Bunched loop)	25	13	25		

The tests on the 74-mile Wheatstone circuit were repeated, with the other pair of the 4-wire core as "ordinary" loop. The results are as follows:

Up station	(Ordinary loop)	40	11·5	22·5	1	Induction from ordinary loop faint; from bunched loop louder.
	(Bunched loop)	25	13·25	26·25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from ordinary loop louder.
	(Bunched loop)	25	13	25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from ordi- loop louder.
	(Bunched loop)	40	19·5	37		

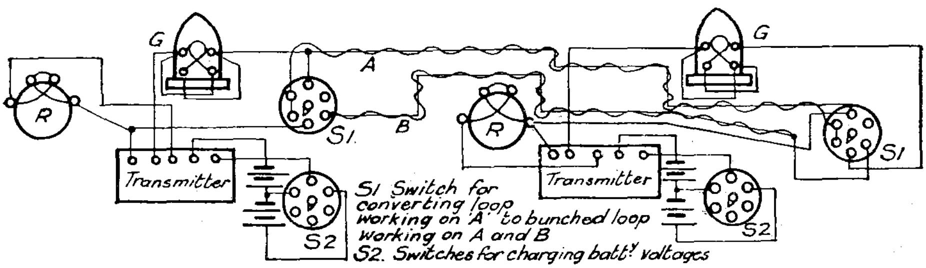


FIG. 10.

It will be seen that the results obtained in the foregoing test varied sometimes with the end sending. This possibly is due to difference in the balance of the pairs at the ends of the circuits.

Test 6 (F).—To compare the overhearing from Wheatstone working in (i) an ordinary loop, (ii) a loop circuit, each line consisting of two wires bunched; the *A* line consisting of the two "*a*" wires of the pairs in the same 4-wire core, and the *B* line consisting of the two "*b*" wires of the pairs in the same core.

A diagram of the connections for this test is given in Fig. **10.**

The results of the test are below:

TABLE XI.

Set No.	Single loop.			Bunched loop.		
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current in line.	Battery surge.
		M.a.	M.a.		M.a.	M.a.
2 Differential Dx. (186 miles) Sx. working:						
Up station . . .	40	3	22	25	2·75	25
Down ,, . . .	40	3	22·5	25	2·75	25·25

In both cases the bunched loop gave less overhearing than did the ordinary (single-wire line) loop.

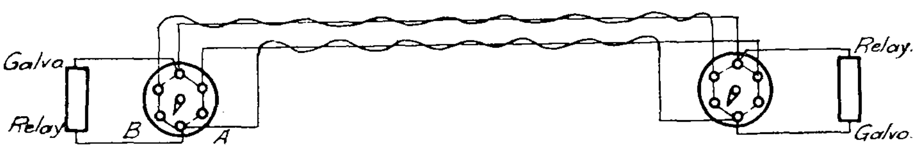


FIG. **11**.

Test 6 (G).—To compare overhearing in an ordinary loop with that on an earthed single line consisting of two bunched pairs (4 wires in the same 4-wire core).

The test on the bunched line was made with 20 volts. The line-current and battery surge were:

TABLE XII.

Set No.	Bunched single conductor circuit.		
	Main voltage.	Steady current in line.	Battery surge.
	Volts.	M.a.	M.a.
2 Differential Dx. (186 miles), Sx. working:			
Up station . . .	20	3·5	40·5
Down ,, . . .	20	3·5	41·0

The induction was prohibitive.

Test 6 (H).—To compare the overhearing on loaded telephone lines caused by Wheatstone working on bunched loop circuits when the bunched loops consist of (*a*) two-bunched pairs in the same 4-wire core, each pair forming one "leg" of the Wheatstone circuit; (*b*) two "*a*" wires bunched to form one leg of the Wheatstone circuit, and two "*b*" wires bunched to form the other leg.

The connections for this test were made as in Fig. **11.**

With switch in dotted position, one pair is bunched to form "*A*" line, and the second pair is bunched to form "*B*" line (position *A*). With switch in other position, two "*a*" lines are bunched to form "*A*" line and two "*b*" lines to form "*B*" lines (Position *B*). The values of the voltage, steady line-current and surge-current are given in the table below, which also shows the results of the tests. Speed, 150 words per minute.

TABLE XIII.

Set No.	Position of switch.	Main volts.	Steady line current.	Battery surge.	Remarks.	Result.
			M.a.	M.a.		
2 Differential Dx. (186 miles): Up station	*A*	40	4.25	39	4160$^{\omega}$ in rheostats at each end	Reversals running. *A* quieter and higher note than *B*. Slip running *A* and *B* equal in volume of sound in listening circuit but *A* gives higher note than *B*.
,, ,,	*B*	40	4	43·5	Ditto	Ditto.
Down ,,	*A*	40	4·5	34	,,	,,
,, ,,	*B*	40	8·75	37·25	,,	,,
Up ,,	*A*	40	8·75	39	0$^{\omega}$ in rheostats	*A* quieter and higher note than *B* with either slip or reversals.
,, ,,	*B*	40	8·75	43·5	,,	Ditto.
Down ,,	*A*	40	9	33·5	,,	,,
,, ,,	*B*	40	9	37	,,	,,

In all the above cases there was less induction (except in the first test when slip was run), when each leg of a bunched loop consisted of the two wires of a pair, than when the leg consisted of two "*a*" wires or two "*b*" wires bunched. This is probably due to the lower capacity given by the former arrangement, and consequently the lower surge-currents. The listening circuit consisted of the 166·5-mile loop made up of loaded pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 + 28.

Test 7.—Superposed Wheatstone working.

Three conditions of working were examined, as indicated in Fig. **12.**

From tests already taken it was known that conditions (*a*) and (*c*) give more overhearing than does loop working. Condition (*b*) according to Test 6 (*E*) would be permissible for a number of circuits so far as neighbouring loops are concerned. A circuit was made up on two lengths of 186 miles under condition (*b*).

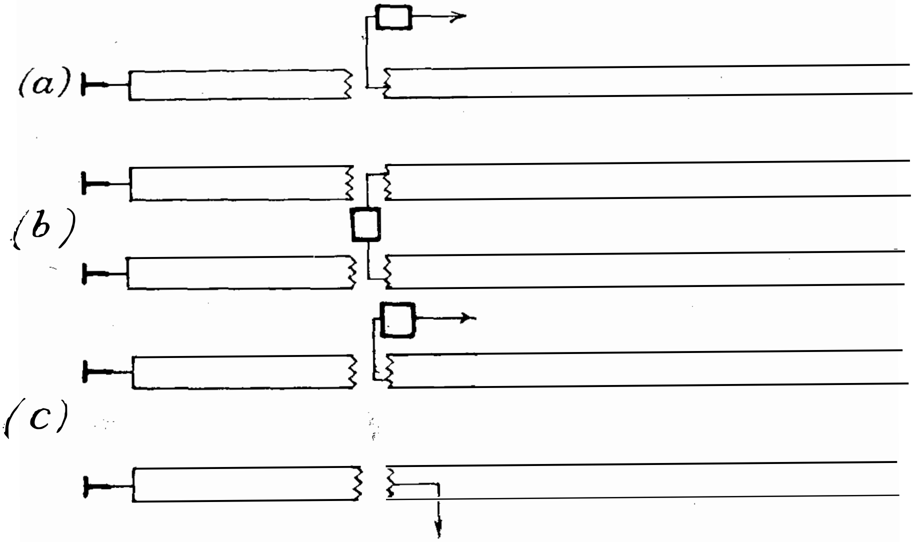


FIG. 12.

The values of the steady line current and battery surge current and volts were :

TABLE XIV.

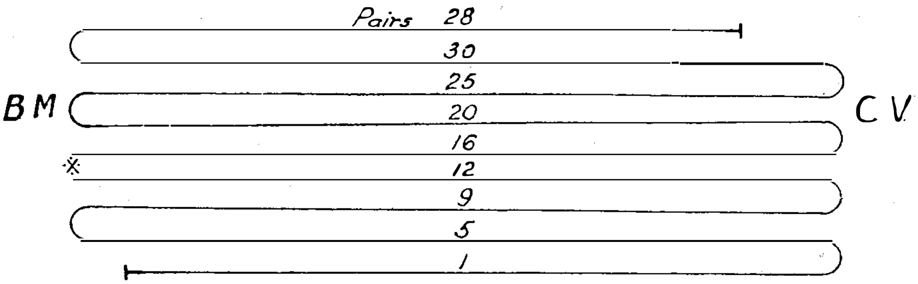
Set No.	Steady current in line.	Battery surge.	Main voltage.
	M.a.	M.a.	
2 Differential Dx. (186 miles)			
Dx. working :			
Up station	17·25	58	40
Down station	17	55	40
Sx. working :			
Up station	3·75	36·25	40
Down station	3·5	35·5	40

The overhearing on the circuits on which the telegraph was superposed was marked when the transmitter of the listening telephone was out of circuit, but was greatly reduced when the transmitter was in circuit.

Test 8.—To ascertain the effect on a long loaded line with a thermionic telephone repeater in circuit.

The telephone loop was made up as in Fig. 13.

The equated length of the circuit normally is about 40 SM; the insertion of the lamp reduced this by 18–20 SM. The Wheatstone transmitters were run at 150 words per minute, and the following values of voltage steady line current and battery surges were obtained.



* Single Lamp Repeater at Birmingham.

FIG. 13.

TABLE XV.

Set No.	Length of circuit.	Main volts.	Steady current to line.	Battery surge.	Remarks.
	Miles.	Up down.	M.a. Up down.	M.a. Up down.	
1 Bdge. Dx.	74	59 58	29 31	46 50·5	Values working. Sx.
2 Diffl. Dx.	186	40 40	8·5 8·5	39 37	Ditto.
3 Sx.	74	40·5	10	19	Resistances at receiving end readjusted to give 10 m.a. steady current.
4 ,,	74	39·5	10	17·5	
5 ,,	74	39·5	10	18·5	
6 ,,	74	39·5	10	18	
7 ,,	37	39·5	10	18	
8 ,,	37	40	10	15	
9 ,,	37	40	10	17·5	
10 ,,	37	40	10	17·5	
11 ,,	37	40	10	17·5	
12 ,,	37	40	10	17·5	

The induction from the Wheatstone was found not to interfere with the working of the telephone loop with thermionic telephone relay in circuit. The insertion of the relay had an effect similar to the closing of the transmitter circuit of a "listening" telephone, *i. e.* the "side tone" completely drowned any induction from the Wheatstones. The Wheatstone induction could more readily be detected when the lamp was not in circuit than when it was inserted. Speech over the telephone loop with the relay in circuit was very easy always.

These tests were repeated on a later date with the same results.

Test 9.—To determine the effect on working circuits when fourteen

Wheatstone transmitters are running in the cable. The Birmingham-Coventry trunks were listened-on with the following results:

Engng. No. 1	Circuit not in use	Subscribers speaking.
	No induction from Wheatstones	Quite quiet.
,, ,, 2	No telegraphic induction from Wheatstones	,,
,, ,, 3	,, ,, ,, ,,	,,
,, ,, 4	Quiet	,,
,, ,, 5	No induction from experimental sets	,,
,, ,, 6	Quite quiet	Howler on circuit.
,, ,, 7	,,	Quite quiet.

Summary of Results.

(1) Over loop circuit 186 miles in length a speed of 150 words per minute duplex can be obtained with 40 volts on the differential system and 60 volts on the bridge system.

(2) The induction on loaded telephone pairs is less from differential than from bridge Wheatstone working.

(3) If the steady line current is raised without altering the surge current, the induction on the telephone loop is unaffected. (The steady current may be varied without altering the battery surge current on a long line by adjusting the resistance at the receiving end.)

(4) The increase in the battery surge current caused by increasing the main voltage or speed of running increases the induction.

(5) Induction on the loaded telephone pairs is increased when the number of Wheatstones working on loops in the cable is increased, but the resultant noise is not proportional to the number of Wheatstone.

(6) Ordinary loop circuits working at 40 volts give about the same induction on a loaded telephone loop as single wire earth return circuits working at 20 volts, when the wire twisted with the line wire is earthed at each end so as to screen the line wire. If, however, the single-wire circuit is worked at a higher voltage, it gives greater induction than the loop.

(7) If "bunching" be allowed for the Wheatstone circuits in a cable, it is better to form each "leg" from a pair than from two "*a*" or two "*b*" wires of two pairs (the two "legs" must be in the same 4-wire core).

(8) If superposed Wheatstone working be permitted, the Wheatstone should be superposed on two telephone pairs and worked as a loop. In the trials made, the induction in the side circuits on which the Wheatstone was superposed was marked.

(9) When a thermionic telephone relay was inserted in a telephone cable line, the disturbance caused by induction from Wheat-

stones was not increased beyond the induction noted without the relay in the listening circuit.

(10) No degrading effect on speech was noted on the loaded circuits when fourteen 40-volt Wheatstone transmitters were running on unloaded loops in the same cable.

G.H.Q. SIGNAL OFFICE, FRANCE.

By A. Speight, late Capt., R.E.

Telegraphically and telephonically the Signal Office at G.H.Q. was the nerve-centre of the British Army's activities, and had direct communication with England, the armies and bases, also Paris and the allied armies' headquarters.

Early in 1918, during the period of the last German offensive, the traffic had increased enormously and the office accommodation was found to be totally inadequate. It was therefore decided to instal a new main office.

At this time the Germans commenced to bomb the back areas systematically, and it became imperative to remove the office under cover with all speed. The bombing was perhaps a blessing in disguise, as it certainly had the effect of speeding up the work generally, which resulted in the new office being completed in record time.

Considerable difficulty was experienced in finding a suitable home for the new office, as the French authorities needed all the places considered safe for use as "*abris*" for the civilian population.

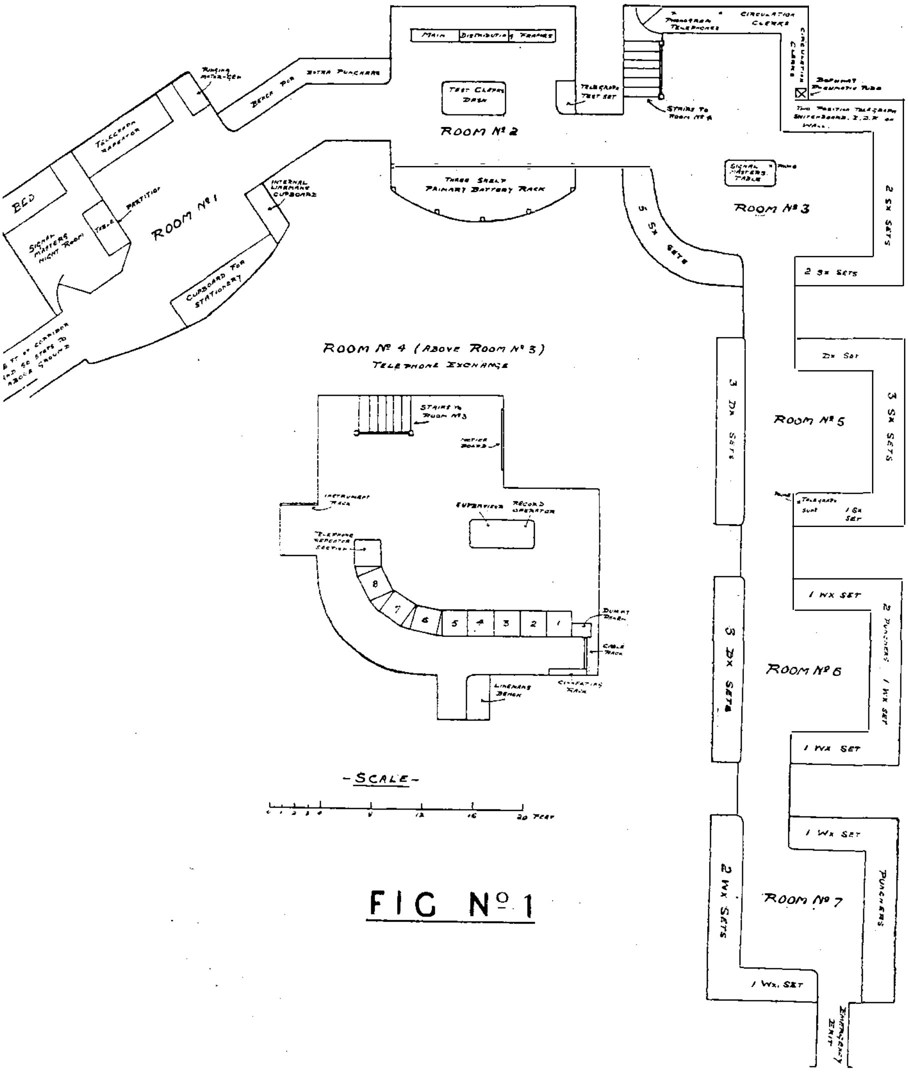
Eventually, however, we were allowed the use of a part of the old fortifications of the town. The walls of these fortifications are 5 to 6 ft. thick and have no windows, the only natural light coming through loop-holes typical of the period in which they were built. It was necessary to descend a flight of steps and traverse a long corridor before one gained access to the chain of dimly-lit rooms.

Lay-out.

No ideal lay-out scheme was possible; the best use had to be made of every inch of space below ground, and the arrangement shown in Fig. 1 was adopted.

Above ground were located huts accommodating the men's mess, the linemen, the public office for the reception and despatch of messages, the cycle orderlies and despatch riders. The power plant for electric lighting was housed in a semi-underground chamber some distance away. A pneumatic tube was installed between room No. 3 and the public reception office above ground.

Although the rooms were whitewashed twice, and one and a-half tons of lime used, it was necessary to use electric light almost con-



LAY-OUT OF SIGNAL OFFICE.

tinuously, and some difficulty was experienced in connection with the heating and the prevention of draughts. No doubt some of the present "T.S." operators could speak feelingly on these matters. Despite these disadvantages, however, the rooms served their purpose as an office where work could proceed in safety during air raids.

Telephones.

Telephonically, the G.H.Q. area could be regarded as a collection of private branch exchanges, and the G.H.Q. main exchange was practically a trunk and junction exchange with a small number of locals.

The traffic was heavy, the calling-rate high (practically twice the highest rate ever recorded in home practice), the holding time long, and the peak loads occurred at unforeseen times. The operating was very fatiguing in view of the fact that rarely was a desired correspondent asked for by his number.

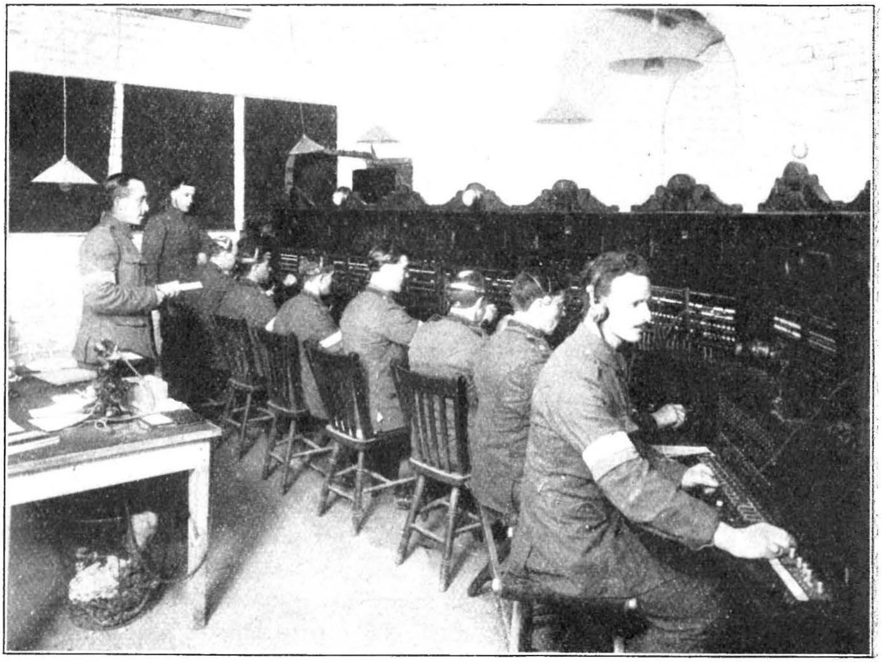


Fig. 2.—Telephone Exchange.

The only switchboard sections obtainable quickly were N.T. magneto one-position sections, and these were installed, each being equipped for twenty locals and twenty junctions or trunks. There was no I.D.F., but the junction equipment allowed some degree of flexibility in the matter of the operator's load. Everything possible was done to reduce the load and assist the operating. Each position was fitted with an outgoing order wire to a trunk record operator who recorded requirements, thus eliminating clerical work at the switchboards during the busy periods, and "tie" lines were installed between many of the P.B.Xs. In the signal office itself direct circuits were provided between the signal master, telegraph superintendent, telephone superintendent, test room, power house, external linemen, despatch riders, letter service clerks and the public counter clerks. Any one of these could call the others without troubling the exchange, and this facility materially helped to reduce the load on the exchange.

The switchboard was fitted with a junction and trunk multiple, and also a local multiple, each being repeated every four panels. The multiple markings were made to confirm as near as practicable with standard practice. Power ringing from a "motor-generator, No. 1" was installed.

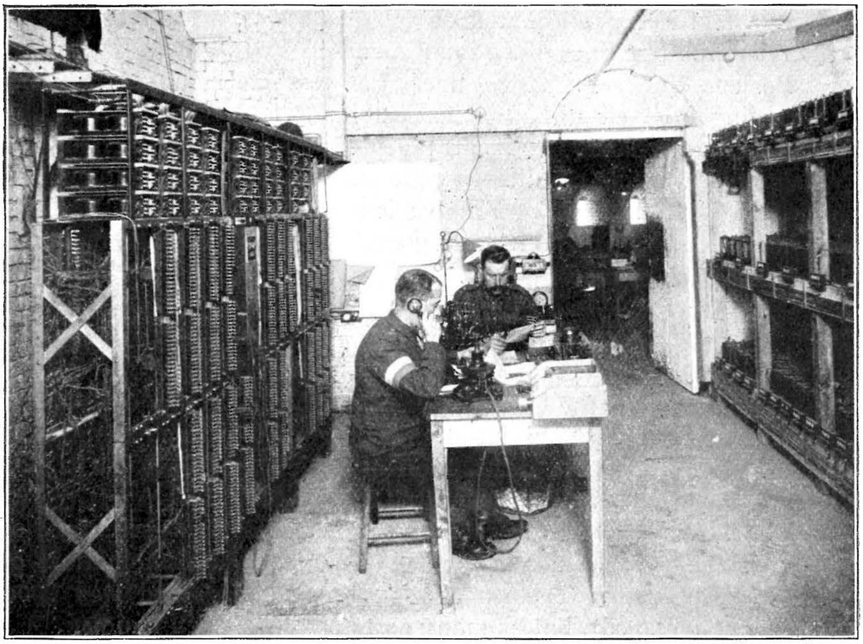


FIG. 3.—TEST ROOM.

TEST ROOM.

The test clerks at G.H.Q. had an unenviable job. This will be understood when it is realised that the majority of the circuits, telephone and telegraph, were long, and had test points at infrequent intervals. It was essential that communication must be maintained either by making up good circuits from faulty ones, or by choosing alternative routes. The armies were constantly on the move and the circuits ever changing. Almost the whole of the trunks were phantomed or superposed for telegraphs, and in many cases both. The Channel submarine circuits and telephone repeaters (fitted later by the Signal Service) further complicated the testing, and added to this a fair knowledge of the French language was necessary for testing on French circuits.

As regards the testing arrangements, the test sets attached to the three portable test frames were removed and fitted in more convenient positions. These sets were in almost constant use and proved to be a great help. The "detector No. 2," with its calibration tables, enabled approximate tests of insulation and conductor resistance to be taken quickly. It is desired to place on record the ideal manner in which these test frames met the requirement.

The various test points along the routes were connected to omnibus circuits, either telephone or telegraph, or both, and at G.H.Q. test room terminated on telephone sets, or, in the case of the telegraph test lines, on a small made-up switchboard.

Besides direct exchange lines, the test clerks' table had ten "plugging up" circuits, used for extending faulty lines which the linemen had in hand. This arrangement obviated the necessity for "tapping" working circuits—a practice which it was found general officers objected to very strongly; it further helped to reduce the exchange load. The fault-finding was effected by linemen mounted on either push or motor cycles.

TELEGRAPHS.

Telegraphically the G.H.Q. office was located at the centre of a network of circuits, and besides dealing with a large number of messages the origin or destination of which was G.H.Q., it also handled a large traffic in transmitted messages.

The traffic was of an exacting nature, as a large percentage of the messages were either in cypher or made up of combinations of letters and figures. The usual twenty-four hours' load was 9000 messages (averaged), but as many as 14,000 have been handled.

The main objects aimed at in the new office were:

(1) Standardisation of the arrangement of the apparatus on the sets, and the elimination of minor faults.

(2) Provision of the greatest flexibility as regards connections between lines or between lines and sets.

A telegraph I.D.F. was provided by utilising a portion of a portable test frame, and on this frame were terminated all telegraph circuits after they had passed through the main frame. Here also terminated the lines from the telegraph sets and the leads to the telegraph switching position or concentrator. Two leads were run from each set, so that any set could be made "intermediate," and reversing keys were fitted on each set. This arrangement provided the greatest flexibility, as any set could be connected to any line either as "up," "down" or "intermediate," lines could be joined as "through" circuits, and any line or set terminated on the telegraph switchboard.

As telegraph wires working Wheatstone were carried on the same poles as telephone trunks, it was found necessary to introduce apparatus on the sets to minimise the inductive disturbance. This was accomplished by joining a bridging coil No. 4 A, $200^{\omega} + 200^{\omega}$ (the two coils paralleled), in series with the transmitter and shunting the transmitter with a 0·25 mfd. condenser.

For the source of battery-power it was considered best to have a separate group of cells, both main and local, for each instrument, and a few groups in reserve for rapid change-over. This was found to be satisfactory and allowed a circuit to be treated individually. The primary cells used were accommodated on a battery rack in the test-room. Terminal blocks, each carrying a non-inductive resistance inserted in the main copper lead, also a label for designation purposes, were mounted on the face of the rack opposite each group of cells.

Telegraph Switchboard or Concentrator.

It has already been mentioned that flexibility of connection between all circuits was essential. The provision of the facility in a practical form was a problem that called for attention in the early months of the war, as soon as the number of circuits began to grow. From crude methods, such as bullet and cartridge case switchboards, the matter was developed until at least one base headquarters had installed a P.O. concentrator of standard pattern.

On examining the question it was found that "concentration" *per se* was of little importance, as the required facilities were almost identical with those given in a telephone exchange, viz.:

(1) A distant office called and requested to be connected either to G.H.Q., or to another office.

(2) To save re-transmission, it was desirable that G.H.Q. should be intermediate, when required.

(3) The traffic was so heavy that the operator had not time to remain in circuit and continue calling, by hand, an office which did not reply promptly. Neither was it desirable to make connection and allow the originating office to try to call; therefore automatic calling was almost essential.

(4) A clear or "ring-off" signal was desirable.

(5) To allow a full load to be carried by each circuit it was essential that the switching operations should be simple and rapid.

It was not possible to provide lines calculated to take care of "freak" loads, so the only alternative was to speed up on the switching position, where the average delay in completing connections was often seven hours. There was no time to go into the question thoroughly and design a switchboard that would meet all these conditions. The system used on the Met. Intercom. Switch was much too complicated, and it was decided to leave the facilities stated under (3) and (4) for future consideration and to provide the others. The most promising method appeared to be to follow the lines of a telephone switchboard, because of the ease with which a telephone key can be manipulated. As a cord connection was necessary, the new switchboard was of single cord design, with keys in circuit on the line. Plans showing the arrangement and equipment of a 5-panel 2-position switchboard, together with circuit diagrams, were sent home and the board was made up by the

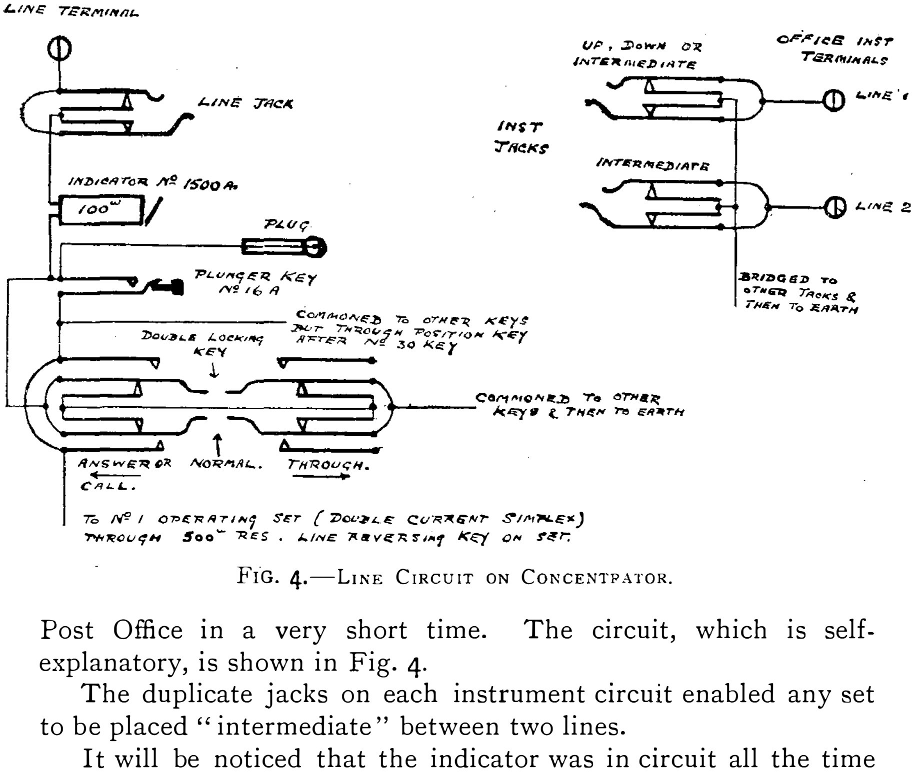


FIG. 4.—LINE CIRCUIT ON CONCENTPATOR.

Post Office in a very short time. The circuit, which is self-explanatory, is shown in Fig. 4.

The duplicate jacks on each instrument circuit enabled any set to be placed "intermediate" between two lines.

It will be noticed that the indicator was in circuit all the time during connection, and, being of the short armature Ericsson type, responded to the signals passing. In the case of Wheatstone working there was a slight buzzing noise varying according to the speed of transmission, and for hand-signalling the signals were distinctive but sounded reversed. It was found that the operators developed a wonderful faculty for reading the indicator sounds and could often tell what was happening on a circuit. The key No. 16A (of the spring plunger type) was, however, used for supervision, and provided a means for the operators to run over the connections rapidly for "listening in" purposes.

Later, when experiments with automatic clearing were being carried out, the wiring was altered so that the indicator was not in circuit when connection had been established.

The installation of the new switchboard resulted in much quicker operating and a big reduction in the average delay in completing connections.

At a later date head-gear sounders were installed and an attempt was made to provide facility (3) (automatic calling). "Plugging-up"

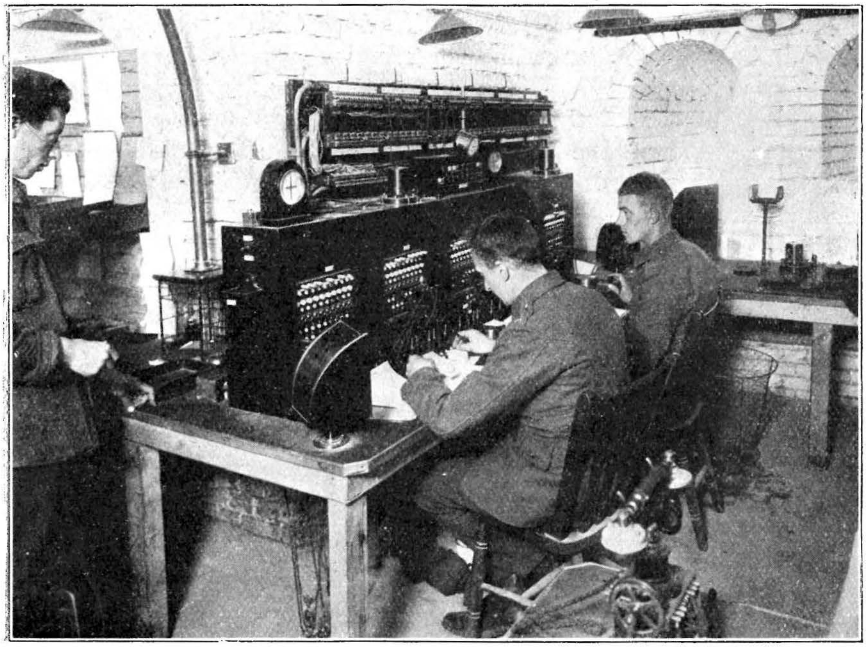


FIG. 5.—TELEGRAPH CONCENTRATOR.

jacks were fitted on the switchboard, and if a distant office did not respond immediately, the plug of the line called was placed in one of these jacks and an automatic call given until they answered. When they answered (*i.e.* placed earth battery on the line by turning the switch to "send") the auto call was disconnected and the G.H.Q. operator informed visually.

This was merely an arrangement to give an intermittent call in the same manner as automatic ringing in a telephone exchange. As there was no rotary interrupter available and pendulum devices were not feasible, the interruptions were obtained from two electrolytic cells joined in opposition, which actuated a P.O. standard relay used for control. The armature of this relay moved from stop to stop in accordance with the reversals in the direction of current produced by the electrolytic cells being charged by a 4-volt battery. A second relay reversed the direction of the charging current each time the first relay was operated. The second relay, in series with other relays associated with the "plugging-up" jacks, placed either earthed battery or generator current intermittently on the jacks.

If at the distant station the line terminated on a switching position equipped with P.O. non-polarised indicators, the earthed battery current effected the call, but if the line terminated on a telegraph set the earthed generator current "rattled" the sounder. When the called station answered, the earthed battery (from the distant station) dropped an indicator associated with the "plugging-up" line concerned. The indicator shutter short-circuited its associated relay, and thus disconnected the intermittent call from the line. When the plug had been withdrawn the indicator shutter was restored.

In connection with facility (4) (clearing signal) the usual methods hitherto employed depend on the connected stations giving a clear, either by depressing a battery-key or ringing by means of generator current. Neither of these methods was practicable, and, if the clear was to be automatic, a relay was required which would satisfy the following conditions:

(1) To be operated whilst a steady battery current of, say, 20 m.a. was passing through it in either direction.

(2) To remain operated whilst the above current was reversed when on a double-current key-worked circuit with all speeds of hand-sending.

(3) As in 2, but on a Wheatstone automatic circuit.

(4) The relay to release when no current passing, but not until thirty seconds after the cessation of the current.

(5) The electrical properties of the relay to be such that it could be joined in series with a telegraph circuit, either key or high speed, without causing deleterious effects.

Condition (4) was desirable because at the end of the message the receiving station might forget to turn the switch to "send" while checking message before sending "R.D.," and so give a premature clear during the short interval when no current was on the line. To provide for this meant either a sounder silencer device or a slow-acting relay such as a dashpot, and as neither of these was at hand it was decided to enforce the Signal Service rule that the receiving station must turn the switch to "send" preparatory to giving "R.D." There were no telephone relays to experiment with, but it was found that a "Bell No. 13A" almost satisfied the remaining conditions. The spring was removed, the bell fixed so that the armature was gravity controlled and adjusted finely. In this manner the bell was used as a relay in series with the line (a clearing lamp being controlled by the key), and it behaved well at all speeds of transmission up to about 150 words per minute, which was the maximum as regards the Signal Service in France.

When the last allied advance was in progress the number of circuits grew to such an extent that the capacity of the switchboard, although previously adequate, was soon overtaxed, and designs were in course of preparation for a new switchboard.

It was intended to instal five N.T. No. 7 sections with a multiple for both lines and office instruments. Double-cord working was to be adopted with headgear sounders. "Busy back" and automatic calling were to be provided from a mechanically driven interrupter. An attempt to improve the automatic clearing was to have been made, either following on the lines previously mentioned, or by making use of rotating mechanism to do away with premature clears. However, the signing of the armistice happily rendered this unnecessary.

External Plant.

Although space will not permit of this portion of the work being treated fully, it would not be right to conclude without some reference to it.

The signal office had to be removed from one corner of the town to another, the crow-fly distance being about ½ to ¾ mile, and extensive dimensions of aërial trunk and telegraph routes were necessary. As the town had a wall or rampart completely surrounding it, the aërial routes had to make detours through the fields to arrive at the desired point for leading-in. In the town itself the majority of the subscribers were served by field cable slung from point to point, and in some parts the buildings were festooned with a score or two of twin cables which had accumulated during two years. The cables had rotted, and when a fault developed the safest plan was to run a new cable and not disturb the others, as an attempt to withraw the faulty cable only caused further faults. A clean sweep of these cables was accomplished by laying underground cables to a convenient distributing point, from which radiated six routes of aërial lead-covered cables. Distribution boxes were fitted in the different areas and the local stations fed from them. For the most important area, which was very dense and contained seven P.B.Xs. in one block of buildings, three 40-pair underground cables were laid direct from the signal office by two different routes to give security.

The trunk and telegraph aerial routes, of which there were fourteen, were diverted, and the terminal poles spaced in groups of two or three round a large semi-circle about ¾ mile from end to end in order to prevent the whole of the routes being damaged by bombing. One D.P. pole in each group was served by underground cable from the signal office, and cab-tyre aerial cable was run from a pole test-box to each pole in the group. Whenever possible the terminal poles were hidden by trees, and in some cases the terminal was camouflaged by continuing the route for some distance beyond the leading-in point.

In connection with the underground cable it is interesting to note that Capt. Rosser, of the American Signal Service, very kindly loaned to us an underground cable gang, who carried through all the jointing in a first-class manner. When digging the cable trenches a number of skulls and an old cannon-ball were found.

The change-over from the old to the new office took place on a Sunday morning at 0100, and went through with only one M.D.F. jumper fault and one circuit lost outside. This was considered satisfactory in the circumstances, which involved men working up poles in the darkness on diversions; in one case at least a route was used temporarily for two other groups of circuits before it received its permanent ones. From commencement to completion the work occupied one month and three days.

G.H.Q.: ARMY OF THE RHINE.

In ordinary circumstances the installation of a 1000-line C.B. exchange is regarded as a commonplace operation in the work of a telephone engineer, but the unusual conditions under which the erection of the G.H.Q. exchange for the Army of the Rhine was carried out may justify the publication of the following description of the job.

During active operations in the field the army had laid down and maintained its own communication systems, but as the forces of occupation debouched from the bottle-neck of Verviers and extended along the Rhine valley they took possession of existing networks, for the German lines had come unscathed through the war. The Commander-in-Chief took up his headquarters in Cologne, with army corps stationed at Bonn, Duren and several other strategic points. The British Army was in touch with the Americans between Bonn and Coblentz, and with the Belgians just outside Dusseldorf and in Aachen (Aix-le-Chapelle); our sphere of influence extended also over an irregular arc some twenty-five kilometres across the Rhine.

With a view to minimising the disturbance in the commercial life of the city, the army authorities determined to leave intact the exchange switchboard positions, but Rhine Signals took control of the distribution frames and external lines. The civil local exchange, a C.B. one, installed by Siemens and Halske, has a capacity for 18,000 lines—with about 10,000 working—and the trunk exchange, on the floor below in the same building, about 200 lines. Very few of the latter were working—only lines to towns in the occupied area—and the switchboard had a very desolate appearance. The exchange is situated in Cäcilien Strasse, off the Neu Markt, the geographical and telephonic centre of the city, and distribution is effected mainly by radial underground paper-core cables. A fine roof standard carrying about 1000 lines serves several main over-house routes.

IG. I.—DEICHMANN HOUSE, PILLARED BUILDING ON RIGHT. C.-in-C.'s HQS. ON LEFT. BRITISH TROOPS CROSSING THE DOM PLATZ IN FRONT OF CATHEDRAL.

The Signal Service on entry had installed a temporary magneto exchange in Deichmann House, a large building facing the main entrance to the central railway station, which also accommodated the telegraph signal office, and had connected it to street cables from the civil exchange. Scattered all over the city, most densely in the neighbourhood of the station and cathedral, were many small boards of various types, including a number of German P.B.Xs. requisitioned by the army. Intercommunication between the military and civil lines was accomplished by means of a 60-line German P.B.X., situated in the centre of the civil switch-room and operated by a German-speaking R.E. sapper.

The service given by this arrangement was not satisfactory, owing to the large number of operating points and their diverse character. In order to make the best and most efficient use of the cable plant it was clear that the army exchange also should be in the telephonic centre, and it was decided to erect a new switchboard in the building in Cäcilien Strasse. Inquiries were made at home for a C.B. equipment. The only sections available were B.E., C.B. multiple, No. 9, and although the cord circuits on these boards are not intended for use in public exchanges, the army authorities accepted them in view of the urgency. The sections were stocked

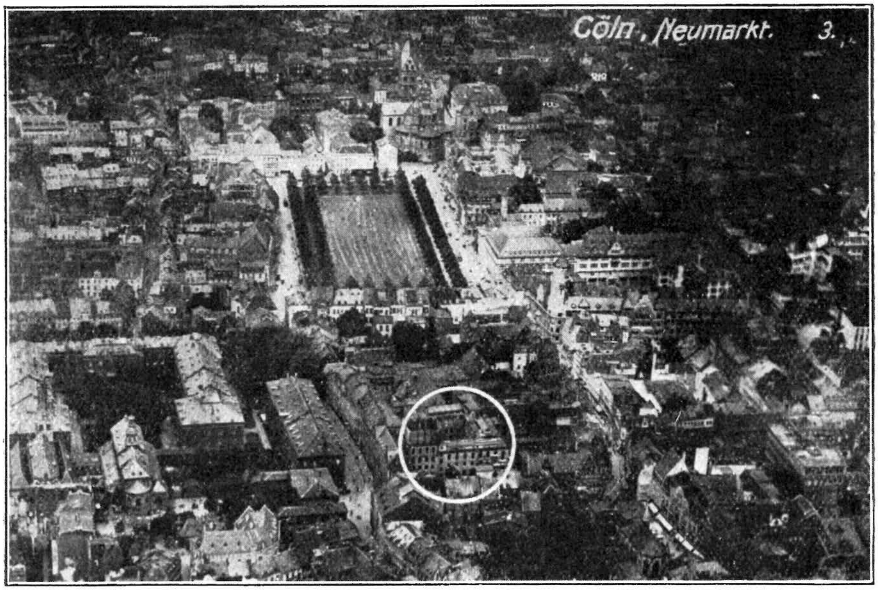


FIG. 2.—COLOGNE FROM AEROPLANE. CIRCLE ENCLOSES CIVIL TELEPHONE EXCHANGE.

in accordance with rate-book detail, but the Western Electric Company speedily modified or increased the apparatus to requirement, and on April 12th, 1919—less than four weeks after the demand had come forward—the goods were despatched from London Docks *viâ* Rotterdam and the Rhine.

The equipment included the following:

18 sections, ordinary, fitted each with 10 exchange and 60 extension lines, 17 cord circuits and 1 order wire.

1 trunk section, fitted with 10 trunks and 12 special trunk cord circuits.

1 test section, also fitted, in addition to standard testing apparatus, with 10 trunks and 5 trunk cords as spares.

Cable turning section and end panel to close suite.

The multiple jacks, 461 strips in all, were cabled at home and despatched in separate cases. Each section had its return cable length coiled up inside. Estimated lengths of switchboard cable to connect the multiple to the I.D.F. were sent on drums.

2 test frames, portable, 160 pairs.

16 transformers, No. 6 double.

10 B.E., C.B. cordless switchboards, $\frac{3 + 7}{10}$.

5 B.E., C.B. switchboards, $\frac{5 + 20}{25}$.

2 ,, ,, ,, $\frac{10 + 50}{65}$.

600 telephones, No. 2.

600 bell sets, No. 1.

2 miles, cable, E and C core 3-wire /10.

5 miles, wire, F.P., 1 pair /12½.

200 condensers, M.C. 2 mf.

Spare items: solder, tools, twine, 2 "old-iron" racks, cable brackets, pins and cleats and all the paraphernalia which we did not think we could obtain on the job were also taken. We were to use the German battery (12 cells, by the way) and ringer, and power cable for the purpose was included.

The installing party, consisting of the writer and five wiremen, three from Holloway and two from Birmingham, left Charing Cross at 11 a.m. on the 16th, and travelling by the Boulogne–Cologne express—a converted hospital train—reported at Deichmann House, Cologne, at 5.30 p.m. on the 17th. Capt. Kemp, the Adjutant of the Rhine Signal Battalion, had arranged for our billets, the five men going to the Gladbacher Hof in Richmod Strasse and myself to the Park Hotel, Hohenzollern Ring. Lieut.-Col. Watson, the O.C., gave us a hearty welcome, which was damped a little by the news that the equipment had not yet left Rotterdam.

I found the Park Hotel—where I was billeted against the wishes of the proprietor, whose countenance bore evidences of having been at the wars—rather noisy as closing time drew near, and I deemed it expedient to lock my bedroom door the first night, as I was the only Briton quartered there. Later, I managed to secure a transfer to a flat in a private house in Richard Wagner Strasse, behind the Opera House. My landlord, one Heinrich Phillip, a Prussian of independent means, according to the list of inmates stuck up behind the door that all may read, inquired what the "W" on my card might stand for? "Wilhelm," I replied. "Ah!" sighed the old man, "Der oder Wilhelm ist unten." The other William—what a falling-off was there—once "Meinself und Gott," now perilously near the other extreme, bracketed with a poor P.O. engineer!

On our first visit to the civil exchange we found that the position originally selected for our board had been changed to meet the wishes of the German authorities. Instead of being on the same floor as the I.D.F., upon which I had estimated my cable lengths, we were going to instal on the floor below. What about getting through the floor and what about the additional cable ? I put the question bluntly to the Ober Direktor. No solution. The building was a ferro-concrete one, very difficult to cut through. They had no cable : the army had taken it all to Belgium and had left it there. The tempting retort to this was that their departure had been too hurried to admit of the recovery of signal stores, but the point was not pressed. The floor must be cut through, a hole 30 x 15 cm., at the position indicated by noon to-morrow was the final decision. Grave shaking of grey and portly heads, and a long discussion amongst the group of uniformed officials followed. Ultimately the situation was saved by the arrival of an underling who knew the building and the exchange from A to *Z*. There was a cable chute down inside the wall, leading from near the I.D.F. into a channel along the floor of room below. Good old Trotsky ! Christened so by little Birbeck of Holloway, you were a good friend to us all through, and even though you did render Birbeck's new flannel shirt "*caput*" with your *ersatz* soap in the wash, we bear no ill feeling on that account and wish you many happy days. Later in the afternoon the authorities presented the only cable they possessed—a short length of 250-pair paper-core cable. None could be obtained from Berlin. I wired to "Engchief, Designs, London," that evening for 2800 yards of switchboard cable, which arrived in due course by rail route.

The non-arrival of the equipment caused us much anxiety, and for a week we searched the docks and river for Barge Mannheim No. 65, on which the stores were said to have left Rotterdam. Ultimately, after we had begun to think that there was "no sich barge," she was located in a string of similar craft at Emmerich near the Dutch frontier, and I persuaded the Inland Water Transport authorities to hitch a special tug on to her and bring her up promptly. The work of unloading was immediately taken in hand. Three-ton lorries and a working party were put at our disposal, and all went well for a time. Fore holds Nos. 1 and 2 were emptied quickly by means of a steam crane on the quay. This crane could not, however, reach the aft holds. Another travelling crane farther down the river was idle, although the berth opposite it was occupied, and I gave instructions to bring it along. The German stevedore said that it had not been moved for ten years and was probably rusted in. I thought we could shift it. Dockers were put on the winch overhead, and a three-ton lorry was secured to the legs by a stout wire hawser. The lorry backed, and came forward full tilt. The hawser snapped swung round and cut off a lamp post as clean as a whistle at the ground line. "*Ce ne fait rien ; c'est la guerre,*" as our allies say. We hitched up four lorries on that crane and could not budge it. Next morning—nobody except ourselves worked after 4 o'clock—I did the obvious thing; we shifted the barge below ours, and drifted No. 65 down to the crane.

Many of the cases had suffered somewhere on their journey from damp, and it was very encouraging to see the packing-case emblazoned "Test Section" in mid-air with the water running out of the

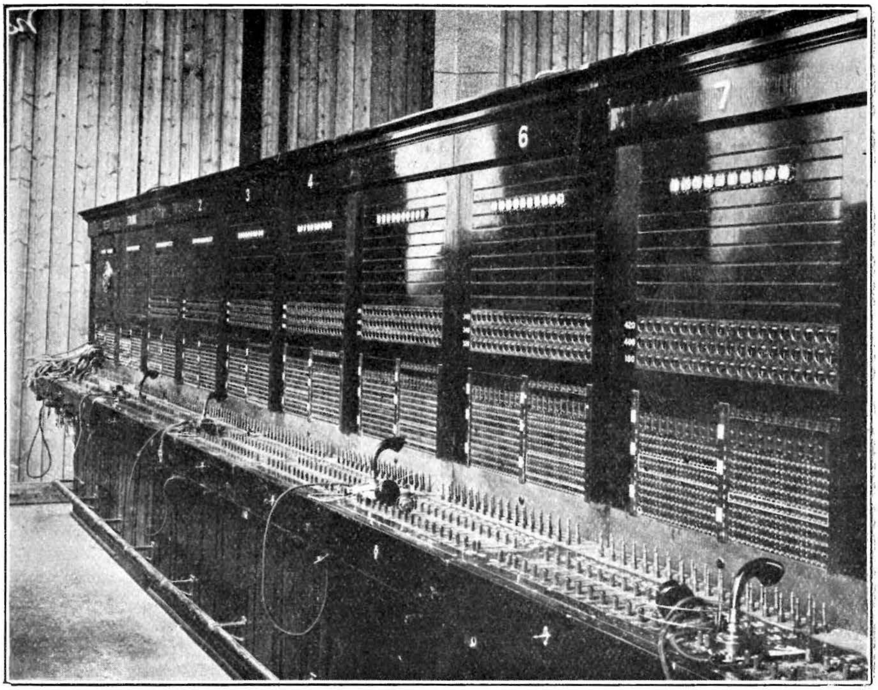


FIG. 3.—FRONT VIEW OF SWITCHBOARD, SHOWING FIRST NINE SECTIONS.

case. The insulation resistance across the tip and ring of the test plug measured less than 1000 ohms. The cords had to be dried out; the pivots and irons of the apparatus on nearly all the sections were rusty and had to be thoroughly cleaned. One section was badly damaged.

In spite of this, however, once we got the sections aligned the work proceeded at a good pace. We ran nearly five miles of jumper wire on the German main frame, teeing-on to the military lines at the exchange side of the protectors—there are no fuses on the frame—and running the jumpers along the frame, over a runway and rack and down to verticals on the I.D.F. As the circuits were scattered all over the M.F. it was not possible to use cable for this part of the work. From the I.D.F., switchboard cable, in 70-metre lengths, was run down Trotsky's chute into the channel and up into the sections. The trunks and junctions (with the exception of the junctions to the civil board, for which a special circuit had to be devised) and the telegraph circuits from Deichmann House were carried through the portable test frames for superposing purposes. The frames were erected just behind the test section, which came first in the suite, the trunk section coming next. The test plug was multipled to a spare

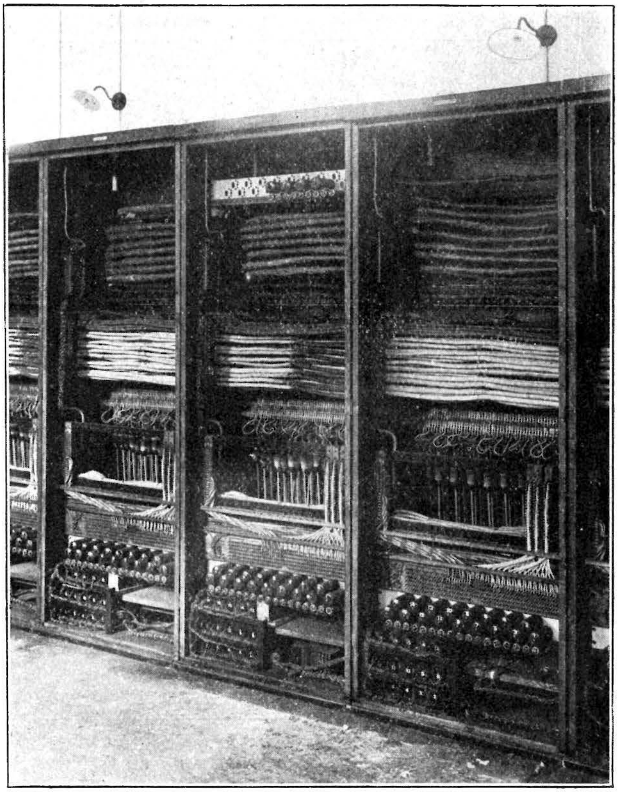


FIG. 4.—BACK VIEW OF SECTIONS, WITH DOORS REMOVED.

plug at the extreme end of the suite, so that tests could be made at the end of the multiple as well as directly on the lines. The jumpers on the I.D.F. were not soldered until the multiple was cabled and in position, and had been plugged up on the first four panels by pegs No. 16, and by dummy wooden pegs we had obtained from the Germans on requisition. Owing to the haste with which the material had been despatched the jacks were not so perfect as they might have been, and many shorts and contacts had to be cleared. Testing-out was done mostly in the evenings and during the night. Testing facilities on the M.F. were provided by means of spare jack strips, which were mounted and wired to the test position.

The trunks included lines to War Office, Montreuil, Wimereux, Spa, Brussels, Antwerp, Rotterdam, Berlin (British Mission), Aix-la-Chapelle and Coblentz. These were not multipled, but the local and junction multiple appeared on the position. An order-wire was run from each subscriber's position to the trunk position, where records were kept. The junctions were lines to the Army Corps Headquarters, Cavalry Divisional Headquarters, Tank Corps, I.W.T., R.A.F., and Naval Headquarters, and to the Civil Exchange. On most of the foregoing, telegraphs were superposed, two cables to Deichmann House being utilised for this purpose, terminating on the portable test frames and jumpered to the tranformer taps.

In the meantime Capt. Carter and Lieut. Shields had been preparing a directory, and everything was ready for the change-over. This was accomplished by withdrawing our plugs in the multiple and inserting similar plugs at the same moment in the multiple at Deichmann House. The jumpers connecting the lines to the cables to Deichmann House were then cut, and, incidentally, little danger of mistaking the jumpers was possible, as the rich blue and blue-red of the P.O. flame-proof wires stood out distinctively against the dingy colours of the German insulation. Some difficulty was experienced in making the Army use the directory. The problem was solved by the opening of an inquiry position, in charge of an officer who is the possessor of a wide and varied acquaintance with the subtleties of modern English. All callers who asked for a name or an official instead of a number were plugged through without comment to "Inquiry." Then the fun began. It was fortunate that the Post Office uses flame-proof wire! The directory was used properly in a very short time.

Much could be told of our personal experiences at a time when there were very few English civilians on the Continent, but the place for the telling is not the pages of a technical journal. At St. Andre, near Lille, we were asked if we had come about the huts; at Ypres, on our journey across the devastated area, we were asked if we were looking after the graves; and on landing at Dover a harbour official inquired if we were the Russians! My mind went back at once to a certain morning in the fateful autumn of 1914 when a Belgian skipper assured me with graphic fervour that he had just seen 12,000 Cossacks landed from England at Blanckenberghe. Were we the sorry remnant of that mysterious army? In these later days, when the captains and the kings depart without let or hindrance, it might be argued, more or less profitably, that after such unimpeachable evidence there was some truth in the Russian story after all.

W. C.

COMPLIMENTARY DINNER TO SIR ANDREW OGILVIE.

PROBABLY one of the most distinguished gatherings connected with the Post Office met at the Connaught Rooms on January 23rd to do honour to Sir Andrew M. Ogilvie, K.B.E., C.B., Joint Second Secretary to the Post Office and Director of Army Signals (Home Defence), upon the occasion of his retirement from the service. The occasion was marked by a complimentary dinner to Sir Andrew, at which some 200 members of the Post Office Staff (London and Provincial) were present, representative not only of the service generally but also of the Army Signal Service. Practically all Heads of Departments and all military ranks from sapper to brigadier-general were present, and the intermingling of those in their respective uniforms and decorations with the more conventionally attired members made the scene both spectacular and memorable. Major T. F. Purves, O.B.E., R.E., M.I.E.E., Assistant Engineer-in-Chief, presided, and among those present were :

Mr. Robert Ogilvie ; The Rt. Hon. H. Pike Pease, M.P., Assistant Postmaster-General ; Mr. W. Noble, M.I.E.E., Engineer-in-Chief ; Sir William Slingo, M.I.E.E., late Engineer-in-Chief ; Sir Robert Bruce, C.B., Controller, London Postal Service ; Brig.-General W. Price, C.B., C.M.G., Secretary for Scotland ; Brig.-General J. P. McGlinn, C.M.G., C.B.E., Australian Imperial Force ; Mr. W. G. Gates, C.B., Mr. F. J. Brown, and Mr. A. R. Kidner, Asst. Secretaries ; Mr. R. J. Mackay, O.B.E., late Asst. Secretary ; Mr. W. H. Allen, O.B.E., Controller, Stores Dept. ; Mr. G. Morgan, C.B.E., I.S.O., late Controller, Stores Dept. ; Mr. G. F. Preston, Controller, London Telephone Service ; Mr. John Lee, M.A., Controller of Telegraphs, London ; Mr. R. A. Dalzell, Chief Superintendent of Traffic ; Mr. Eustace Hare ; Mr. J. I. De Wardt, O.B.E. ; Mr. A. Moir, O.B.E., Superintending Engineer, London ; Major H. C. Gunton, Principal Power Engineer ; Mr. J. McL. Robb, O.B.E., Mr. J. F. Lamb, and Mr. F. Tandy, Superintending Engineers ; Mr. A. L. De Lattre, Mr. J. Sinnott, Mr. S. A. Pollock, and Mr. E. H. Shaughnessy, O.B.E., Staff Engineers ; Col. T. Kelly, C.M.G., D.S.O. ; Col. C. B. Clay, London Electrical Engineers ; Col. W. B. Vince, D.S.O., M.C., Post Office Rifles ; Lt.-Col. Wheeler, O.B.E. ; Lt.-Col. W. G. Carter, M.C. ; Major Angwin, D.S.O., M.C. ; Major W. Batchelor, D.S.O., M.C. ; Major H. Brown, O.B.E. ; Major G. H. Comport, M.C. ; Major H. E. Higginbottom ; Major A. A. Jayne, D.S.O., O.B.E., M.C. ; Major D. H. Kennedy ; Major J. R. Kingston, and Major A. G. Lee, M.C.

Mr. PIKE PEASE proposed "The Guest of the Evening," to whom he paid a warm tribute. The toast was supported by Brigadier-General PRICE, who dealt particularly and appreciatively with the military side of Col. Ogilvie's career.

Major PURVES said: Gentlemen, Mr. Pike Pease and General Price have well expressed what is, I am sure, in all our hearts, but I cannot refrain from exercising the chairman's privilege of butting-in with just a word or two. We are accustomed to saying an official good-bye to our colleagues with more or less tranquillity, for in most cases we can comfort ourselves with the reflection that it does not involve the complete severance of personal relations. That, we may well hope, will also apply to the retirement of Sir Andrew Ogilvie, but in his case the mere official farewell carries with it a particular element of regret—I might almost say of desolation. He has been guide philosopher and friend for so many years that we may well be excused for wondering how we are going to get along without him, and it is, I am sure, no reflection upon the brilliant personalities that remain with us to say that somehow we feel that, in his retirement, one of the sheet anchors of the Post Office has been dragged from its hold. His great services to the country during the war as Director of Army Signals are, to us who know him, only one short phase of Sir Andrew's distinguished career, but the fact that he has closed it in that position makes me look back with all the more pleasure to the fact that my first association with him was also in the Army Signal Service, when, nearly thirty years ago, I was under his command in the famous R.E. Telegraph Reserve attached to the 24th Middlesex Post Office Rifle Volunteers, about which General Price has already told you something. Many a hot field-day we had on the Fox Hills and in the Long Valley at Aldershot, and with air-line sections and cable wagon sections, in these days when the R.E. vibrator, superposed on a Morse circuit, was looked upon as the last word in scientific military signalling, and when a thin single steel cable, with a perfectly appalling number of ohms to the mile, was the last word in line equipment. Little did we think then that we should see our armies carrying about with them multiple switchboards of three or four hundred lines' capacity, and that 50-pair lead-covered paper-insulated cables would be buried ten feet deep on the actual battle-field. The first occasion on which I had the pleasure of seeing Colonel Ogilvie was, I may say, a quite unique opportunity, because—he had no clothes on. I must explain that this was not due to any eccentric habits on his part, and that the circumstances were, as one may say, entirely honourable. I had unexpectedly to return from camp to London for a day, and early in the morning I sought him out in order to get him to countersign my leave pass. I tapped gently on his tent and told him what I wanted, and in a minute a big bare arm appeared, with a good-humoured face behind it, and, as he turned away to sign the pass, the flap of the tent fell open a bit more, and I could see his bath standing ready and observe that he was entirely "in the buff." I think he is a bit surprised to hear that. Even in those old days Sir Andrew was coming to be known as the active administrative power in Post Office telephones, and you well know how he has been the pilot through the strenuous years that have seen so many great developments of the service since then, how he came to the front and stayed there, and how he has carried the responsibility for most of our big decisions of administrative policy on his broad shoulders. I was rather sorrowfully amused a few days ago by an article on Sir Andrew's retirement in a newspaper which has for some time somewhat conspicuously refrained from praising the Post Office. It suggested that now was the opportunity for getting a really big telephone man into the Post Office service. What do you think of that ? Why, for the past fifteen years at any rate there has not been in the world a bigger telephone man than Sir Andrew Ogilvie. I am not giving you this merely as my own opinion ; nearly ten years ago one of the biggest telephone men in America told me exactly the same thing. We have been fortunate indeed in having at the head of affairs a man so splendidly equipped, both by nature and experience, to cope with the remarkable series of problems and difficulties which have successively, and almost continuously, confronted the Post Office telephone authority ever since its administration began. His broad and statesmanlike mind, massive sanity, absolute freedom from red tape and every kind of littleness, and his wonderful mastery of the complex technicalities of telephony have given him an unrivalled position. We in the Engineering Department have had special reason to admire the way in which he has kept himself abreast of scientific progress. He has been quick to seize what I know I shall not offend him by calling the horse-sense of new discoveries, and he has all along exercised a real initiative in spurring on our efforts to realise and reap their practical advantages. Now he is leaving us. We shall have to take a deep breath and carry on. We wish him all that is good in the coming years. We shall like to think of him in his retirement, perhaps, as Mr. Pike Pease has suggested, getting married, perhaps swinging a salmon-fly on the Teviot or the Tweed, or enjoying in other pleasant ways the time of leisure which he has so richly earned. We appreciate very much his kindness in allowing the many Post Office representatives of the Army Signal Service this opportunity of bidding him God-speed, and one is pleased to see around him on this occasion a gathering so great and so fully representative. I think I may add that the presence of Mr. Jordan of the P.T.C.A. and of Mr. Stuart Bunning on such an occasion as this gives us special pleasure. Gentlemen, the toast is—Long life, and health, and happiness, to Colonel Sir Andrew Ogilvie.

The toast was most enthusiastically pledged.

SIR ANDREW'S REPLY.

After the very kind speeches of Mr. Pike Pease, General Price and Major Purves, I find myself this evening in the most difficult and at the same time the most pleasing position I have ever been in during the course of my Post Office career. It is difficult because I do not know what to say to the high compliments—far beyond my deserts—in what has been said about my work. It is difficult also to find words to express my thanks for your kindness in inviting me to this wonderful gathering, and for the friendly greeting given by every single person present, but above all it is pleasant that in the painful moment of ending my Post Office career I should have received such friendly and affectionate testimony to the feelings of those with whom I have served. If my halting words fail to express my gratitude, you must believe it is not because I do not feel most deeply all the kindly feeling shown to-night, and I can assure you that the memory of this evening will remain as a most cherished recollection to the end of my days.

It must always be a painful experience to arrive at the end of life's main work. No doubt there are some alleviations. Mr. Pike Pease has hinted that release from official ties may allow opportunity for others of a more romantic nature, but I am afraid that even in Leap Year this prospect is too good to be true. I hope however to keep in touch with friends in the service at the meetings of Post Office Societies of various kinds and possibly also in our Journals, though I promise you that in any reminiscences I may indulge in I will not, like some eminent contemporaries, attempt to tell the whole of the horrid truth, or in speaking of my late colleagues call on the Postmaster-General to "sack the lot."

Perhaps the most painful thing in retirement is to feel how little has been done of all that one hoped to do. My main work has been in the telephone service. I joined the Post Office in 1881, about the date when the first telephone licenses were granted, and I had always hoped before leaving to see the telephone service of the Post Office permanently established and in thoroughly satisfactory working order. Unfortunately the outbreak of war interrupted the fulfilment of this cherished hope—though not for long as I firmly believe.

On the other hand the war developed another side of our work in which I am glad and proud to have had a humble share, and if you will allow me I should like this evening to speak of this special work of our telephone and telegraph services, not because I can claim more than a modest share in it, but because I was fortunately so situated as to obtain a general knowledge of many things that were well done, but were known only to a few, and about which little could be said while the war lasted.

Before the war the Post Office had engaged to provide 320 skilled linemen and telegraphists as a reserve for the Signal Service of the Expeditionary Force. They were punctually mobilised with the army, and the communications which they established helped the successful transport of the army to France. But the formation of the new armies and the importance of signal communications for artillery work and aviation created huge demands on the skilled *personnel* of the Post Office. Never at any moment was there any lack of volunteers to meet those demands. To the Royal Engineer Signal Service we sent 17,355 non-commissioned officers and men and 531 officers, in addition to 1174 men and 73 officers to the Air Force and 688 men and 5 officers to the Navy, making a total of 19,217 men and 609 officers, or practically 20,000 in all. These Post Office men have served on every front and in every phase of the war, and their combined knowledge and skill has been a magnificent technical contribution to success in the long struggle.

The Post Office has also done splendid work in the instruction in telegraphy and telephony of all branches of our forces. In 1915 a staff of telegraph instructors was formed from volunteers in the Central Telegraph Office over military age to assist in the establishment of the Signal Service Training Centre for the new armies. In that year also the experimental loan of an instructor and some apparatus to an artillery brigade proved so successful that the Army Council accepted an offer to extend the system to the whole of the artillery centres. A syllabus of instruction in artillery signal work was drawn up, and a staff of fifty instructors used to the delivery of technical lectures was organised from the Traffic and Engineering Staffs and, with the assistance of the Engineer-in-Chief, equipped with sets of demonstration apparatus. Until the autumn of 1916 these instructors were responsible for all telegraphic and telephonic training of the artillery, and even after military schools were established their work continued. At the end of the war about 60,000 signallers had attended their courses of instruction. When it is realised that in previous wars nearly all artillery shooting had been at visible targets, and that in this war it was nearly always at invisible targets and required control by telegraph and telephone from distant points, it is easy to see how important was this training work done by Post Office men.

In 1915 also the Post Office found most of the equipment and a staff of instructors from the Central Telegraph Office and other offices under Capt. Perrin, of the Engineering Branch, for a wireless telegraph school for the Air Force. Major Kennedy and Mr. Turner also helped to organise at the Polytechnic another school, where some thousands of wireless operators were trained for the Air Force, and I should like to mention also the excellent work done by the Telegraph School of the Post Office Engineer Volunteers commanded by Major Gunton, where, by the devoted work of Mr. North, hundreds of signallers were trained in telegraphy.

Another branch of Post Office work was the supply of signal stores for the armies abroad. Very early in the war Woolwich Arsenal failed to meet demands, and on a smaller scale the same difficulty occurred as with the supply of munitions. Fortunately there was not the same difficulty in meeting the situation. In 1915 and 1916 the Post Office supplied large quantities of poles, cables, wire and apparatus to meet emergency demands, and in 1916 we volunteered to act as the purchasing, storing and testing organisation for army signal stores of all kinds except wireless telegraphs and some special apparatus. The splendid organisation of the Stores Department under Mr. Morgan and Mr. Allen and their able staff undertook the whole of this work without hesitation and carried it through without a hitch. The value of the stores supplied for army purposes during the war was about £6,400,000, and among the articles supplied were 90,000 poles, 400,000 miles of copper, bronze and iron wire costing about £2,500,000, 47,000 miles of trench cable of special designs devised chiefly by Mr. Sinnott, of the Engineering Branch, and switchboards and telephones of the value of over £500,000.

The Post Office did not only supply stock articles for the Signal Service, but it rendered most valuable aid in devising new and specialised forms of apparatus to meet the new requirements of trench warfare and of artillery and air fighting. This work was under the direction of our Chairman, Major Purves, who was then in charge of the Engineering Designs Section. All special military requirements were met with remarkable promptitude, and he made many journeys along our front in France to see his apparatus in practical use and to ascertain and discuss new requirements. About 200 special designs were furnished and 50,000 diagrams circulated in the armies abroad. This special apparatus included 40,000 protected trench telephone sets, 36,000 buzzer switchboards for artillery observation control, and 10,000 portable test and protector panels for field telephone installations, besides many portable and collapsible switchboards and test-boards for large headquarter offices. Other items were 15,000 "screening buzzers" to prevent inductive overhearing of our trench communications, large numbers of Post Office "Fullerphones," portable testing sets, range-signalling apparatus for anti-aircraft guns, control switchboards and signalling apparatus for locating enemy guns by cross-bearings on the observed flash, and I could go on for a long time describing the wonderful "gadgets" provided by Major Purves and other Post Office Engineers.

I must refer specially to one more achievement of this kind. Most of you probably know more or less about "sound-ranging" and the superiority which it gave to the allied artillery in the later years of the war. It was certainly one of the factors of victory, but little could be said about its achievements while the war lasted. The method used by the British Army was devised by Capt. Tucker. It was subsequently used by the American Army and also, I believe, by the French and other Allies. It is said that if a hostile heavy battery opened fire at nine or ten miles it could be located to within fifty yards in less than half an-hour, and it is easy to estimate the enormous importance of the system. Its success depended on the use of a stable but very sensitive form of hot wire microphone, and no such form was available at first. The assistance of the Post Office was sought by the inventor, and I am proud to say that Mr. Pollock, the head of the Engineering Research Section, and his assistants not only devised a successful microphone on Capt. Tucker's plan, but also manufactured many thousands in a secret factory in the General Post Office, thus making a practical success of this very important invention.

During the war nothing could be said of the services rendered by the special wireless stations set up under the direction of Mr. Shaughnessy, the head of the Engineering Wireless Branch, for the detection and direction-finding of enemy wireless signals. By these stations we obtained an assurance that no illicit enemy-working took place in this country—a matter on which otherwise most disturbing doubts might have arisen, and the course of hostile Zeppelins, which was regulated by wireless telegraphy, could be followed during their passage across the North Sea. In this way the information required by our defences and for warning purposes was obtained with great certainty and accuracy, and precautionary measures could be taken to limit the damage done in these attacks. On one occasion these direction-finding stations rendered another notable service. Signals from a "Telefunken" station in this country were overheard by one of our coast stations. They were taken to indicate an attack and probable landing in force in this country, and the Home Defence Forces were on the point of moving to their battle positions, with the probable result that roads and railways would have been blocked in all directions by the movements of reserves and supplies. Business in the country would have been at a standstill and large expenditure would have been incurred. Fortunately, within half-an-hour of the signals being reported to the Post Office stations, the cause of the disturbance was located in a Government establishment, where an enthusiastic officer was making unauthorised experiments with a wireless set of German pattern, and we were thus saved from a very bad twenty-four hours.

Another important duty undertaken by the Post Office was the transmission of reports of the movements of hostile aircraft to the Military Headquarters from the hundreds of observation posts distributed over all parts of Great Britain, and the issue of warnings to every town threatened and to every institution of importance or place of popular resort in every town. When the military authorities asked for help in this way the Post Office telephone system was mapped out into large areas over which easy communication could be had with central towns, and these places were accepted as the control headquarters for our anti-aircraft defences. During raids hundreds and sometimes thousands of reports were transmitted from the observation posts to the defence controls in an average time of three or four minutes, and the warnings issued, sometimes to fourteen or fifteen thousand buildings, reached their destinations in less than five minutes in 95 per cent. of the cases. You can imagine how much work was involved in providing special connections and emergency switchings to secure this prompt transmission, and how much organisation and care were involved in the distribution of the warnings through the trunk and local telephone systems. It is greatly to the credit of the telephone staff that no serious hitch ever occurred in the distribution of warnings, and especial credit is due to the traffic officers working under Mr. Preston in the London Trunk Exchange, on whom rested the main responsibility for circulation.

Finally I must say a few words about the splendid work done all through the war period by the superintending engineers and their staffs in providing for naval and military requirements and for aircraft defence. The formation of the new armies called for the erection of thousands of lines to provide communications for the numerous training camps, ranges, supply depôts and other establishments which suddenly sprang into existence all over the country, and I am sure that the devoted work given to the provision of these communications was an important factor in the organisation of our national forces. Perhaps the most striking work in the later years of the war was the system of anti-aircraft defence communications. Our defending air force was arranged in a chain of aerodromes at intervals of about fifteen miles from Dover to the Firth of Forth. Searchlight stations in connection with these aerodromes were placed at 5-mile intervals over the same distance. All these stations had to be connected with one another and with squadron headquarters and control headquarters. Then, again, all the chief towns and even the larger munition factories were defended by encircling guns and searchlights, all of which were controlled by telephonic communication. For the guns and their lights some 1800 circuits were required to serve 450 gun positions. For the observation of gun-fire over 700 circuits were provided, together with 300 circuits for height-finding posts. There were also 600 searchlight stations for the guns and 150 for aeroplane defences, so that you may imagine what a network of lines providing instantaneous communications connected our air defences with the fifteen controlling points—altogether, including training grounds, about 600 aerodromes of the air force were equipped with elaborate installations in direct communication with the trunk system. The observer stations watching the movements of hostile aircraft were 450 in number. Almost all these systems involved the design of special circuit arrangements, and Mr. H. P. Brown and Mr. Greenham rendered notable service in this connection. These are only a few of the figures and particulars I might quote to show the splendid work done by the Engineering Staff, which had sent more than half its skilled men to the armies abroad, but nevertheless never flagged and never complained, however great were the demands upon them. Naturally it was in the east coastal districts and in the midland districts that most of these defences were grouped, and the chief strain perhaps fell upon the staffs under Mr. Lamb, Mr. Robb, Mr. Tandy, Mr. Johnson, Mr. Elliott and Mr. Taylor, but the other districts also had a large share of naval and military work, and the spirit with which the work was done was equally admirable in all.

Most of you who are here to-night took an active part in one or other of the achievements to which I have referred, and each could tell you much more than I can of his special work, but I thought it might be of interest to attempt some general account of the more notable things of this kind. I am glad and thankful to have been in a position to know what was being done, and it is a deep gratification that so many of those with whom I have been associated should have given to-night such pleasant testimony to their goodwill towards me. As I said before, I shall remember this evening to the end of my life.

Colonel VINCE, in giving the toast of "The Signal Service," caused considerable amusement when he said he wondered why he, as an infantryman, had been asked to propose this toast. His personal experiences had not at all times filled him with gratitude towards the Signals. He had many painful recollections when taking over battalion headquarters of having planted in his dug-out a fearsome instrument known as the Fullerphone, which throughout the night kept up a wail like a cow in distress! And those occasions when aroused in the early hours of the morning with a despatch which contained the vital information "that clean socks could now be drawn from the laundry." Colonel Vince, however, paid a high tribute to the efficiency of the Signals at all times, more particularly during times of battle when the maintenance of communications was so difficult, and when information to and from the front line was so vital.

In responding, Major JAYNE said that he naturally coupled with it the name of Colonel Sir Andrew Ogilvie, for throughout all ranks of Post Office servants in the Signal Service Sir Andrew was held in respect and esteem, and it was surprising how well known he was in other arms of the service. He thanked Colonel Vince and his supporters for the kind manner in which they had received the toast. It was particularly gratifying to have it proposed by an infantry officer, and if only an artillery officer had seconded it their cup of happiness would have been overflowing. It was quite obvious that Colonel Vince had taken a good deal of interest in his Signal Section, as instanced by his not regarding the carrier pigeons solely from the point of view of their edibility. He was very proud of the fact that the policy of the Signal Service had been to put the very best of everything in the front line, in order to provide the communications which were so vital for the success of their comrades the Infantry, the Artillery and the Air Force.

Mr. JOHN LEE proposed the health of the Chairman in a witty speech in his well-known characteristic vein, and Major Purves replied. Major Purves proposed a vote of thanks to the committee to whose efficient organisation the success of this almost historic gathering was so largely due. This was warmly received, and Mr. Best, who has been for several years Sir Andrew Ogilvie's official secretary, suitably responded. An excellent musical programme, mainly due to Post Office talent, agreeably varied the proceedings and contributed to the success of what all agreed had been an exceedingly pleasant evening.

EDITORIAL NOTES AND COMMENTS.

FIFTY years ago, on the fifth day of February, 1870, the telegraphs were acquired formally by the Postmaster-General from the existing companies at a cost to the State of £6,400,000. The Post Office opened business with 1000 telegraph offices and 1800 offices at railway stations. Although the Wheatstone and Cooke 5-needle instrument had been patented as far back as 1837 and introduced in the same year between Euston and Camden Town, the progress made had been very slow. The telegram for long was a message of bereavement, and years elapsed before the business world appreciated the importance of quick communication. The directors of the North-Western Railway gave the inventors notice to remove the "new-fangled thing" from their line. In two years' time, under State operation, the number of offices increased to 5000, and the messages dealt with rose from less than seven millions in 1869 to fifteen millions in 1872; the number is now nearly ninety millions per annum. The headquarters of the Electric and International Company in Telegraph Street, Moorgate, was selected as the C.T.O. until the G.P.O. West building could be completed. "This room, the most sensitive spot in the whole world"—we quote from an article in the 'Edinburgh Review' in 1870—"may be looked upon as one of the most curious sights in the metropolis. Although hundreds of minds are simultaneously conversing, some with tongues of steel, some with the clear sound of the bell, some again by means of piano-like notes; although we have the clatter of all these sounds mixed with the metallic tinkle of the electric bell, not a human voice is heard, although, stranger still, the manipulators are all women. They are evidently drawn from the middle rank of life, and we are informed that they make capital manipulators, the delicacy of their fingers seeming to point out to them the telegraphic instrument as a suitable means of employment."

The State telegraphs, with its younger, and some would say livelier brother, the telephone service, have provided many of both sexes and of several ranks of life with employment since 1870, and will provide work for many more in the next fifty years. One of the difficult tasks confronting the administrators of the engineering service, however, will be to secure, not a suitable means of employment, but men suitable for employment. An American has said that an engineer is a man who can do for one dollar what any fool can do for two. The aphorism is as true as most generalisations, but it does not cover the whole ground. In a public industry like ours, in which the course of development is intimately dependent upon the advances constantly being made in physical science, the engineer must be at once a student and a man of tact and *savoir faire*, as well as one who can do things cheaply and efficiently. At no time in the history of the service have there been so many intricate problems before us. The necessities of the war called incessantly for closer attention to research work, and the products of the military years are now being utilised in the arts of peace.

Instead of discussing the progress made during the last half century, we propose to discuss the position as it stands to-day in the science of communications, although the more tempting theme would have been one of self-congratulation upon the achievements of the past.

In our April issue of 1917 we published the report of the Committee on High-speed Telegraphs, which indicated clearly that for busy commercial circuits the multiplex machine-printing telegraph possessed distinct advantages over the Wheatstone automatic, even when the latter was equipped with keyboard perforators. It was inevitable that during the war we should witness a recrudescence of Morse working—it would be interesting to ascertain the total number of men in the armies who learned the Morse code and who managed to send by key and to read by sound more or less well—but we are convinced that its reign is coming to an end and that the future lies with the machine telegraph. The necessity for circuits that cannot be interrupted by severe climatic conditions is driving more and more of our lines underground, where their electrical characteristics are practically constant. At the same time these characteristics operate against the transmission of signals beyond a certain speed of working, and affect adversely the chances of Wheatstone against the slower speed of the unit channel of the multiplex. The question of page-printing *versus* slip-printing is an economic one, depending mainly upon the capital and maintenance costs of the apparatus and upon the wages of a skilled Baudot operator compared with those of a typist; it will be affected also by the demand of the public for a message form typed instead of slip-gummed. The application of the Gulstad relay and its Post Office equivalent, the relay G, to subterranean circuits has increased the speed on these lines considerably, and has also reduced the number of repeaters in use. The next step forward will probably be in the direction of the use of the thermionic valve amplifier, which has proved so successful in wireless work and on telephone trunk lines. By its aid the wire capacity of an underground pipe or duct can be considerably increased, owing to the possibility of the use of smaller gauge conductors, whilst the danger of inductive disturbances on single-wire circuits will be lessened by the use of only the small currents required to operate the valves. So far this matter is in the experimental stage; we have merely indicated the direction in which it is hoped progress will be made.

The extended introduction of valve repeaters on telephone lines, combined with systematic loading, opens a wide vista in the development of inter-city communications. A start has already been made with the laying of a 40-lb. underground cable from London to Manchester, with divergences to other cities *en route*, which will increase considerably the number of trunk channels between the metropolis and the Midlands. It must not be forgotten that a loaded line is a very sensitive one, and out-of-balance conditions introduce dangers of cross-talk, which the valves will amplify as well as the conversation proper to the line. To be forewarned is to be forearmed, and the Department has taken the necessary steps to ensure that the pairs shall be well and truly laid. Experiments have also been made in the direction of the application of multiplex telephony by the system of "wired wireless," using carrier currents of high frequency and low amperage which are by themselves beyond the range of audibility. From a purely scientific point of view these circuits have been proved practicable, but it is doubtful whether they would succeed as a sound economical proposition on the comparatively short lines in this country.

Telephone exchanges of the machine-switching type have demonstrated practically that they are capable of providing a service at least equal to that given by a C.B. manual equipment, and judging from reports they have also found favour in the eyes of the public. The question, however, remains: Can the automatic be installed and maintained as cheaply as the manual? Under the present industrial conditions it is an extremely difficult matter to decide. The costs of materials and labour from the manufacturers' point of view have increased enormously, and this applies to both equipments although we should think the manual would be cheaper by reason of its more standardised form, which would keep down the expenditure on machine tools. On the other hand, the Department cannot operate and maintain its exchanges at 1914 figures. In America it is doubtful whether the prices of raw and finished materials have increased at such a rate as have the operators' wages—to say nothing of the difficulty the companies are finding in securing and retaining their services—and there the balance would appear to be swinging in favour of automatics. The conditions are not the same in this country, and at the moment the question must remain open. In the meantime the service must be extended, and this is proceeding as fast as contractors can install or deliver equipments. Orders have been placed for a large number of common battery signalling sections, which will be installed by the Department's own workmen.

In no branch of the nation's activities—save perhaps in the development of aircraft—has there been such useful progress made during the period of the war as in wireless telegraphy and telephony. As reported elsewhere in the JOURNAL, the Department has taken over from the naval authorities a number of stations which had been administered and operated by them for observation and control purposes. The evolution of the continuous wave system of transmission, from the singing arc of Duddell up to the oscillating thermionic valve, has been one of abnormal progress, and has placed in the hands of the engineer an instrument pregnant with possibilities. The successful trials of the American Telegraph and Telephone Company in long-distance telephonic transmission without wires, in the autumn of 1915, demonstrated the practicability of trans-Atlantic speech under more favourable conditions. The fine tuning possible with C.W. sets permits the use of relatively small power plants for transmission purposes and a simple amplifying valve set for reception. Many workers are engaged in the field, and in order to secure the best results for the State the Department of Scientific and Industrial Research has appointed a Radio Research Board to co-ordinate and develop researches which are at present being prosecuted by various Government departments. The Board is composed as follows: Chairman, Admiral of the Fleet Sir Henry B. Jackson, G.C.B., K.C.V.O., F.R.S., Commander J. S. Salmond, R.N. (representing the Admiralty); Lt.-Col. A. G. T. Cusins, C.M.G. (War Office); Wing Comdr. A. D. Warrington Morris, C.M.G., O.B.E. (Air Ministry); Mr. E. H. Shaughnessy, O.B.E. (Post Office); Prof. J. E. Peltavel, F.R.S.; and Prof. Sir E. Rutherford, F.R.S.

To improve the technical knowledge and skill of its workmen, the Department has resumed on a larger scale the courses of training it had commenced prior to the war. A long series of pamphlets on the various phases of the work is in course of preparation—many of the papers have already been printed and issued to the men—which should prove extremely valuable in conjunction with the theoretical and practical classes. We have found already a demand arising from the outdoor staff for copies of the pamphlets dealing with internal work, which so far have not been issued to them. This is a gratifying and significant response, especially since the men offer to pay for these extra booklets. An ambitious scheme of this nature should be followed by an equally bold plan of advancement to able men, and in this connection it is interesting to note that the Secretariat is prepared to consider any proposals on the subject that the Federation may lay before them. We intend to return to this subject in our next issue.

In spite of the increased size of the JOURNAL we regret that we have not been able to find room for several articles submitted to us, and also for a few valuable papers read before Local Centres, which have been recommended for publication in our pages. These will be dealt with as opportunity arises.

We have the privilege of presenting our readers with a frontispiece showing the portraits of all the engineers who have occupied the Chief's chair since the State purchase of the Telegraphs in 1870. As it is believed there will be a considerable demand for unfolded copies of this group, we have arranged for a supply to be printed on paper suitable for framing. Copies can be obtained on application to the local representatives of the JOURNAL, price one shilling each.

HEADQUARTERS NOTES.

AUTOMATIC TELEPHONY DEVELOPMENTS.

DURING the autumn of last year arrangements were completed by which the trunk operators at Liverpool complete connections direct to the subscribers on Blackburn and Accrington Automatic Exchanges without any intervening operator. The circuits over which this has been done are underground loaded cable 70-lb conductors, from Liverpool *viâ* Wigan and Bolton to Blackburn, a route distance of 44 miles and a conductor loop-resistance of 1200 ohms.

Owing to the satisfactory working of these circuits a similar system has been introduced at Manchester in connection with the trunk traffic to Leeds over lines having a route distance of 47 miles.

The direct dialling method of handling trunk traffic meets with the approval of the Trunk Operating Staff at Liverpool and Manchester, and has resulted in a reduction of the delay on the services concerned.

An order has recently been placed with Messrs. Siemens Bros. for a rural automatic telephone exchange at Hurley. The immediate capacity is for 25 subscribers with an ultimate estimated development of 40 subscribers.

An extension of the Leeds Automatic Exchange for 200 P.B.X. subscribers has been arranged for.

TELEPHONE EXCHANGE DEVELOPMENTS: C.B. MANUAL EXCHANGES.

Orders have been placed for new exchanges at Glasgow South (No. 1) 1920 lines; Harrow (No. 10), 1400 lines; Northampton (No. 1), 1300 lines; Toll (London), 2020 Toll lines and local junctions.

An order has been placed for the extension of Birmingham North Exchange (No. 1) 250 lines.

POST-OFFICE WIRELESS STATIONS.

During the war the Post Office Ship and Shore Wireless Stations were taken over by the Admiralty. These stations in Great Britain have now reverted to Post Office control, and, in addition, five Admiralty Stations have been transferred to the Post Office.

The following Wireless Stations for Ship and Shore and other medium distance communications are now in the control of the Post Office:

Station.	Power of transmitter.	Station.	Power of transmitter.
*Wick	2 kw.	St. Catherine's	1½ kw.
*Lerwick	2 ,,	Bolt Head	3 ,,
Stonehaven	30 kw. and 5 kw.	Guernsey	1½ ,,
		Land's End	5 ,,
Cullercoats	5 kw.	Fishguard	3 ,,
*Scarborough	2½ ,,	Seaforth	1½ ,,
*Grimsby	1½ ,,	*Port Patrick	2 ,,
Caister	1½ ,,	Tobermory	1 ,,
North Foreland	1½ ,,	Lochboisdale	1 ,,

Stations marked * are former Admiralty Stations now transferred to the Post Office.

The Board of Trade (Exhibitions Branch) has sent to Mr. H. North, Engineer-in-Chief's Office, a Commemorative Diploma conferred upon him by the International Jury of the Ghent Exhibition, 1913, for the valuable assistance rendered in connection with the General Post Office Exhibit in the British Section at the Ghent International Exhibition, 1913.

In consequence of the war the Belgian Exhibition authorities have been prevented from issuing the diplomas at an earlier date.

DISTRICT NOTES.

LONDON DISTRICT.

INTERNAL CONSTRUCTION.

Telephone Lines and Stations.—During the thirteen weeks ended January 20th, 1920, 5153 exchange lines, 6399 internal extensions and 456 external extensions were provided. In the same period 1395 exchange lines, 3876 internal extensions and 978 external extensions were recovered, making net increases of 3758 exchange lines and 2523 internal extensions, and a net decrease of 522 external extensions.

Relief Exchanges.—Two relief exchanges have now been opened in the London District, viz. Latchmere and Broadway, the former acting as a relief exchange to Battersea, and the latter acting similarly to Stratford.

Latchmere Relief Exchange consists of 7 "A" positions and 4 "B" positions of the No. 9 exchange type, with a capacity for 740 subscribers' lines, 80 incoming and 80 outgoing junctions. The opening took place on January 10th, 1920, with the transfer of 119 subscribers from Battersea Exchange.

Broadway Relief Exchange consists of 6 "A" positions and 3 "B" positions of the No. 9 P.B.X. type with divided cord circuits, the equipped capacity being 500 subscribers' lines, 100 outgoing junctions and 70 incoming jack-ended junctions. This exchange was opened on February 14th, 1920, with the transfer of 222 subscribers from Stratford.

In both cases the exchanges were entirely free from faults when opened.

EXTERNAL CONSTRUCTION.

For the three months ended January 31st, 1920, a net increase of 25,608 miles of telephone exchange wire in the London Engineering District is recorded, 25,481 miles of underground, and 137 miles of open wire having been added, and 10 miles of aërial cable wire recovered during the period. Telephone trunk wire mileage was increased by 344 miles of underground wire, and telegraph wire (public) decreased 431 miles—11 miles open and 420 underground.

The single wire mileages, exclusive of wires on railways maintained by railway companies, are now as follows:

Telegraphs	17,321 miles.
Telephone (exchange) . . .	1,043,670 ,,
,, (trunks) . . .	18,328 ,,
Spare wires	17,201 ,,

The aggregate pole and pipe line mileages increased by 59 and 21 miles respectively, the totals now being as under:

Line Mileage.

Pole line . . . . . . 2,719 miles.
Pipe line . . . . . . 3,615 ,,

The length of underground cable in the District now stands at 7221 miles—an increase of 45 miles during the period.

Presentation of Royal Humane Society's Certificate for Life-Saving.

Mr. G. E. Hawes, Skilled Workman, London Engineering District, was presented on February 13th with the Honorary Testimonial of the Royal Humane Society inscribed on Vellum for saving a woman and child from drowning in the Thames at Southwark on August 4th, 1919.

The incident occurred on the occasion of the River Pageant. Mr. Hawes was in a crowded boat proceeding from the shore to a barge in the middle of the river, when on reaching the barge a sudden rush of the occupants of the boat caused it to heel over, and a woman and child were thrown into the water. Mr. Hawes immediately jumped in and rescued the woman. In the meantime the child had been carried away by the current, and Mr. Hawes swam a considerable distance to effect the second rescue.

The presentation to Mr. Hawes was made before a number of his colleagues by Mr. J. Brown, and he afterwards received the hearty congratulations of all present.

Provincial Districts.

Line and Station Plant provided during the three months ended February 28th, 1920.

District.	Lines.			Stations.			Miles of new ducts.	Miles of wire. Overhead.			Miles of wire. Underground.		
	Prov.	Rec.	Net.	Prov.	Rec.	Net.		Prov.	Rec.	Net.	Prov.	Rec.	Net.
North Eastern	832	258	547	1200	404	796	31	491	554	—	1895	211	1684
Northern*	539	—	—	752	265	487	9	439	92	347	385	16	369
Scot. East	746	419	327	983	581	402	4	872	730	142	797	120	677
Scot. West	897	390	507	1278	589	689	20	1088	168	920	3541	101	3440
North Midland	1116	—	1116	1673	577	1096	104	609	—	609	1581	—	1581
South Lancs	1333	244	1089	2263	641	1622	22	613	777	—	11481	617	10864
North Wales	858	298	560	1217	441	776	20	386	272	114	633	347	286
South Wales	470	201	269	756	268	488	4	1455	290	1165	1132	1680	—
South Western	810	341	469	1026	447	579	4	1676	151	1525	1482	82	1400
South Midland	1022	453	569	1489	722	767	28	840	598	242	1991	291	1700
South Eastern	1224	283	941	1548	356	1192	74	—	—	471	—	—	·2976
Ireland	838	250	588	866	254	612	0·326	271	180	91	322	—	322
Eastern	1024	186	838	1196	247	949	3	650	305	345	589	160	429

* The period for the Northern District is for the three months ended January 31st.

The wire provided includes spare wires; the wire recovered includes wires made spare.

It will be observed that the above list is not complete. In our next issue we hope to publish the total list of plant *in situ* at the end of the financial year, and in subsequent numbers to give the increase or decrease per quarter in the Districts.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

COUNCIL NOTES.

A MEETING of the Council was held in Newcastle on February 10th last. The following, amongst other items of business, were dealt with:

Reference Libraries.—The Council propose to supply each Centre with a small number of standard works which are most suitable for reference purposes, and will replace those which have been in use for some years. There are indications that the provincial members and associates do not make full use of the Central Library in London, which is of a most comprehensive character. Many of the books suggested by the Local Centres were not of the class suitable for reference but for continued study. These are readily obtainable by any member or associate direct from the Central Library on requisition. Catalogues and application forms have been supplied, and further supplies of the latter will be forwarded if desired.

Arrears of Subscriptions.—The Secretary reported that there had been a great improvement in this connection, and several Centres were practically clear of arrears.

Collection of Subscriptions.—In order to avoid the heavy and continued labour involved in the collection of subscriptions at intervals throughout the session, it is proposed to arrange for all subscriptions to be paid not later than the end of June each year. Inquiries have been made of the Local Centres, and members and associates have been asked to agree to the deductions from salary due in one particular month by the Superintending Engineer. It is hoped to secure uniform agreement with this proposal, which, in conjunction with other suggestions, is being communicated to the Local Secretaries, and which will doubtless result in a great saving of time and trouble both to the members and associates, and to the Local Secretaries concerned.

Papers recommended for Printing.—The following papers are being considered by the Council with a view to general circulation:

"Electric Lifts," Mr. C. McDonald.
"Notes on Accidents," Mr. A. J. Stubbs.
"Aircraft Telephones," Major B. S. Cohen.
"Motor Transport," Mr. G. W. Hammond.
"Motor Transport," Major G. H. Comport.

Central Library.—The Librarian reported the purchase of eight new books and two new editions of standard works, details of which will be circulated shortly. They include two books written by members of the Institution, viz. 'Flow and Measurement of Air and Gases,' by Mr. A. B. Eason, and 'Telephonic Transmission,' by Mr. J. G. Hill.

The Council attended a meeting of the North-Eastern Centre at the Mining Institute, Newcastle, when a paper entitled "Underground Construction: New Methods and Materials," was read by Mr. A. O. Gibbon, Treasurer. The meeting was well attended, and a very instructive discussion followed the reading of the paper. Mr. J. R. M. Elliott, Chairman of the Centre, and Mr. J. E. Gregory, Local Secretary, presented an excellent report as to the lectures given, attendance, etc., during the current session, and the Chairman of the Council, Mr. A. J. Stubbs, congratulated the members on the satisfactory work which was being done.

T. SMERDON,
Secretary.

LOCAL CENTRE NOTES.

EASTERN CENTRE.

THE second meeting of the 1919–20 session was held at Cambridge on January 8th, 1920, when a paper entitled "Signal Work with the B.E.F." was read by the vice-chairman of the Centre, Major Batchelor. The chair was occupied by Mr. J. F. Lamb, and there was a good attendance.

Major Batchelor first briefly explained the organisation of the army in the field, showing how the Signal Service is closely associated with each formation.

The methods adopted in laying out the plant when establishing an office and a description of the arrangements made for carrying out a series of rapid moves followed.

Details of the apparatus in general use throughout the army, methods of constructing overhead and underground routes, followed by particulars of overhearing experiments and special plant designed and constructed in the field brought the paper to a close.

Amongst those taking part in the subsequent discussion were Messrs. Lamb, Scarr, Wise, Moses, Maber, Andrews and Pooley. The speakers touched on various points arising out of the paper, all of which were dealt with by Major Batchelor in his reply. The meeting closed with a hearty vote of thanks to Major Batchelor for his interesting and instructive paper.

THE third meeting of the 1919–20 Session was held at Cambridge on February 19th, 1920. The Chairman of the Centre, Mr. J. F. Lamb, presided, and there was a large attendance.

The minutes of the previous meeting having been read and passed, the Chairman called on Mr. S. Moody to read a paper entitled, "Everyday Difficulties in the Preparation of Development Schemes."

Mr. Moody explained that his object was to deal with the points that crop up in carrying out standing instructions. The scheme is the arrangement of the necessary plant in the most economical manner. It may apply to overhead as well as underground plant, and it is important to ascertain the requirements for some years ahead before any new open lines are erected. Mr. Moody mentioned especially the undesirability from a financial point of view of providing individual circuits from time to time by work involving renewals and extensions of existing open lines in lieu of the adoption of a considered scheme of cabling. The lecturer referred to the instruction about the laying of ducts for future needs when roads are being opened or repaved by local authorities, and urged that careful and constant attention should be given to this point.

The necessary initial steps were described, including the difficulties met with in defining the area to be served when exchanges are comparatively near together. Typical cases were illustrated by diagrams. Mr. Moody dealt with the method of arriving at the block totals and the various considerations in this connection that must be taken into account. Reference was made to the question of the trunk and junction circuits, including the calculations necessary in order to obtain the required transmission efficiencies.

He thought that the duct-laying can be done more cheaply by contractors than by the Department, but that it is more economical for the latter to undertake the cabling. The procedure after the receipt of the development forecast was detailed, including the settlement of the type and lay-out of the plant and the method of showing it on the plans. The paper closed with a reference to the difficulties met with in congested areas of indicating the proposals clearly on the ordnance maps, with suggestions for overcoming these difficulties.

A very full discussion followed, amongst those taking part being the Chairman, Messrs. Ralph, Calveley, Gardner, Wellington, Cobbe and Greenfield. A hearty vote of thanks to Mr. Moody brought the meeting to a close.

NORTH-EASTERN CENTRE.

George H. Vernon is dead—the local branch loses a valuable member, and the Department an efficient, conscientious officer.

His life has been a struggle for years, and the wonderful fortitude he displayed against overwhelming odds impressed all who came in contact with him.

On some days when "the demon was a-sleeping" Vernon displayed all his native wit and brilliancy, and although these days were not frequent, the display of the spirit that was in him was helpful to all around.

Throughout his journey he carried a millstone around his neck, yet he carried his burden cheerfully, and has left his mark—courage. Of him it can be said he was a man of great courage.

Our session has been a most successful one so far.

The subjects dealt with—"Motor Transport," Mr. G. W. Hammond; "Training of Youths," Mr. T. Baker; "Internal Combustion Engines," Mr. E. S. Francis—were admirably dealt with by the gentlemen named, and the discussions which followed clearly indicate that if the Institution is to be a live body it must deal with subjects new to the Department. The time for striking out in new directions has arrived. During the early years of the Institution it has been necessary to treat with what one might term purely departmental subjects, but now that the phase of development has passed there is an opportunity for the "prophets." We want men with imagination, seeing into 1940 and organising for that period. The work of the next few years of the Institution should result in ideas being put forward which will make our Department sure of a position in the first rank of those departments who have had "vision."

NORTHERN CENTRE.

Ordinary Meeting, December 10th, 1919. At the usual monthly meeting, Capt. B. S. Cohen, of the "Research Section" at Headquarters, read a most interesting and instructive paper on "Aircraft Telephony," illustrated by a fine series of lantern-slides. Complete sets of apparatus connected up for working were exhibited and explained, and the demonstration which took place at the end of the meeting was highly appreciated.

Particulars were given of the difficulties encountered in providing communication between the kite balloon and ground or ship's deck, and how they were overcome, a single wire circuit being usually adopted.

Details of the equipment of airship telephones were given, and explained by apparatus as installed on the large airship R34, a complete switchboard equipped with two distant stations being joined up and operated.

Telephones for use on airplanes and seaplanes and the methods of wiring and use were explained, as also the throat transmitter used where interference of speech is caused by aircraft-noises. The transmitter consists of a microphone which is insensitive to air-borne sounds, and is capable of being operated by the vibrations of the throat. Its adaptation for use on noisy aircraft has proved a great success.

Capt. Cohen was heartily congratulated for his valuable address.

MEETING DECEMBER 16TH, 1919.—By the kind permission of Messrs. A. Reyrolle & Co., Ltd., an interesting and instructive visit was made to the electrical works at Hebburn-on-Tyne. Through the courtesy of Mr. H. W. Clothier the members were conducted to a room in which is a small "automatic private branch exchange." The installation—on the Siemens system—comprises a frame fitted with relays, selectors, etc., and has a capacity for twenty-five lines, but at present is only equipped for twenty-three circuits. It has now been in use for two and a-half years, and given satisfaction. The members were highly gratified by the many details given in explanation of its working.

The party then proceeded on an inspection of the works under the guidance of several of the principals, who explained the various units of apparatus under construction. The large power switchboards in the erecting shop claimed special attention, as also the high-voltage testing enclosure with its automatic safety devices. The fitting and coil-winding departments proved of great interest.

On the conclusion of the tour of the works an unexpected kindness was shown by the firm in providing refreshments for the company at the County Hotel.

The management and especially Mr. Clothier, who had arranged the visit, were cordially thanked by the chairman for their kind reception of the members. Thanks were expressed to those gentlemen who had shown so much interest and explained the working details while conducting the party round the works.

On January 28th a paper entitled "Breakdown Organisation" was read by Mr. G. F. Bellwood, who outlined the general features of the scheme recently promulgated for dealing effectively with breakdowns of an extensive character in the Northern District.

The paper was illustrated by a number of interesting lantern-slides, several of which had been prepared from photographs of actual snowstorm damage within the district.

Animated discussion followed, and it was particularly gratifying to be able to record the names of the following junior members who took part: Messrs. T. Davidson, Wade, Clementson and Hastings.

The fifth monthly meeting was arranged to be held in the Lecture Theatre of the Mining Institute, Newcastle, on February 10th, to coincide with the visit of the Council to the Northern District for the annual meeting.

A hearty welcome was extended to the visitors by the Chairman, Mr. Elliot, and in the course of his address he alluded to the present flourishing state of the local centre, particularly in regard to increased membership and local popularity of the Institution.

The local librarian, Mr. Armstrong, and the local secretary, Mr. Gregory, urged the need for more books and the provision of a lantern respectively.

Mr. Stubbs, as Chairman of the Council, in responding, commented on the excellent results attained by the Northern Centre, which he characterised as most encouraging, and hoped that such energy would continue and be a source of help to others.

The main business of the evening was the reading of a paper on "Recent Developments in Underground Construction" by Mr. A. O. Gibbon, Construction Section, Engineer-in-Chief's Office. In the discussion which followed, and in which the following gentlemen took part, Messrs. Baldwin, Kitehen, Whillis, Peel and Gaskins, the author was highly commended on the excellence of the information presented to the meeting.

In replying, Mr. Gibbon expressed his pleasure at the popularity which had attended his effort in Newcastle, and replied to the many questions so far as the limited time at his disposal would permit.

An excellent attendance was recorded, and after the meeting refreshments were provided in the Library Hall of the Institute.

E. E. GREGORY,
Hon. Sec.

SCOTLAND WEST CENTRE.

A MEETING of the Scotland West Centre was held in the Royal Technical College on January 27th, when an interesting and instructive paper on "Accidents" was read by Mr. A. J. Stubbs, Assistant Engineer-in-Chief, Mr. Waring in the chair. Mr. Stubbs had some very valuable statistics to give regarding the incidence of accidents which have been reported from time to time, as well as the monetary loss to the Department and the officers concerned which followed as a consequence. Stress was laid upon the importance of observing the motto, "Safety first," under all circumstances, not only from a humanitarian but from an economical point of view. Figures were given representing the expenditure incurred by various undertakings in adopting safety devices and the saving effected by the elimination of accidents. The prominence given to this aspect of the subject in America was illustrated by lantern-slides indicating the methods adopted there to bring home to all concerned the importance of the matter.

On February 16th a meeting of the Centre was held, when a paper on "Secondary Cells" was read by Mr. R. G. de Wardt, E. L. and P. Engineer, Glasgow, Mr. Waring in the chair. The subject was treated in a most comprehensive manner, and dealt with on all points, from the manufacture of the plates to their assembly in the cell and subsequent treatment, including charging, discharging, faults, repairs, tests and general precautions. The paper contained much useful practical information, and was highly appreciated by a large audience. A number of specimen plates was obtained on loan for the purposes of the meeting, and thanks are due to the following firms for their kindness in supplying the material: Messrs. The Chloride Electrical Storage Co., Pritchetts and Gold and E.P.S. Co., Hart Accumulator Co., D. P. Battery Co., and the Tudor Accumulator Co.

JAS. A. JACK,
Local Sec.

NORTH WALES CENTRE.

DURING the period of the war a fair degree of activity has been maintained, and papers on a variety of up-to-date subjects have been read and discussed.

The paper on "The Desiccation of Lead-Covered Paper-Core Cables," contributed by Mr. J. Caradoc Jones, was subsequently printed.

Headquarters officers were invited to read papers on four occasions.

The present session opened on December 2nd, 1919, with a record attendance. Mr. Plummer occupied the chair, and Capt. N. F. Cave-Browne-Cave read a paper entitled "The Foreman and the Inspector." The recruitment, training and status of these officers were dealt with in the author's characteristically thorough manner. So many points for discussion were raised that a second meeting was held on February 10th to continue the discussion. This was followed by a short paper on "Estimating" by Mr. F. W. Turner.

Further meetings will be held as follows:

March 9th, 1920, "The Maintenance of Automatic Exchanges," Mr. H. W. Green.

April 6th, 1920, (1) "The Communications of a Division in

Action," Major E. A. Lewis; (2) "Repayment Works Accounts," Mr. A. J. W. Dauncey.

The Local Committee wish to place on record their indebtedness to all those who have assisted the work of the Institution by contributing papers, etc., and hope for a continuance of their support in the future.

BOOK REVIEWS.

'Telephone Transmission: Theoretical and Applied.' By J. G. Hill. (Longmans, Green & Co. xvi + 398 pp. 21s. net.)

This book—the first of a series of Manuals of Telegraph and Telephone Engineering, edited by Sir William Slingo—covers the whole ground of the theory and practice of the science of telephone transmission. The theory has been given previously in several works, but there is no other English volume which gives so many details of the manner in which the results of mathematical and scientific research in telephone transmission are, or may be, applied in modern practice. It is in its practical aspect that the book has its greatest value.

As regards the "set-out" of the book, there does not seem to be any real reason for establishing fundamental formulæ in appendixes while elementary mathematics and definitions are given in the early chapters of the book. Space does not offer justification on the facts of the case. It would be preferable from the student's standpoint if the appendix matter were incorporated in the body of the book. Further, chapters and paragraphs, as regards subject-matter do not always follow in natural sequence.

The author has adopted the use of β for the attenuation constant and α for the wave-length constant. This is a pity in a book which will undoubtedly be regarded as a standard work. The advocates of $\alpha + i\beta$ and of $\beta + i\alpha$ respectively, for the propagation constant, have argued many times. The author has the justification of Post Office practice. Cannot an official edict be issued establishing $\alpha + i\beta$- the straightforward way of writing? Mr. Hill would himself probably welcome the official change.

On p. 118 Z_a and Z_0 are stated to be vectors, on p. 128 the moduli of vectors. In accordance with accepted practice they should always represent vectors, being of the general form $A/\underline{\theta}$.

The curves and letterpress in Chapter VII on reflection in telephone circuits provide material for comparing the volume of speech over different classes of line, taking impedance as well as attenuation into consideration—a very necessary thing. The curve in fig. 83 which compares calculations with measured results for loaded lines is especially welcome in view of modern practice.

The chapter (IX) on loading contains a store of useful matter and instructive sketches and diagrams. The curve showing the relation between inductance and attenuation in loaded cable circuits (fig. 90) offers a ready and sufficiently accurate means for determining the attenuation on all sizes of underground conductor loaded to various degrees. Fig. 101 illustrates in an ingenious manner the electrical conditions in the different portions of loaded side and phantom circuits when speech is conducted on the sides and phantom simultaneously.

There are one or two slight defects in the chapter which might be remedied in later editions. First, in discussing continuous loading, the formulæ for calculating added inductance and effective resistance give values per kilometre, and the diameter of the conductor and thickness of iron lapping are expressed in centimetres, which, at all events in the case of the effective resistance calculations, necessitates conversion of units when British standard gauges are under consideration. The coil-loading formulæ give values per mile; there is no reason for this difference.

On p. 182 L is used for inductance per mile in the statement "spacing distance (of coils) varies as $\frac{1}{\sqrt{LC}}$," and for the total inductance of a coil in the statement of the rule that $CLD = 25$. This may be misleading to the unwary.

An addition of great practical value to this chapter would be a table for loaded lines similar to Table II on p. 165 for unloaded lines. This table should give the transmission data for the various standards of loading adopted in practice.

With regard to the table comparing the spacing of coils for loading underground lines in Great Britain, America and Germany, it should be stated that the standard spacing adopted in this country gives the numbers of coils passed by a wave-front per second as follows: light loading, 6620; medium and heavy loading, 7400. The figure 6325 given by the author is evidently deduced from the equation $CLD = 25$.

Chapters XI and XII, dealing with standard cable measurements and cost problems respectively, give a great deal of information especially useful to the engineer in determining the gauges of lines required and the most economical lay-out of plant in connection with developments in areas and zones. The study of the economics of transmission by all responsible for the lay-out of line plant is imperative, and this study has been made less complicated by the facts that the amounts of loading for the various sizes of underground conductor have been standardised, and that the use of underground cable is rapidly extending. The introduction of the telephone relay, too, helps to make the study simpler.

In a book generally so complete in its information on the various subjects which it touches it would have been well to have included in Chapter XIV fuller information as to the 4-wire system of telephone repeater working. The 4-wire system is now a practical proposition in this country, and further information, such as particulars of methods of coupling the 4-wire system to the existing 2-wire telephone circuits, would have been welcomed by Post Office engineers, who are always on the look-out for the latest information.

The many references given in the book to other writings and to specifications will be found of great use. The author is to be congratulated on producing a work so thorough and sound.

W. J. H.

'Flow and Measurement of Air and Gases.' By Alec. B. Eason, M.A., A.M.I.E.E. (Charles Griffin & Co. 25*s.* net.)

The writer of this work is to be congratulated, in that he has supplied a long-felt want on an important subject which has received too scanty consideration in the scientific literature of the past.

For those interested in the theory of the principles that determine the flow and measurement of gases, and who wish to investigate more thoroughly the sources from which the usually accepted formulæ are derived, this book should prove exceedingly valuable. The author has gone to considerable trouble to collect and tabulate all available information bearing upon the subject, and his own comments and deductions should greatly assist anyone who may make a study of this branch of physics.

Post Office engineers, who may wish to further investigate the theory underlying the practical methods upon which pneumatic tube systems are worked, will find that the author has devoted a large portion of the book to this branch.

In the opening chapter a brief description is given of the scope of the work covered, and the sources from which the information has been obtained. The writer then passes on, in Chapter II, to the various attempts made to determine the coefficient of friction of gases in pipes. The following chapter gives new and very valuable information regarding the loss of pressure in various types of fittings, bends, etc., and in Chapters IV, V, VI and VII problems met with in connection with pneumatic tubes are fully dealt with. The information here given amplifies and explains that to be found in Technical Instruction X, and this should certainly be one of the most useful parts of the book to Departmental officers.

Chapters VIII, IX and X are devoted to a very full description of the various means adopted to measure air and gases, and in XI and XII the flow from orifices and the friction to which moving surfaces are subjected are explained.

Chapter XIII is perhaps the most practical one, and the various pneumatic tube systems are described here. The work is closed with a general description of the various means by which air currents can be produced.

Throughout the book the information and formulæ are most excellently and simply tabulated, and full references are given to the various works from which quotations have been taken. It probably forms the most complete source of information on this particular subject at present available.

'Electrical Phenomena in Parallel Conductors'; Vol. 1, "Elements of Transmission." By F. E. Pernot, Ph.D. (Chapman & Hall. 18*s*. 6*d*.)

In the preface to the volume under review the author states that it is intended as a general introduction to the problem of transmission, and that it will be followed by further volumes dealing with special branches of the subject. The series will be written so as to form in themselves a complete treatment of the subject. The author lays stress on the fact that exact solutions involving the use of hyperbolic functions are more easily applied to practical cases than the approximate formulæ frequently used. He assumes a thorough knowledge of the general properties of electrical circuits; of the properties of vectors and of complex hyperbolic functions; of the differential and integral calculus and their application to electrical problems.

The following is a summary of the individual chapters:

Chapters I and II deal with direct current transmission. The formulæ are built up in a very clear way, starting with continuous current on a non-leaky line.

Chapter III deals fully with Fourier's analysis of periodic curves. Detailed examples are given showing the method of tabulating the analyses.

Chapter IV deals with the use of the oscillograph in analysing wave forms. The special point brought out is the use of distorting circuits to accentuate the higher harmonics.

Chapter V gives the theory of the oscillograph and corrections to be applied. The explanation of the theory would be clearer if the steps leading up to the general equation of the motion of the vibrating parts were given, together with a diagram of the essential parts of the oscillograph.

Chapter VI deals with the development of alternating current formulæ in uniform lines. Excellent numerical examples and curves are given. It is shown by means of these examples that the labour in working out the exact formulæ is actually less than that involved in the use of approximate formulæ. It would have made this and other chapters much clearer to British readers if international symbols had been used. As instances, V is used for the propagation constant, U for the characteristic impedance and Z_0 for the impedance at the receiving end. At the beginning of the chapter the term "line conductance" is used instead of "leakance."

Chapter VII deals in a very full and clear way with the effects of frequency upon transmission. The highest frequency considered in the case of telephonic lines is 800 p.p.s. It is thought that higher frequencies, say up to 2000 p.p.s., should have been given.

Chapter VIII gives the method of measuring line-constants by means of the open and closed impedance. Details of the measuring apparatus and method of procedure are given. Although it is pointed out that the higher harmonics tend to reduce the sensitivity of the measurements, the use of filters to eliminate these harmonics is not mentioned. It is pointed out that the results obtained by this method are to a certain extent ambiguous, owing to the fact that there is no indication of the total number of wave-lengths in the circuit. This fact is familiar to all who have made these measurements, but has not, so far as is known, been published in English before.

Chapter IX deals with the distortion of wave-shape applied to power transmission. This chapter is of especial interest from the point of view of interference with telephone circuits. It is shown that the effect of transmission may accentuate the higher harmonics as compared with the fundamental. A numerical example is worked out in which it is shown that the seventh harmonic, which was originally 5 per cent., becomes 36 per cent. of the fundamental at certain points of the line.

Chapter X deals with power formulæ and the conditions for maximum efficiency. For telephonic engineers the chief point of interest is the development of the formula giving the best impedance of the receiving instrument.

Chapter XI deals with voltage regulation of power circuits.

At the end of the book tables and formulæ of hyperbolic functions are given. Excellent numerical examples and curves are given throughout the book.

A number of books, such as those by Fleming, Kennelly and Malcolm, have been written on telephonic transmission. The present volume may be specially recommended to those who wish to study the problem from a somewhat wider point of view.

'The D.U. (Directly Useful) Technical Series: Mathematics for Engineers.' Part II. 416 pp. By W. N. Rose. (Chapman & Hall, London. 13*s.* 6*d.* net.)

It is a truism that mathematics constitutes a most powerful tool in the hands of the engineer who is able to use it effectively, and in no science is this more true than in that of electricity. One naturally asks, however, what reason can be given for adding to the almost infinite variety of mathematical works which already exist. In this case the answer is readily forthcoming, and it is valid and convincing. The object of the course is to supply a work intermediate between the highly academic, and the severely "practical" mathematics which omits the scientific bases on which the subject is built. Those who have had experience of the highly useful but dry-as-dust qualities of the latter type of book will readily welcome the innovation now offered. The present volume is a continuation of the more elementary one by the same author, which was reviewed in the July, 1918, issue of the JOURNAL. The book now before us is an advanced one, and is very largely devoted to the development and application of the differential and integral calculus to engineering problems.

The first six chapters deal with the development of differentiation and integration. The chapters following include Mean Values, Polar Coordinates, Simple Differential Equations and Applications of the Calculus. In this latter chapter worked examples are given for a wide range of subjects, the assumption being that the reader is familiar with the technical processes involved; the subjects dealt with include Thermodynamics, Loaded Beams, Applied Electricity, Strength of Materials, Friction and Hydraulics. Next follows a useful chapter on Harmonic Analysis, and, finally, there are chapters on the Solution of Spherical Triangles, Mathematical Probability, and the Theorem of Least Squares.

The number of worked examples included in the volume is very large.

The treatment throughout justifies the claims made for the book, which is well printed, illustrated and bound. J. G. H.

'The Telegraphist's Guide.' By Bell and Wilson. Eighth Edition. (S. Rentell & Co. 5*s.* net.)

Away back in the nineties the first edition of this book was published, after the chapters had appeared, if we remember rightly, in the pages of the *Telegraph Chronicle*. It served a very useful purpose then, and even now it should meet the requirements of a large body of students who are interested in Morse working and who are not prepared to pay a larger sum for a more elaborate treatise. The present edition has been brought up to date, and covers a large number of useful points in connection with later developments, especially in connection with cells, testing, and common battery telegraphs. It should be very useful for telegraphists and others who are studying for the C. and G. Examinations.

'Conquest: A Monthly Magazine of Modern Endeavour.' (The Wireless Press. 1s.)

Commencing in November last, the five issues of this magazine maintain the promise of the first number. The journal is on the lines of the 'Scientific American,' but is written in more popular language. Its object is to bring before the general public the romance and marvel of modern science and its applications to modern industrialism. Lavishly illustrated and well written, 'Conquest' should form a serious competitor to the Sexton Blake type of literature, and should help to indicate to the older reader that the pursuit of scientific knowledge and the actual making of things are as interesting as and more important to-day than the scratching of black on white in a ledger.

Messrs. John Davis & Son, Ltd., All Saints' Works, Derby, have sent us a copy of their leaflet No. 1919 A, dealing with the "Davis-Grinsted" Slide Rule for complex quantities.

The slide rule greatly facilitates calculations involving the conversion of complex quantities from the form $a + i\beta$ to $R/\underline{\theta}$, and *vice-versâ*. It should prove a useful tool in the hands of those engaged in calculations in which vector as well as scalar quantities are employed.

'Telephone Transmission of Superimposed Circuits.' By Kazukiyo Ogawa. 53 pp. Being No. 78 of 'Researches of the Electro-technical Laboratory Department of Communications, Tokio, Japan.'

This pamphlet was briefly acknowledged in our last issue. We have here another example of the useful researches in telephonic transmission conducted by our Japanese *confrères*. The superimposed telephone circuit gives rise to a number of difficult problems, some of which lend themselves much more readily to experimental treatment than to mathematical calculation.

For example, the calculation from fundamental principles of capacity and inductance in cables, is found by the author to be impracticable, owing largely to the proximity of the wires to each other and the unequal distribution of current and charge in them. In the case of aërial lines, however, where the wires are sufficiently far apart, the difficulty disappears, and this case is dealt with from the mathematical point of view in the study before us. It is demonstrated that in the case of four wires placed on two pole arms at the corners of a square, where the diagonals are the side circuits and the two pairs of diagonals constitute the limbs of the phantom circuit, the inductance of the phantom circuit is less than half that of the side circuit, and the capacity of the phantom circuit is more than double that of the side circuit; as a consequence the phantom circuit is not so efficient for speech as the side circuit.

If the square formation be maintained, but the side circuits be formed in each case from two wires on the same arm, then the inductance of the phantom circuit is greater than half that of the corresponding side circuit, and the capacity is less than half. As a consequence the attenuation constant of the phantom circuit is less than that of the side circuits. The side circuits are, however, slightly less efficient for speech in this case than where diagonals were used.

If the four wires making up the phantom combination are spaced at equal distances apart on the same arm, the distances being the same as the side of the square, we have again, as in the case immediately preceding, a more favourable inductance and capacity for the phantom circuit as compared with the side circuits, and, indeed, the advantage of the phantom circuit for transmission is decidedly more marked than in the preceding case. It may here be stated that these general conclusions are supported by experiments made by the Post Office. It is to be observed, however, that the square-formation was probably adopted, not on account of circuit efficiency, but because it was considered to be a highly efficient anti-induction device.

Mr. Ogawa promises to give the results of his investigations as to cross-talk in the phantom combinations investigated by him at a later date, and this study will be looked forward to with interest.

J. G. H.

GEORGE STANNAGE.

Mr. George Stannage, Assistant Superintending Engineer, South Wales District, retired on September 30th last. Mr. Stannage started his career with our Telegraph Department in Ireland after having been for a time in the service of the Belfast and Northern Counties Railway Company. Later he was successively attached to the Superintending Engineers' offices at Belfast, Cork and Dublin, subsequently taking charge of engineering sections both in the west of Ireland and the capital. He did much pioneer work at that time in extending railway and postal telegraphs to the remote districts in the west, and his fund of amusing stories of experiences in that connection as also of the many "special arrangements" for the political events of those stirring times would fill a volume. In the earlier days of wireless telegraphy—in 1901—Mr. Stannage erected the 170-ft. mast at Howth, near Dublin, in connection with wireless experiments across the Irish Sea. Shortly afterwards he transferred to London and took up construction work on the telephone development then inaugurated. He remained in the Metropolis until promoted to Cardiff some six and a-half years ago.

GEORGE STANNAGE.

Mr. Stannage took a large share in the formation and early guidance of the Society of Post Office Engineers and the Institution of Post Office Electrical Engineers.

Always most popular with his colleagues and esteemed by the staff wherever he has been stationed, he enters on his retirement with the heartiest of good wishes from all for his future happiness and prosperity. W. F. W.

EDWARD THOMAS TITTERINGTON.

MR. E. T. TITTERINGTON, for many years sectional engineer at Cambridge, retired from the service on November 20th last. A very considerable gathering, representing all ranks of the staff in the

Eastern District, paid their official farewell to him at Cambridge on November 27th. The Superintending Engineer, Mr. J. F. Lamb, who presided, and several other members of the Engineering Staff paid warm testimony to the loyalty and helpful influence of Mr. Titterington upon the work of the Department and upon all who came into contact with him in connection with it. Mr. Lamb subsequently presented to Mr. Titterington, on behalf of the Eastern District staff, a handsome armchair as a token of the affection and esteem in which he is held. Mr. Titterington, although labouring under considerable emotion, responded in his usual happy and eloquent manner, recalling many amusing little episodes in his

EDWARD THOMAS TITTERINGTON.

official career and expressing his deep appreciation of the feeling which had prompted the gift.

Mr. Titterington entered the P.O. service at Liverpool in January, 1873, when there were still evidences of the transfer from the Telegraph Companies. In May, 1878, he was offered the position of Junior Clerk in the Engineering Department at Cambridge. He at once accepted and within three hours was on the way there! It is interesting to note that at that time the District Headquarter Staff consisted of the Superintending Engineer and two clerks. The total *personnel* for the district, including gang hands, was 24. Mr. Titterington's exceptional abilities soon became evident, and after successive stages of promotion he was appointed Senior Clerk in 1887. Rearrangements in 1892 afforded an opportunity of transfer to the Cambridge Section, of which he remained in control as 2nd class, 1st class, and finally " Executive " Engineer for 27 years.

Mr. Titterington is well known, not only in the Eastern District and in his own section, but throughout the Engineering Department, having represented the Executive Engineers on the Central Committee of the I.P.O.E.E. for four years. He enjoys a good "yarn," and can recall many amusing incidents connected with his official life. During the " invasion " scare in the early days of the war he was arrested as a German spy when making a survey for a military line along the North Norfolk coast, being marched two miles between two sergeants, with fixed bayonets, for identification. This was on a Sunday morning, and the vicar of the place was considerably annoyed when the church emptied on the report that two German spies had been caught.

A native of Windermere, Mr. Titterington is a great lover of natural history and gardening. He has always led an extremely active life and is an enthusiastic worker amongst young men and boys. He recently had the honour of being " Mentioned in Despatches " to the War Office in respect of over 25 years' service with the cadet movement.

The Post Office loses the services of a loyal and conscientious officer worthy of the best traditions of the Engineering Department.

May he long enjoy the rest which he so well deserves.

W. S.

H. C. PRICE.

OUR photograph is of one of the best-known members of the Post Office Engineering Department, Mr. Hugh Christmas Price, who retired on December 25th last, after nearly fifty years' service. Born on December 25th, 1857, Mr. Price entered the service shortly after the transfer of the Telegraphs to the State in 1870, at the tender age of twelve years. He was then a skilled operator on the Single Needle, the most important telegraph instrument of that time, and as an assistant in the Post Office at Brecon, South Wales, one of the first telegraphic messages which he dealt with was the " Daily Bulletin " issued during the Franco-Prussian war. On this particular occasion it announced a serious disaster to the French arms at Woerth. In May, 1882, he was transferred to the Cardiff office.

In 1885 Mr. Price made his entry into the Engineering Department as a junior clerk in the office of Sir John Gavey, who was then Superintending Engineer of the South Wales District. At that time the Superintending Engineer's clerical staff at Cardiff consisted of four persons. In 1893 he became senior clerk in the same office, and in 1895 was appointed second-class engineer in charge of the Cardiff Section.

During Mr. Price's chargeship of that section a successful wireless system of telegraphy was installed between Lavernock Fort on the Welsh coast of the Bristol Channel and the fortified island of Flat Holm. Both stations were in the Cardiff Section, and the system was maintained for some years by Mr. Price's staff. It was in connection with this system that Sir John Gavey and the late Sir

HUGH CHRISTMAS PRICE.

William Preece carried out many interesting experiments—the first probably in connection with signalling through space without wires.

Some years later the Lavernock Fort–Flat Holm Island–Brean Down route was selected for the early experiments undertaken by Signor Marconi, and as the operator at one of the terminal points, Mr. Price had the satisfaction of exchanging the first wireless signals across the Bristol Channel—a momentous event at that time which led up to the attempt of greater things afterwards.

In 1904, on promotion to the rank of first-class engineer, Mr. Price was transferred to London, and with headquarters at Hampstead, Willesden and Dalston he had charge of important sections in the London Telephone Area. In 1911 he became an executive engineer, and at the time of his retirement was in charge of the North-East Internal Section of the London Engineering District.

For several years Mr. Price represented the London Executive Engineers on the Council of the Institution of Post Office Electrical Engineers, and his services in that connection were greatly valued.

As Chairman of the Society of Post Office Engineers, a position he held for many years, Mr. Price, by his unfailing courtesy and unremitting energy on behalf of their cause, will ever be gratefully remembered by his colleagues. Recently, on the occasion of his retirement from that position, he was made the recipient of a valuable presentation as a token of the esteem and regard in which he is held.

As a conversationalist and *raconteur* Mr. Price probably had no equal in the Engineering Branch, and any function which could secure his services in the "chair" was assured of success.

All his life a clean and careful liver, Mr. Price retired at the age of sixty-two a comparatively well-preserved man, with every prospect of living many years in the enjoyment of his well-earned retirement. That this will prove to be so is the heartfelt wish of everyone who had the privilege of knowing him and enjoying his friendship.

H. E. A. W.

MILITARY HONOURS.

The Board of Editors has great pleasure in publishing the further list of honours awarded to members of the Engineering Department on active service:

Sergeant W. Hodge, Scots Guards (Unestablished Skilled Workman, Scotland East). Awarded the Military Medal.

Company Quartermaster-Sergeant J. V. B. Mosdell, R.E. (Clerical Assistant, South Midland). Awarded the Meritorious Service Medal.

Sapper A. Buchanan, R.E. Signal Service (Unestablished Skilled Workman, Scotland West). Awarded the Military Medal.

Company Sergeant-Major J. Cooper, Gordon Highlanders (Labourer, Scotland West). Awarded the Distinguished Conduct and Military Medals.

Lance-Corporal D. M. Currie, R.E. Signal Service (Unestablished Skilled Workman, Scotland West). Awarded the Military Medal.

Sapper W. Graham, R.E. Signal Service (Skilled Workman, Class II, Scotland West). Awarded the Military Medal.

Second Corporal D. Miller, R.E. Signal Service (Unestablished Skilled Workman, Scotland East). Awarded the Military Medal.

Sapper A. H. Muir, R.E. Signal Service (Skilled Workman, Class II, Scotland West). Awarded the Military Medal.

Major R. D. Oliver, Labour Corps (Clerical Assistant, Northern). Mentioned in Despatches.

Leading Air Craftsman W. M. Fraser, R.A.F. (Clerical Assistant, Scotland East). Awarded the Meritorious Service Medal.

Company Quartermaster-Sergeant E. F. Hillard, East Surrey Regiment (Skilled Workman, Class II, London). Awarded the Meritorious Service Medal.

Sapper C. Smith, R.E. Signal Service (Skilled Workman, Class II, London). Awarded the Meritorious Service Medal.

Sergeant T. Forsyth, Royal Marine Artillery (Unestablished Skilled Workman, Scotland East). Awarded the Distinguished Conduct Medal.

Lieutenant H. D. Hanbury, R.E. Signal Service (Third Class Clerk, South Lancs.). Awarded the Military Cross and Mentioned in Despatches.

Corporal F. W. Arnold, R.E. Signal Service (Labourer, North Wales). Awarded the Military Medal.

Sergeant J. Fletcher, R.E. Signal Service (Skilled Workman, Class II, Northern District). Awarded the Meritorious Service Medal.

Sergeant E. Leonard, Cheshire Regiment (Labourer, North Wales). Awarded the Military Medal.

Gunner C. J. A. Mintern, R.G.A. (Skilled Workman, Class II, London). Awarded the Distinguished Conduct Medal.

Corporal L.C. Suggars, P.O. Rifles (Unestablished Draughtsman, Engineer-in-Chief's Office). Awarded the Military Medal.

Second Corporal J. O. Walker, R.E. Signal Service (Inspector, North Western). Mentioned in Despatches.

Company Quartermaster-Sergeant A. T. S. Maber, R.E. Signal Service (Inspector, Eastern). Awarded the Meritorious Service Medal.

Lieutenant J. Hopkinson, R.E. Signal Service (Third Class Clerk, North Wales). Awarded the Croix de Guerre (Belgian).

Leading Air Craftsman G. A. Ward, R.A.F. (Unestablished Skilled Workman, London). Awarded the Meritorious Service Medal.

Company Sergeant-Major J. Campbell, H.L.I. (Labourer, Scotland West). Awarded the Military Medal.

Sergeant J. A. Hilling, London Regiment (Unestablished Skilled Workman, S. Midland). Awarded the Military Medal.

Sergeant M. E. King, R.E. Signal Service (Skilled Workman, Class I, S. Midland). Awarded the Medaille Militaire and Mentioned in Despatches.

Sergeant C. H. Little, York and Lancs. Regiment (Labourer, S. Midland). Awarded the Distinguished Conduct Medal.

 ROLL OF HONOUR

ROLL OF HONOUR.

SOUTHAMPTON SECTION ROLL OF HONOUR.
(Drawn and painted in water colours by J. S. Brown, Southampton.)

THE Board of Editors sincerely regrets the deaths on active service of the undermentioned members of the Engineering Department. Twenty-second List.

Name.	Rank.	District.
J. Greenwood	Labourer	N. Midland.
A. H. McLaine	Youth	S. Lancs.
O. R. Williams	Unest. Skilled Workman	N. Wa.
G. A. Whelahan	Clerical Assistant	N.W.
E. Ratcliffe	Labourer	London.
A. G. S. Bartholomew	Youth	Eastern.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	District.	From.	To.	Date.
Bartholomew, S. C.	E. in C.O. (Construction)	Asst. Engr.	Executive Engr.	9 : 1 : 20
Hook, R. M.	E. in C.O. (Lines)	,,	,,	,,
McCarthy, J.	Ireland	2nd Cl. Engr.	Asst. Engr.	12 : 1 : 20
Harrison, W. L.	London	,,	,,	To be fixed later
West, G. E.	E. in C.O. (Lines)	,,	,,	,,
Jones, J. C.	North Wales	,,	,,	,,
Tanner L.	North-Eastern	,,	,,	,,
Hindle, J. N.	E. in C.O. (Telephone)	Junior Engr.	,,	,,
Matthews, W. H.	E. in C.O. (Staff)	3rd Cl. Clerk	2nd Cl. Clerk	13 : 11 : 19
Smith, H. S.	London	,,	,,	17 : 2 : 20
Webb, J. T.	,,	,,	,,	,,

Resignations.

Name.	District.	Rank.	Date.
Street, C. F.	E. in C.O. (Lines)	Assistant Engineer	31 : 1 : 20
Marris, G. C	South Lancs.	,,	28 : 2 : 20
Murphy,	E. in C.O. (Telephone)	,,	16 : 3 : 20

Deaths.

Name.	District.	Rank.	Date.
Vernon, G. H.	North-Eastern	Assistant Engineer	13 : 2 : 20
Leggett, S. C.	North-Western	3rd Class Clerk	29 : 11 : 19

Transfers.

Name.	Rank.	Transferred. From	Transferred. To	Date.
Andrews, J. R.	Exec. Engr.	Northern	Eastern	1 : 11 : 19
Monaghan, T. J.	Asst. Engr.	Ireland	E. in C.O. (Wireless)	5 : 1 : 20
Gilbert, D. P.	,,	S. Lancs.	E. in C.O. (Power)	1 : 12 : 19
Henrici, R. C.	,,	E. in C.O.	S. Wales	14 : 2 : 20
Davies, D. E.	3rd Cl. Clerk	N.-Western	N. Wales	24 : 8 : 19
Dineen, W.	,,	S. Midland	Ireland	18 : 2 : 20
Roberts, D. R.	,,	London	Ministry of Pensions	19 : 2 : 20
Dorrian, T.	,,	Scot. W.	Eastern	25 : 2 : 20

COMMUNICATIONS.

All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.1.

Binding covers and copies of the Contents Index for Vol. 3 to 12 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 12 bound, with index included, at a cost of 2*s.* 6*d.*, by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, are required.

A supply of copies of the Station List of Engineering Officers, down to Assistant Engineers, is in stock, and may be obtained on demand, price 3*d.* each.

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the JOURNAL to 2*s.* (2*s.* 3*d.* post free) per copy from this issue onwards. This price applies also to annual subscribers commencing with this Part (Part 1, Vol. 13), the subscription being 9*s.* per annum, post free. All back numbers 2*s.* each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 12, parts 1 and 2. Two shillings each part will be paid for clean copies in good condition.

The following papers read before local centres have been recommended by the local committees for the consideration of the Board of Editors with a view to their publication, or to be summarised, in the JOURNAL:

"Faults": Mr. W. Atkins, South Midland District.

"Laying and Recovering Submarine Cables in and from the Itchen": Mr. J. S. Brown, South Midland District.

"The Training of Youths": Mr. T. W. Baker, North-Eastern District.

In our next issue we propose to publish an article on "Speeds of Working on the Cables of the World." A paper on "The Relationship between Efficiency and Working Costs for Small D.C. Motors and Dynamos," by Mr. E. G. Kennard, has been unavoidably held over.

TEN WAYS TO KILL A BRANCH OF AN ENGINEERING SOCIETY.

(1) Don't come to the meetings.

(2) If you do come, come late.

(3) If the weather doesn't suit you, don't think of coming.

(4) If you attend a meeting, find fault with the work of the officers and other members.

(5) Never accept office, as it is easier to criticise than to do things.

(6) Nevertheless get sore if you are not appointed on a committee, but if you are, do not attend the committee meetings.

(7) If asked by the chairman to give your opinion on some matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.

(8) Do nothing more than is absolutely necessary, but when members roll up their sleeves and willingly, unselfishly, use their ability to help matters along, howl that the branch is run by a clique.

(9) Hold back your dues as long as possible, or don't pay at all.

(10) Don't bother about getting new members. "Let George do it."—('The Popular Engineer: Journal of the Engineering Institute of Canada,' November, 1919.)

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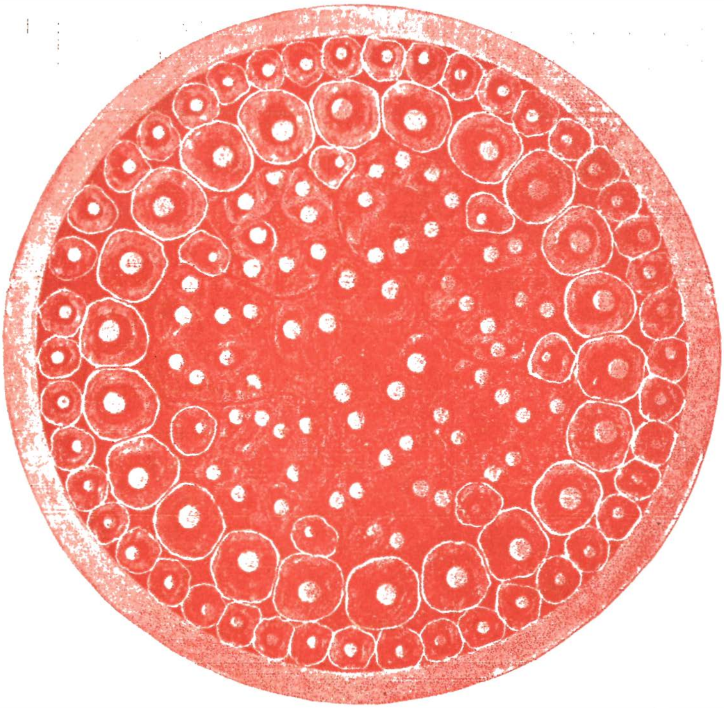

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