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ADVERTISEMENT INDEX
see page xx.

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CONTENTS FOR APRIL, 1914.

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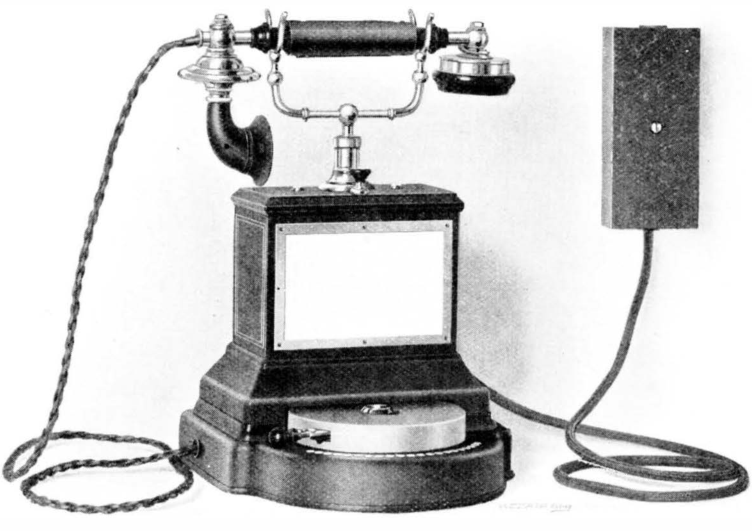

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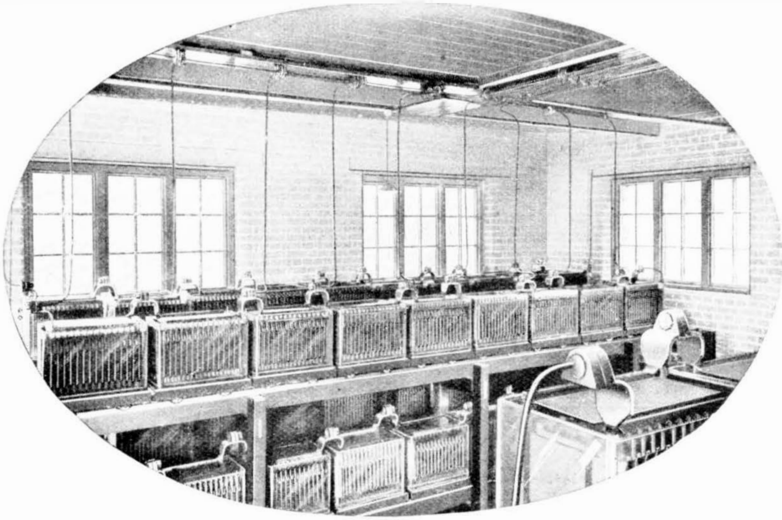

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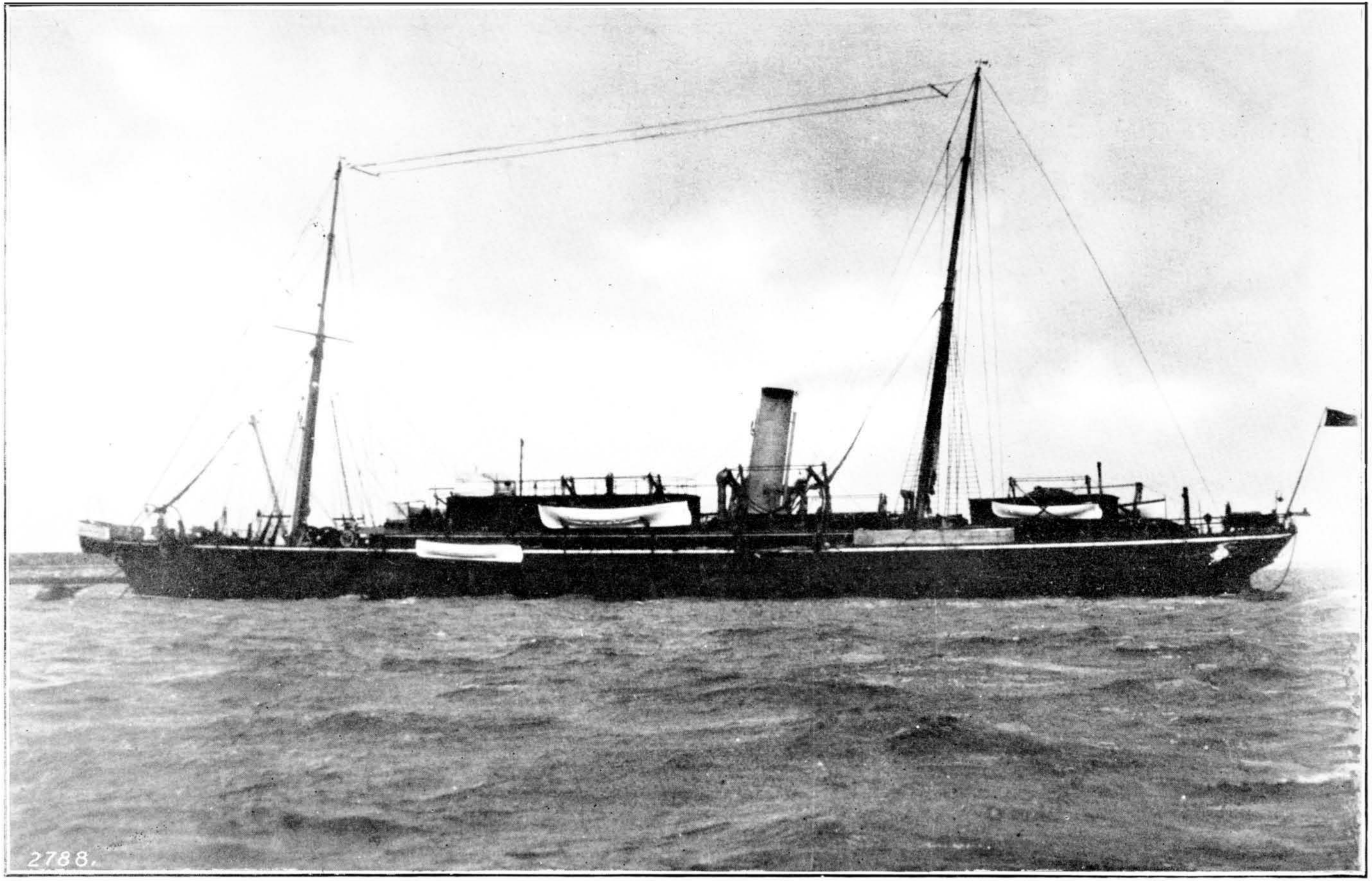


H.M.T.S. "Monarch" in Kingstown Harbour.

THE
Post Office Electrical Engineers' Journal

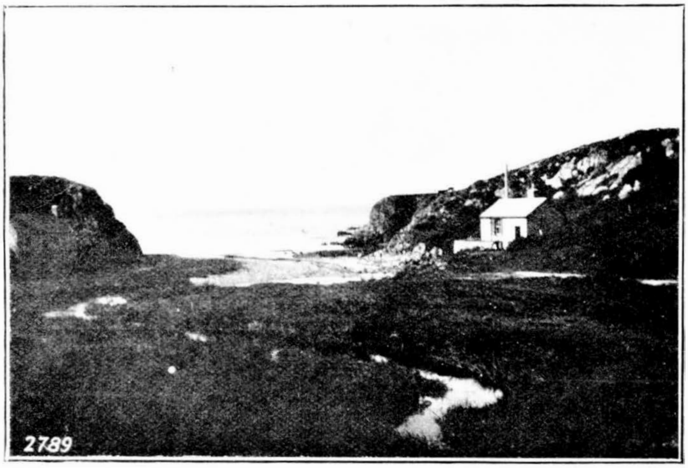
ANGLO-IRISH (LOADED) TELEPHONE CABLE.

IN the last issue of the JOURNAL there was an article giving the electrical data and details of the construction of the new loaded cable recently laid between Nevin and Howth, and the following notes on the laying operations will probably be of interest.

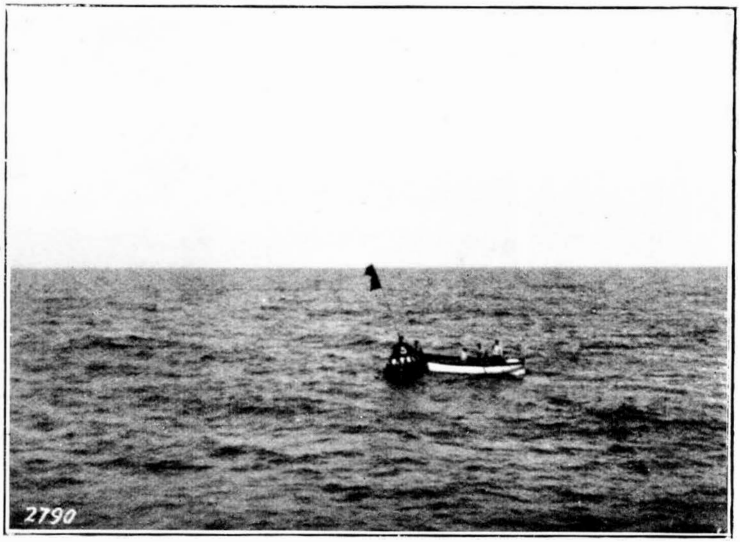
A view of H.M.T.S. "Monarch" is given in the frontispiece. The "Monarch" not being large enough to take the whole sixty-four nauts on board, the cable had to be laid in two halves.

The shipment of the first half of the cable from the works of Messrs. Siemens Bros., Woolwich, to the "Monarch" commenced on the evening of October 29th last, and finished on November 1st. On October 31st Sir A. F. King paid a welcome visit to see the cable being taken on board, and he also made a survey of the ship.

Late in the afternoon of Saturday, November 1st, the "Monarch" left the Thames for Nevin on the North Wales coast. On Sunday morning, owing to a strong south-westerly gale and a very rough sea, the vessel had to be anchored off Deal for four hours before the conditions moderated sufficiently to allow the voyage to be continued. During Sunday night the wind and sea again increased, and the ship, heavily laden as it was, encountered such bad weather that progress was very slow, a speed of only three knots, as against the usual ten knots, being obtained. The bad weather conditions prevailed until the "Smalls" was passed, and the passage consequently occupied more than double the normal time, the Abergeirch Hut (shown in 1) not being sighted until daybreak on November 6th. On this date the weather was comparatively calm, and it seemed as though the luck had turned, a good day's work being done. Six buoys, to indicate the correct route for the cable, were placed at intervals of about five nautical miles, and in addition a "mark" buoy inshore and one beyond the outermost buoy were also placed. Early on the morning of the 7th the "Monarch,"

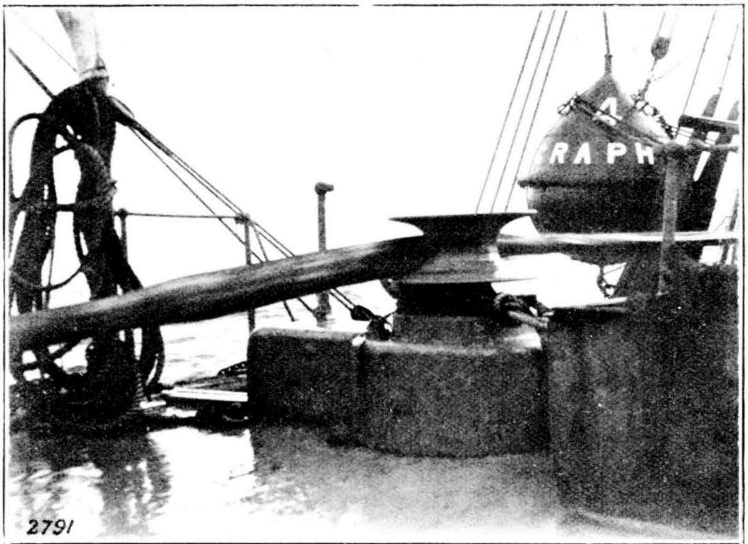


1.—Abergeirch Cable Hut, Nevin.



2.—Recharging the Buoy-lamps.

lying about half a mile off the coast, sent the steam launch ashore for the writer and Messrs. Dieselhorst and Dyke, the representatives of Messrs. Siemens Bros. It was soon evident, however, that the luck had again turned against Mr. Pollard, the sea, breaking roughly on the shore, making it impossible to land the cable end. It was therefore decided to steam along the proposed course to check the line of buoys and renew the oil in the lamps on the outer buoys, which had to be lighted as a guide for the ships passing north and south. The recharging of the lamps during a rough sea appears to a layman to be a risky operation. 2 shows the work being done at one of the buoys. The bad weather which continued during the three following days prevented a start being made with the cable-laying, and it was not until the 11th that the conditions moderated sufficiently to allow the landing operations to be carried out. At four in the morning the "Monarch" anchored off the landing place,

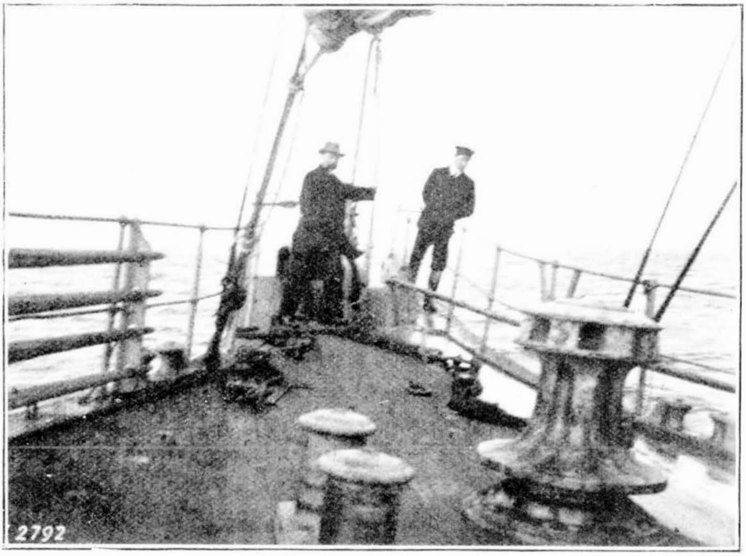


3.—Loading Coil passing out at speed of 5 Knots.

the shore end was transferred to a raft consisting of two large life-boats, and the cable paid out. Before eight o'clock this work was completed, and the "Monarch" immediately proceeded to sea, paying out at the rate of five knots. During the morning the wind increased to a gale of exceptional violence and the sea became very rough, making the task of cable-laying no light one. The outer end of the Welsh half of the cable is laid at the deepest part of the channel (70 to 80 fathoms), and the ship becoming lighter and lighter in draught as the paying out proceeded, the utmost difficulty was experienced in keeping the ship to the course during the laying of the last six miles of cable. In 3 a loading-coil is seen passing out at a speed of five knots. 4 shows the cable passing over the bow, the list of the vessel giving some idea of the weather conditions.

There was a feeling of great relief when, at about three o'clock in the afternoon, the cable end was passed out and buoyed.

The "Monarch" immediately proceeded to Holyhead, and was compelled to lie there for nine days, during which time the weather conditions were too bad to allow the buoys to be picked up. As there appeared no prospect of the weather improving, it was eventually decided to leave the buoys and return to Woolwich for the second half of the cable. During the stay at Holyhead the "Monarch" shipped sixty tons of coal in twenty minutes from the L. & N.W. Railway Company's special mechanical loading collier, see 5. This collier is capable of coaling the Company's steamers, for



4. Paying out Cable; Bow Baulk Watch.

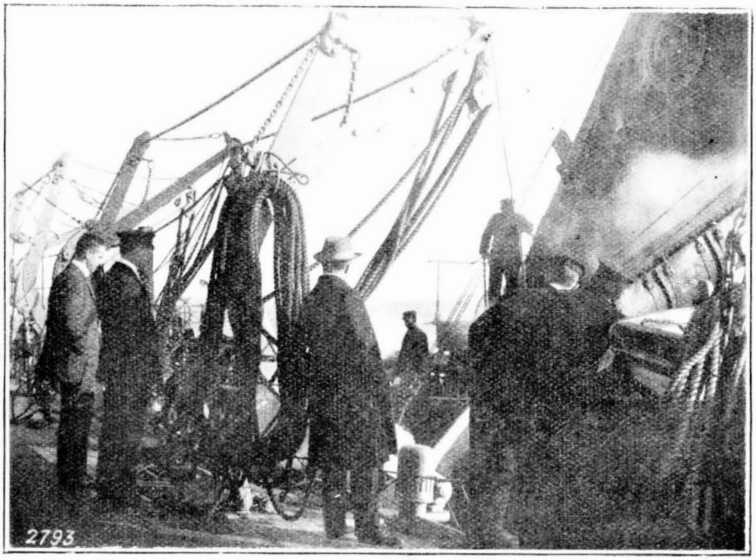
which work she was designed, at the rate of three and a half tons per minute.

It will be readily understood that the strain on the officers and crew had been very great indeed, and it was necessary, much to the regret of all on board, to land at Rosslare the popular chief navigating officer (Mr. Broadbridge) suffering from a serious nervous breakdown.

Woolwich was reached on November 24th, and three days later the "Monarch" left for the cable ground with the second half of the cable. The buoys on the Welsh side were picked up, and on December 1st the second series were placed in position on the Irish side. The Engineer-in-Chief joined the ship on that date to see the second half laid, but the weather was so very bad on the five following days that cable-laying was impracticable. It was not until

Sunday, December 7th, that the Irish end could be landed at Howth. 6 shows the landing place, the Martello tower seen in the photograph being used as a cable hut.

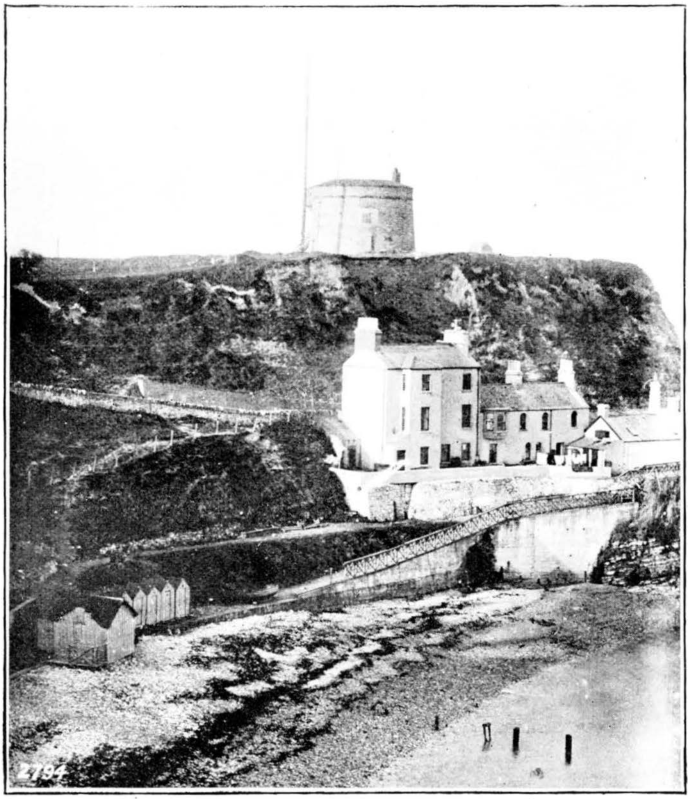
The "Monarch" left Kingstown at three in the morning, and after landing the shore end, the laying of the second half commenced shortly after nine, the buoyed end of the first half of the cable being reached about 3.30. It was then found that the cable was short by about two hundred yards, and efforts were made to pick up the slack on the Welsh side until darkness prevented further operations. The ship was kept close by the buoy all night in order to continue the operations at daybreak. Unfortunately on the following day the



5.—Coaling the "Monarch" in Holyhead Harbour.

weather was again stormy and the greatest difficulty was experienced in handling the ship relieved of its cargo. Bad weather continued for several days, and when at last it was possible to proceed with the operations a fault was discovered on the Irish side. The cable had been mechanically damaged by fouling something on the sea bottom, resulting in the cores being crushed. Owing to the weather conditions, considerable difficulty was experienced in picking up and relaying the cable, and it was not until 9.15 p.m. on December 13th that the last splice was completed and slipped overboard. At 10.15 p.m. the very welcome report was received from the testing officers at Nevin that the cable tested satisfactorily.

Thus ended one of the most arduous operations ever undertaken by the Department's Submarine Staff. During the whole period of the Commission every conceivable difficulty had been experienced; the few hours of daylight, the persistent bad weather and rough seas, the exceptional difficulties in landing, and, finally, the damage to the cable in mid-channel all contributed to throw a severe strain on the staff, and it is impossible to speak too highly of the zeal and *esprit de corps* of all the officers and men under the command of Mr. Pollard during a time of unparalleled difficulty, not to say of danger.



6.—Howth Cable Hut.

It must be remembered that the "Monarch" is essentially a cable-repairing vessel and is only equipped with the necessary picking-up gear; and in consequence the cable had to be paid out over the bow sheave. The experience gained during the laying of the Anglo-French and Anglo-Belgian cables warranted the assumption that the ordinary equipment of a cable-repairing vessel was sufficient for any emergency which might arise during the operation of laying. The fact that the laying of this Irish cable was successfully carried out by the "Monarch," notwithstanding the severe and adverse conditions, clearly demonstrates that this type of coil-loaded cable can be handled in the same way as any other type of submarine cable.

The necessity for picking up and relaying a portion of the cable, to which reference has already been made, resulted in some variation and irregularity in the spacing of some of the loading coils; in fact circumstances occurred which would be expected to arise during the course of an ordinary repairing operation. It should be noted, however, that this alteration in the spacing of the loading coils was not accompanied by any appreciable change in the electrical values of the cable. The cable has been working continuously since completion, and the tests indicate that it is in perfect condition.

W. N.

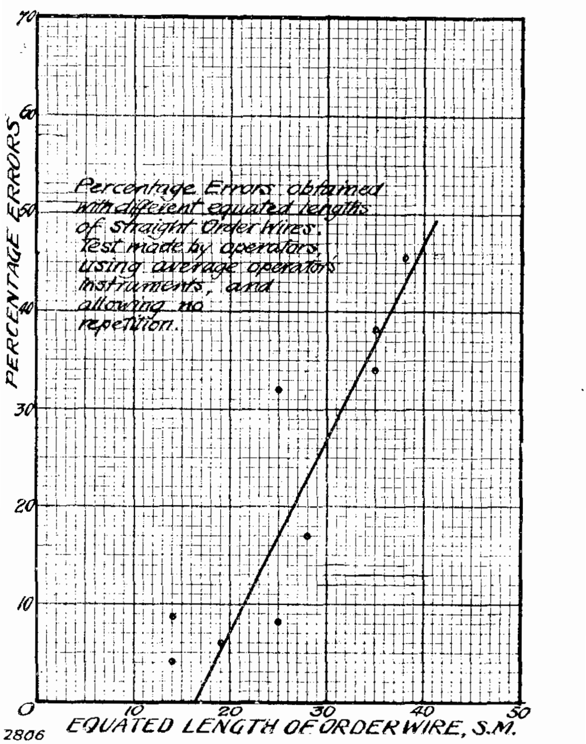
TRANSMISSION RESEARCH WORK: MISCELLANEOUS NOTES.

By Bertram S. Cohen, A.M.I.E.E.

Transmission over Order Wires.—The quality of transmission that it is necessary to give on order wires for satisfactory working merits very careful consideration. It is necessary to realise that the transmission of telephone numbers at a considerable speed over the order wire requires to be of higher quality than that which would suffice for an ordinary local conversation. The first effect observed on a gradual reduction in the audibility of order-wire transmission is an increase in the number of repeats. A decided increase is experienced long before the audibility either by reason of reduction in volume or in articulation has reached a point at which any noticeable effect on an ordinary conversation is to be observed.

In order to obtain the necessary data for the standardisation of order-wire transmission, tests have been carried out, using operators working under conditions approximating as closely as possible to those existing in practice. Each operator read lists of 100 selected numbers to another operator over lines of various equated lengths representing order wires, and an observer checked the sending operator in order to ensure that she gave no wrong numbers. No repeats were allowed. I indicates the percentage errors obtained with different equated lengths of straight order wires. It will be observed that up to an equated length of about 16 s.m. no repeats would be necessary, but that at 21 s.m. 10 per cent. of the orders would require repeating, and this percentage would rapidly increase, until at 40 s.m. 47 per cent. of the orders would be incorrectly received. It is scarcely necessary to mention that beyond a certain point no perceptible improvement would be obtained by repetition, as the reduction in audibility is quite likely to cause the originating operator to fall into error when the " B " operator repeats.

The losses due to a number of " A " operators being on the order wire simultaneously and those due to split order wires now require consideration. With regard to the losses due to a number of " A " operators being on the order wire simultaneously, from figures furnished by the Metropolitan Traffic Department some time ago, it



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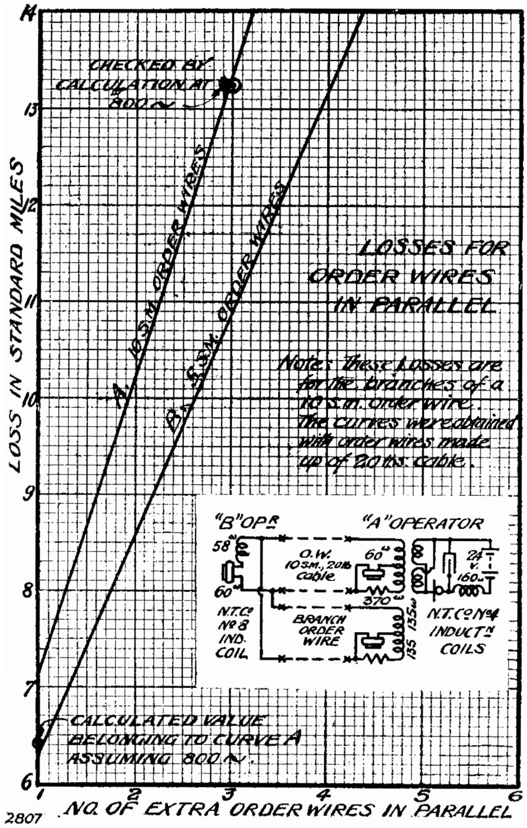
may be taken that the average number of " A " operators simultaneously on a straight order wire would be four. The sending loss due to four operators' instruments is about 8·5 s.m. It may, therefore, be concluded that if a negligible percentage error assuming no repeats is required, the straight order wire should not exceed about 16 − 8·5 = 7·5 s.m. in equated length. The case of split order wires is more complex. The effects on the transmission of any one branch due to the remaining branches depends so much on the position, length and type of the components of the network that no universal law can be given. It is, of course, always possible to calculate the equated length of any one branch by allowing for the effects of the sending end impedances of the remaining branches at their points of junction.

A very general case is that where the order wires are grouped at the incoming exchange, and **2** with curves and diagrams gives the allowances to be made for certain specific cases. In these curves it is assumed that the equated length of an order wire consisting of 10 s.m. in cable is desired, when other branch order wires of either 5



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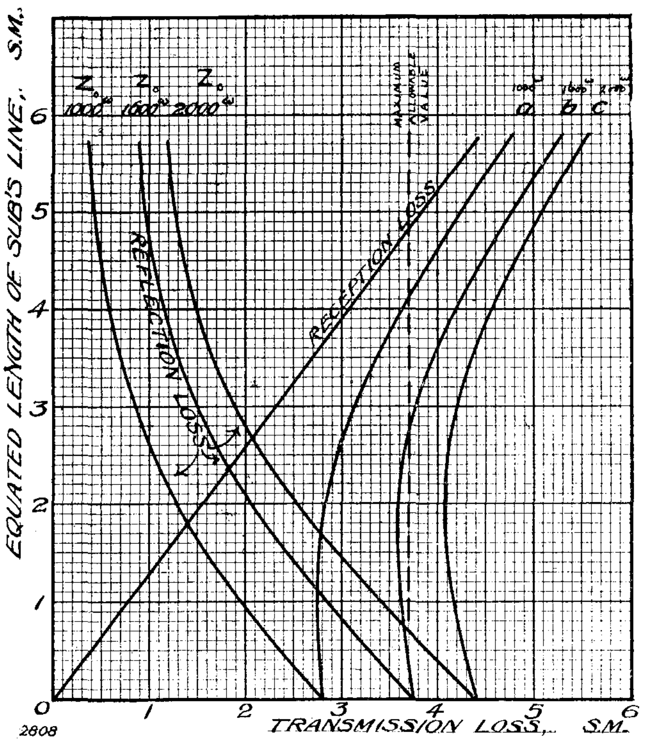
s.m. or 10 s.m. are connected at the incoming exchange. An example of the use of this curve will now be given. The equated length of an order wire of 10 s.m. of cable, with two 5 s.m. branches in parallel at the "B" end, will be 10 s.m. + 8·6 s.m. = 18·6 s.m. If with three branches of 10 s.m. each, it would be 10 s.m. + 13·3 = 23·3 s.m. These curves were obtained by standard cable measurement and agree with the calculated values. If the "A" operators are not on the branches, the allowance for the branch is reduced somewhat. When the necessary allowance is made for the number of "A" operators on each branch simultaneously, and the percentage errors due to this total equated length is obtained from I, it will be seen that order-wire grouping is a matter which requires very careful consideration from the transmission standpoint.

THE LOADING OF SHORT LINES.—Owing to the special conditions existing in this country prior to the transfer, a great deal of investigation, particularly in connection with transmission, has been carried out along lines which an administration with undivided control would find unnecessary. In some cases, however, notably the loading of short lengths of cable line, information of considerable interest and of practical application for special cases has been obtained. According to the agreement that existed between the Department and the National Telephone Company, the maximum equated lengths of the lines from the subscribers' offices to the trunk exchange were specified, and in many cases the existing trunk junctions, consisting of comparatively short lengths of cable, required improving in transmission by a small amount. It has been found that a small increase in volume can be obtained by placing a single load in the centre of the line. Thus, a coil of ·1 henry inductance and 7 ohms effective resistance at 800~, when placed at the centre of four standard miles of 20 lb. low-capacity cable terminated with an instrument having an impedance of $1060/\underline{60^\circ}$ at one end and a long unloaded line of 20-lb. cable at the other end, was reduced to 2 s.m. when talking in one direction and to 1·6 s.m. in the other direction. Such a method of improvement is, however, unsatisfactory, as the single load will to some extent degrade instead of improve the articulation. By using, however, two coils in a short line consistent improvement in volume and articulation can be obtained, and the usual loading formulæ can be adopted. The following example may prove of interest: Trunk junction four miles of 20-lb. low capacity cable having an equated length of 4 s.m., terminated at one end by a subscriber's line of 2 s.m. in 20-lb. cable and with a primary battery instrument having an impedance of $1060/\underline{60^\circ}$, and terminated at the other end by twenty miles of open wire 100-lb. copper followed by 20 s.m. of 20-lb. cable, which combination was used to approximately represent a trunk line. Two loading coils, with an effective inductance and resistance of ·1 henry and 7 ohms respectively, were inserted in the 4 s.m. trunk junction, and this line was thereby reduced to about 2 s.m., which agrees well with the result obtained by calculation.

TRANSMISSION LOSSES IN PRIVATE BRANCH EXCHANGES WORKING THROUGH LOADED JUNCTION LINES.—In standardising the transmission of a given exchange area where loaded junctions exist, it is necessary to deal with P.B. exchange lines, or, indeed, any apparatus introducing transmission losses, with special care, particularly in cases where no terminal reflection-reducing devices are in operation.

Assume standard C.B. instruments and circuits are in use. By combining local line curves (**12** and **13**) with reflection loss curves (**16**) given in my paper on "Standard Cable Measurements" (POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, April, 1913), some important and interesting results will be obtained.

3 shows such a combination. The reception losses of various



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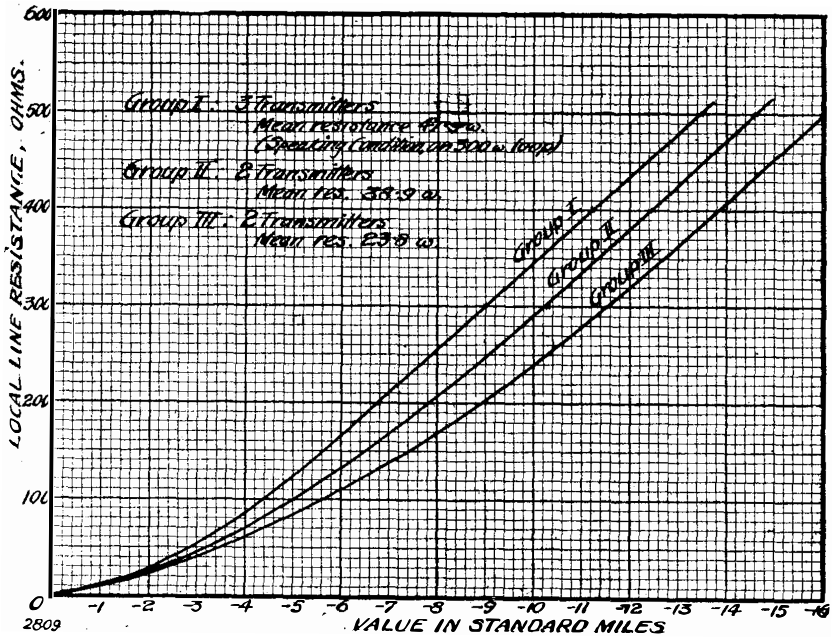
equated lengths of subscribers' lines in either 10 lb. or 20 lb. cable are plotted, and, in addition, three curves giving the corresponding reflection losses when such lines are connected to loaded junction lines of either 1000, 1600, or 2000 ohms characteristic impedance. It will at once be noticed that the resultant curves are practically vertical and are actually re-entrant. The practical application of this is somewhat remarkable. Take a case where the maximum allowable subscribers' line is to be 300 ohms in, say, 10-lb. cable. This represents 1·7 miles of cable having an equated length of 2·8 s.m. From the curves plotted in **3**, it will be noted that the receiving loss for this line is 2·1 s.m., or rather less than the equated length (see POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, April, 1913, p. 15), Suppose that the heaviest loaded junction line to which this local line may be connected has a characteristic impedance of, say, 1600 ohms, then the reflection loss of the length of local line under consideration will be 1·6 s.m., and the addition of the receiving and reflection losses gives 2·1 + 1·6 = 3·7 s.m. This value is plotted as a dotted vertical line in 3. Now, in the ordinary way, if this is the maximum allowable value, any extra losses due to P.B. exchanges or extra apparatus in exchange circuits must be compensated for by a reduction in the allowable equated length of the local line, either by increasing the weight of copper or reducing the allowable length, but it will be noted that this dotted line limit is so close to the curve for combined receiving and reflection losses marked (*b*) that we arrive at the important result *that no alteration in type or length of local line will compensate for any additional apparatus loss of even such a small amount as ·5 s.m.* This is a point worthy of serious consideration, and indicates the necessity of adopting reflection-reducing devices where junction lines are loaded. The reception loss is the only one considered here, as it will be found on examination that this is the controlling factor in these cases.

SOLID-BACK TRANSMITTER RESISTANCE.—There is a fairly definite relationship between the resistance of a solid-back transmitter and its volume efficiency, and the result of a research in this direction which was undertaken in connection with the determination of local line values may prove of interest. The resistance values were obtained with various local line conditions and whilst the transmitters were spoken into in a uniform tone. It was found that all the transmitters tested, with one exception which can be taken as abnormal, increased regularly in resistance as the feeding current decreased with increase in the loop resistance. The values for seven transmitters on 300-ohm loops are given in the following table :

Transmitter.	Resistance on 300-ohm loop 22v.	Group	Mean group resistance.
a	49·8	1	47·3
b	46·5		
c	45·7		
d	40·8	2	38·9
e	37·0		
f	23·7	3	23·8
g	24·0		

These transmitters were divided into three groups of similar resistance instruments, as indicated in the table, and the local line sending value plotted for each group; 4 is the result. It will be observed that the highest resistance transmitters change least in efficiency as the loop resistance increases, the difference between the three groups being of the order of 1 s.m. for local line resistances of 200 ohms upwards. The values plotted were obtained with local lines of all types, 10 lb. and 20 lb. cable and ohmic resistance. The transmitters were all of the same type. A batch of 50 C.B. solid-back transmitters of a particular pattern recently tested give some further interesting results demonstrating the relationship between resistance and volume efficiency. The 50 transmitters were divided into six groups *a* to *f* in accordance with their volume efficiencies as shown on **5**. The mean volume allowance and the mean speaking resistance, both on 300-ohm loops, were plotted for each of the six



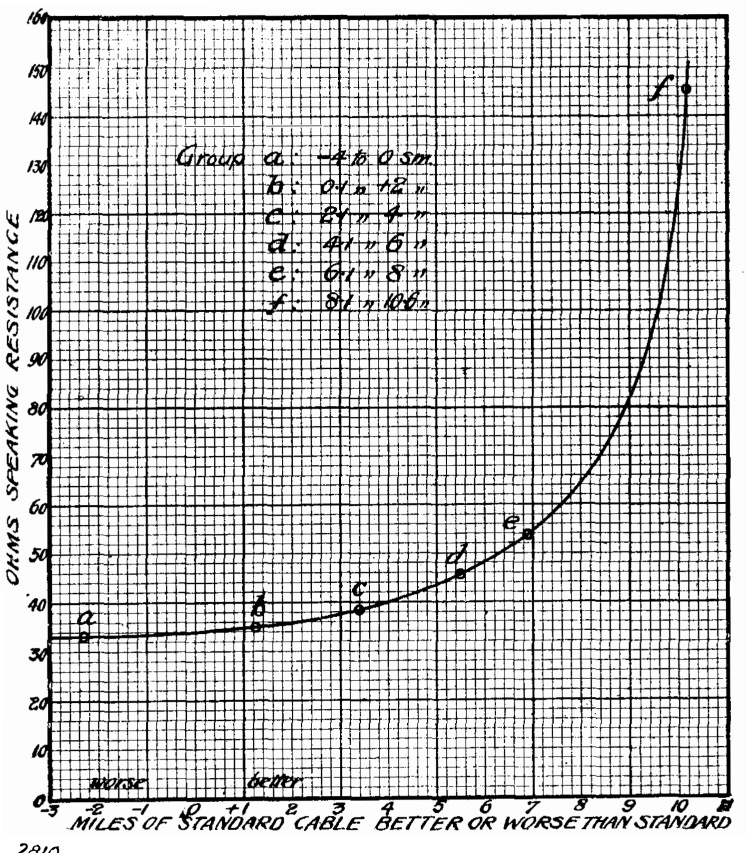
4.

batches, and it will be observed that the values lie regularly on a curve.

If the transmitter resistance were pushed up further, using the same pattern of transmitter, it can be assumed that the curve would begin to turn back, *i. e.* the volume of efficiency would decrease.

Although **4** and **5** are of interest as demonstrating the fact that a local line curve may be regarded as a characteristic curve for the transmitters used, further data is required before such curves can be utilised to express the volume efficiency of any type of transmitter in terms of its resistance.

Losses due to Intermediate Exchanges.—The losses due to an intermediate No. 1 C.B. exchange "**B**" operator's circuit between two other No. 1 C.B. exchanges do not appreciably vary with the position of the intermediate exchange with respect to the junction lines on each side of it. The loss with a toroidal repeater can be taken as 0·7 s.m. The introduction of a long line equipment to enable the supervisory signals to be actuated properly when the junctions are long, causes a further loss of 1·5 s.m. This loss is for an equipment consisting of a double wound 75 ohm + 75 ohm relay with windings inserted in series in the lines, each winding shunted



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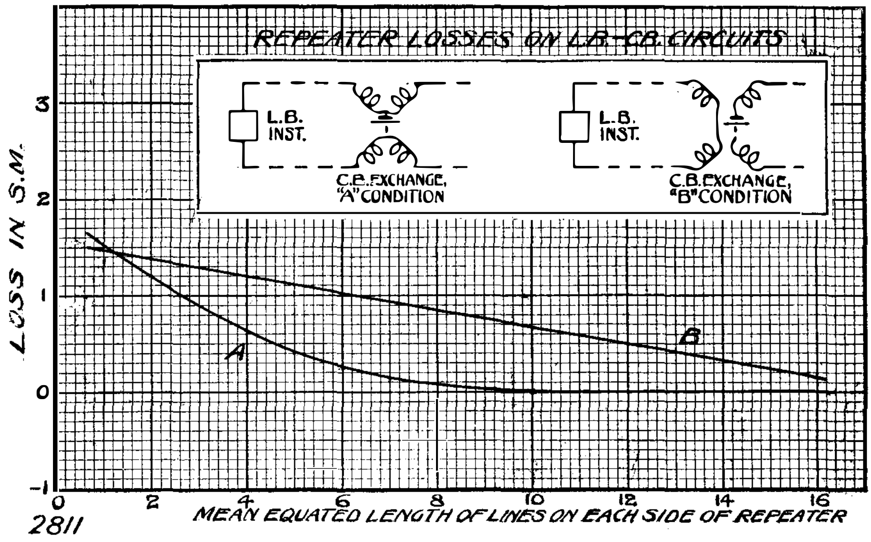
by a 2-mfd. condenser and a 600-ohm bridging coil across the line. The series apparatus is responsible for 0·8 s.m. of this loss and the remainder is due to the bridging coil.

When the C.B. exchange is intermediate to another C.B. and to a local battery exchange, the loss will be found to vary with the location of the intermediate exchange. Curve **6** shows this variation for an intermediate exchange with toroidal repeaters. The mean standard mileages of the lines on each side of the intermediate exchange are plotted against the loss. It will be noted that the loss increases as the lines decrease and is almost negligible with a mean mileage of 14 s.m. These losses vary slightly according to the direction of transmission, and the values given are the mean of those obtained in both directions. The curves can be taken to apply to all cases where the equated length of line on one side of the intermediate exchange does not exceed the equated length of the line on the other side by more than 50 per cent.

Two curves are given, A for the losses when the "A" cord circuit is used at the intermediate C.B. exchange. In this case the L.B. instrument is polarised, *i. e.* joined up so that the C.B. current circulates in the L.B. receiver so as to assist the magnetism. This will tend to improve the L.B. instrument reception efficiency, and this



6.

improvement is allowed for and eliminated from the result plotted in the curve. This curve will therefore also apply to the case where special apparatus is employed at the L.B. exchange to prevent current circulating in the instrument, provided that the additional loss due to such apparatus is allowed for. In the case of Curve B, this is for the "B" cord circuit at the intermediate exchange, and no C.B. current will flow through the L.B. instrument. The writer would like here to draw attention to the misuse of the term "primary battery" in connection with telephone instruments and exchanges. This is an unsatisfactory designation, as the logical term is undoubtedly "local battery" as opposed to common or central battery, and the letters "P.B." are in general use to designate "Private Branch."

There have also been cases where primary cells were used for the common battery, and other cases where secondary cells were used at the subscribers' instruments.

THE ALLOWANCES FOR "A" AND "B" CORD CIRCUITS IN NO. 1 C.B. EXCHANGES.—It may be of interest to mention here that the ordinary "A" operator's cord circuit on a No. 1 C.B. exchange and using toroidal repeater differs from the standard transmission circuit only in the arrangement of the repeater and the fact that two supervisory signals are used. The former difference does not appear to affect the losses, but the latter adds 0·5 s.m. Again, the "B" cord circuit, using a 12,000-ohm + 27-ohm relay at the centre of the repeating coil shunted by a 2 mfd. condenser, is worse than the standard transmission circuit by 0·5 s.m., so that in an ordinary No. 1 C.B. local junction connection there is always 1 s.m. loss due to extra apparatus.

In some cases it has been the practice to reverse the "B" end repeater when intermediate to a local battery exchange in order to prevent the dropping of indicators by inductive kicks, and in some cases to prevent false rings on party line instruments from the same cause. The transmission loss is, however, increased to 2·5 s.m. in the case of the toroidal pattern repeater. It is interesting to note that the No. 12 type of repeater, which is considerably less efficient than the toroidal repeater when used in the normal manner, lends itself better to this reversing method of stopping inductive kicks and gives a loss when so reversed of only 1·2 s.m.

THE EFFECT OF LOCAL LOSSES ON THE OVER-ALL EFFICIENCY OF LONG-DISTANCE TALKS.—It will be evident from a consideration of the transmission losses given in these notes and the notes in vol. 6, part 1, that the over-all talking efficiency depends to a striking extent on the losses in the various local circuits employed and in the terminal instruments and apparatus, quite apart from the attenuation due to the trunk and junction lines.

To render this perfectly clear, take a typical case which can occur at any time on a trunk connection between two subscribers in any large town in the United Kingdom. The case selected at random is that of an actual subscriber "A" in London with a large C.B. multiple board private branch exchange and a subscriber "B" in a moderate-sized provincial town, also with a similar type of private branch exchange.

The losses in the case of subscriber "A" are tabulated below:

Subscriber "A": Sending Losses.

Resistance of exchange line	270 ohms
,, of extension line	100 ,,
,, of P.B.X. apparatus . . .	66 ,,
Total	436 ,,

Sending loss for this resistance from local line curve	13·4 s.m.
Loss in P.B.X. apparatus	2·7 ,,
Total sending loss . .	16·1 ,,

Subscriber "A": Receiving Losses.

Equated length of extension + exchange lines	3·5 s.m.
Receiving loss from local line curve . . .	2·6 ,,
Loss in apparatus	1·7 ,,
Total receiving loss . .	4·3 ,,

To both these figures must be added the following losses, which are independent of sending or receiving:

Wiring loss at main exchange	0·6 s.m.
Cord circuit loss	0·5 ,,
Trunk exchange loss, London	2·0 ,,
Total	3·1 ,,

This makes—

Subscriber " A " over-all sending loss .	20·2 s.m.
,, ,, ,, receiving loss .	7·4 ,,

Now taking the case of Subscriber " B " in a provincial town with a similar type of private branch exchange.

Subscriber " B ": Sending Losses.

Total resistance of line and apparatus . .	350 ohms
Sending loss from local line curve . . .	11·4 s.m.
Loss in apparatus	2·7 ,,
Total sending loss .	14·1 ,,

Subscriber " B ": Receiving Losses.

Equated length of line	2·7 s.m.
Receiving loss from local line curve . .	2·0 s.m.
Loss in apparatus	1·7 ,,
Total receiving loss . .	3·7 ,,

Wiring loss at main exchange	.	0·4 s.m.
Cord circuit losses	.	0·5 ,,
Trunk exchange loss	.	1·0 ,,
Total	.	1·9 ,,

This makes—

Subscriber "B" over-all sending loss	.	16·0 s.m.
,, ,, ,, receiving loss	.	5·6 ,,

The combined losses sending from "A" and receiving at "B" will be 20·2 + 5·6 = 25·8 s.m., and in the reverse direction 16·0 + 7·4 = 23·4 s.m. To ensure commercial transmission between these two subscribers it is therefore necessary to see that the total remaining losses, including the equated lengths of the trunk and junction lines, does not amount to more than about 20 s.m. In other words a good 56 per cent. of the available transmission is used up in the subscribers' apparatus and lines and in the local exchange quite irrespective of the losses in the junction and trunk lines.

It should be borne in mind that these are distinctly normal subscribers' conditions and that no allowance is made for any ageing effect on the efficiency of the subscribers' instruments, which are assumed to be equal to the standard both for sending and receiving; nor do the cases taken include intermediate exchanges or cases where any extra apparatus, such as long-distance signalling equipment, etc., is inserted. Figures such as these should render it unnecessary to emphasize the importance of keeping the losses in the subscribers' instruments and in the exchanges, both private branch, local, and trunk, down to the absolute minimum.

THE TELEPHONE CABLE EQUIPMENT OF LARGE BUILDINGS.

By F. G. C. Baldwin.

Very little information has been published regarding the cable equipment of large buildings, probably because it is only of late years that the proprietors of such buildings have recognised the importance of a complete telephone installation.

In order that the most efficient and economical cable system may be evolved, it is necessary that each case should receive very careful investigation and be dealt with according to its own particular merits.

Two main classes of telephone service have usually to be provided:

(*a*) private branch exchange service, for hotels, stores, factories, large works; (*b*) local exchange service, where the occupants of buildings comprising blocks of offices, suites of chambers and apartments, markets, require independent connection to the local exchange. Features of a distinctly different type are presented in these two classes.

The chief difficulties in the design of a system are: (1) The short time usually afforded for the execution of the work, and (2) the absence of reliable information as to the probable future requirements. The first of these tends towards an undue haste in carrying out the necessary preliminary surveys and in the work of installation. To meet these difficulties the telephone requirements should be ascertained in the early stages of the building operations, and by a careful study of the growth of telephones in buildings of similar class, due regard being given to the probable requirements of the building under consideration. For a building which is to be wholly served by a private branch exchange, the future as well as the initial requirements are controlled by the proprietors, and usually fairly accurate information can be obtained from them. In buildings requiring a number of independent services, however, the ultimate requirements are difficult to determine.

In providing for a building of the office class the following are the types of line which must receive consideration:

(*a*) Direct exchange lines.

(*b*) Exchange extension lines, internal.

(*c*) Exchange extension lines, external.

(*d*) Private lines, all classes (including fire-alarms, time service lines, etc.).

(*e*) Power lines.

(*f*) Ringing lines.

In ordinary cases it is customary to count all lines other than direct exchange lines as "miscellaneous," the latter being usually few in number as compared with the direct exchange lines, and in making a development study for such cases it is usually sufficient to add a certain percentage of the estimated direct exchange lines to cover provision for "miscellaneous" circuits. The percentage to be added should be determined carefully, as in some cases, such as buildings in large commercial and financial centres, the miscellaneous requirements may be considerable. In London, for example, the number of miscellaneous circuits (not including internal extension lines), is sometimes considerably in excess of the number of direct exchange lines.

With the exception of large private branch exchange installations, internal extension lines can as a rule be provided independent of the cable system proper, as and when required. Special difficulties arise in connection with the provision of party lines, time service lines, power and ringing lines, as more than one subscriber may be served from a circuit and "grouping" is therefore permissible, and the economical arrangement thereof requires serious consideration.

The telephone demands of a building occupied by one firm and served wholly by a private branch exchange do not vary very materially, but the same is by no means true of a suite of offices or building of a like nature where fluctuations in the demand for telephone service are frequently taking place between very wide limits, and must be suitably arranged for. To provide the latter type of service is perhaps a more difficult matter than might appear at first sight.

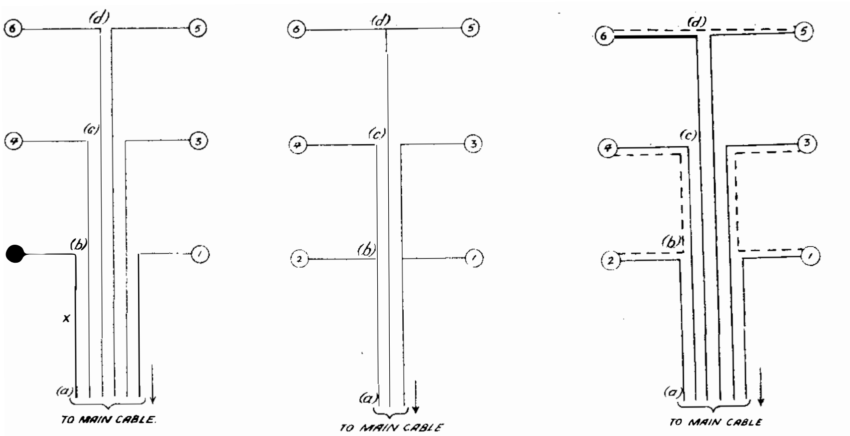
Several different methods of cable distribution are in existence, and a description of some of these may be useful. Owing to the height of buildings it is convenient that distribution should be arranged vertically, generally from the basement or ground floor upwards, and in the examples given the distribution has been carried out in this manner. It should be explained that in the following diagrams (see **1** to **6**) the circles represent distributing points, and each of the straight lines represents a group of pairs of wires connected to a distributing point, but not necessarily separate cables. The points numbered 1 and 2 are on the lowest floor, 3 and 4 on the next, and 5 and 6 on the floor above.

1 illustrates simple distribution, where a number of pairs are led from the street cable direct to distributing points, suitably terminated and left for connection to the subscribers' telephones as required. This arrangement is not flexible, as pairs of conductors terminated at any of the points 1, 2, 3, 4, 5, or 6 are solely available at that particular point, and when all the wires at one of these points have been appropriated relief can be afforded only by a redistribution of the pairs.

The second case (**2**) illustrates the use of "teed" or, as the Americans term them, "bridged" pairs, in affording flexibility. It does not necessarily follow that the whole of the pairs from each point are teed, as only a number of them may be so dealt with, the remainder being connected direct as in **1**.

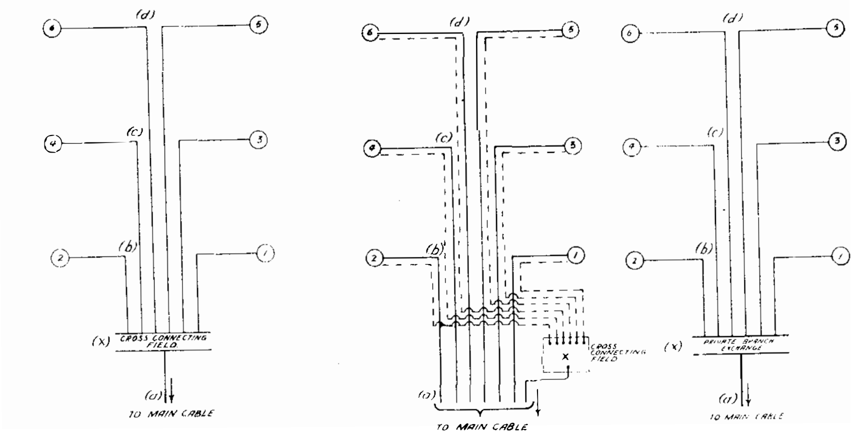
In **3** the use of "interconnected" or "linked" pairs is illustrated. In addition to the pairs connected from each distributing point to the exchange, certain other pairs are provided between one distributing point and another. These pairs may be utilised for internal extension lines, or for connection to the exchange from one distributing point *viâ* another when the spare pairs in the former have been exhausted, or for grouping subscribers on a party line, power, ringing or time service line.

The system illustrated in **4** provides the maximum amount of flexibility obtainable, but this is not always necessary or desirable. The essential difference between 4 and 1 is the introduction of a cross connecting field at point *x*. The whole of the circuits from the



1. 2. 3.

1.—Simple Distribution. **2.**—Teed (or Bridged) Pairs.
3.—Interconnected (or Linked) Pairs.



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4. 5. 6.

4.—Main Cross Connecting Field. **5.**—Main Cross Connecting Field.
6.—Simple Distribution for Private Branch Exchange.

street cable and from the several distributing points are, therefore, available for cross-connection at that point.

Generally a certain number of pairs are required to pass direct from the street cable to the various distributing points, and these need not necessarily be carried through the cross-connecting field, see **5**. The proportion of intercepted pairs provided depends upon the degree of flexibility required, which, of course, varies for different buildings. The number of pairs connected from the main cable system to the cross-connecting field is less than the aggregate number of pairs connected therefrom to the distributing points.

The diagram shown in **6** illustrates a typical private branch exchange installation and needs no special comment.

Each of the systems typified in **1** to **5** possesses its own distinctive advantages, and opinions differ as to the best means of securing the necessary flexibility in any system of cabling. Some degree of flexibility is undoubtedly necessary, but it is exceedingly easy to err on the side of giving too much, thereby producing the following disadvantages :

(1) Increased complexity of the distributing system and a greater cost in the preparation and upkeep of the necessary records.

(2) Increased prime cost.

(3) Increased maintenance charges.

(4) Maintenance rendered generally more difficult.

(5) Increased possibility of interruption to the working lines by the occurrence of faults.

Simplicity is a highly desirable and valuable characteristic, and its application to cable systems is worth serious consideration.

In designing a cabling system tracings of the architect's plans of each floor should be obtained, and upon these should be plotted, either individually or in groups, the lines to be provided immediately and the estimated ultimate lines. These may then be arranged in groups conveniently disposed for distribution. The number of lines included in each group depends upon their initial and ultimate density, and upon the configuration and internal decorations of the building. Regard must also be given to the circuit capacity of the standard cable sizes. The positions of the distributing points are then fixed. If the wiring is to be exclusively external, suitable positions for the distributing points must be selected upon the external walls of the building. When decided, the boundaries of the distributing areas (formed in defining the groups of lines), the branch cables, and the positions of the distributing points are marked upon the floor plans, and the distributing points allotted a distinguishing number. **7** is a plan of the third floor of the Hotel Cecil, London, and shows the details mentioned above. The development information as compiled for each area of distribution is given in the rectangle shown against each distributing point, its upper portion being intended for the number of existing lines (*nil* in this case), the second division showing the number of lines initially required, and the lower portion the number of lines to be accommodated at the end of the period being planned for, as determined by the development study. It will be noticed that the ultimate number of circuits required is in this case very little in excess of the initial number to be fitted.

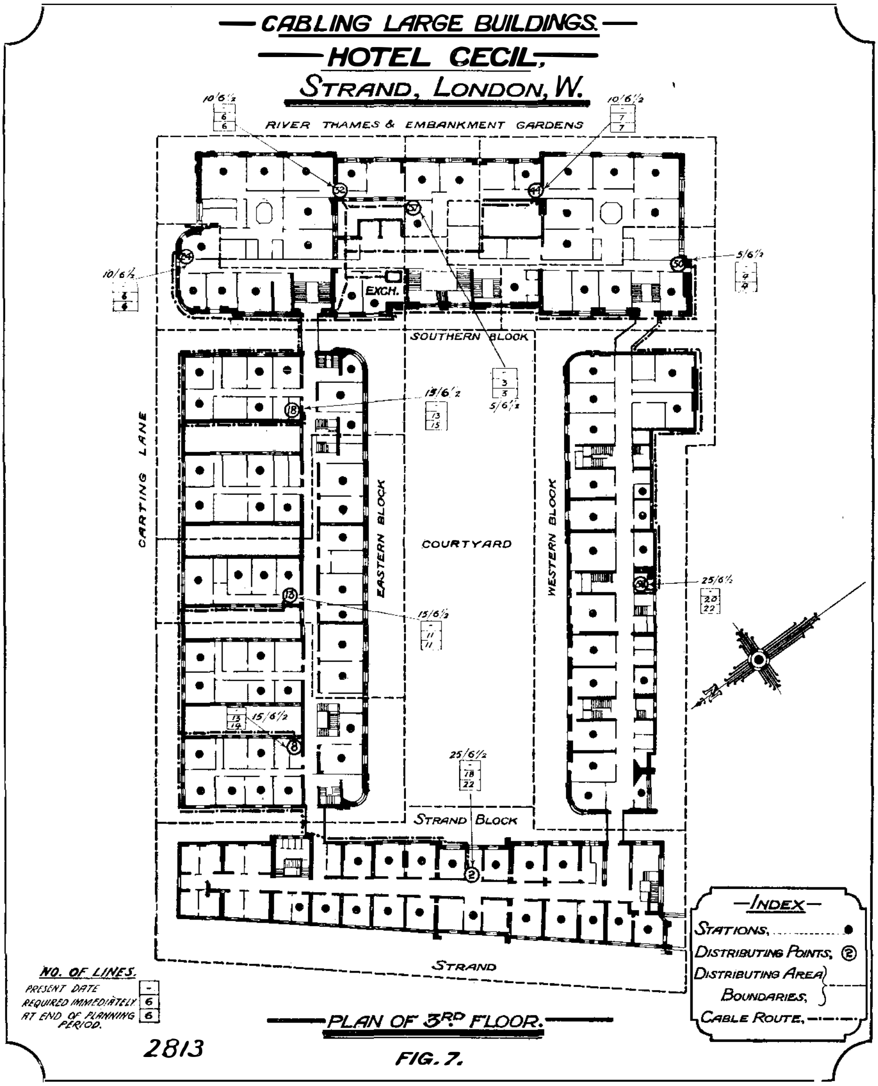
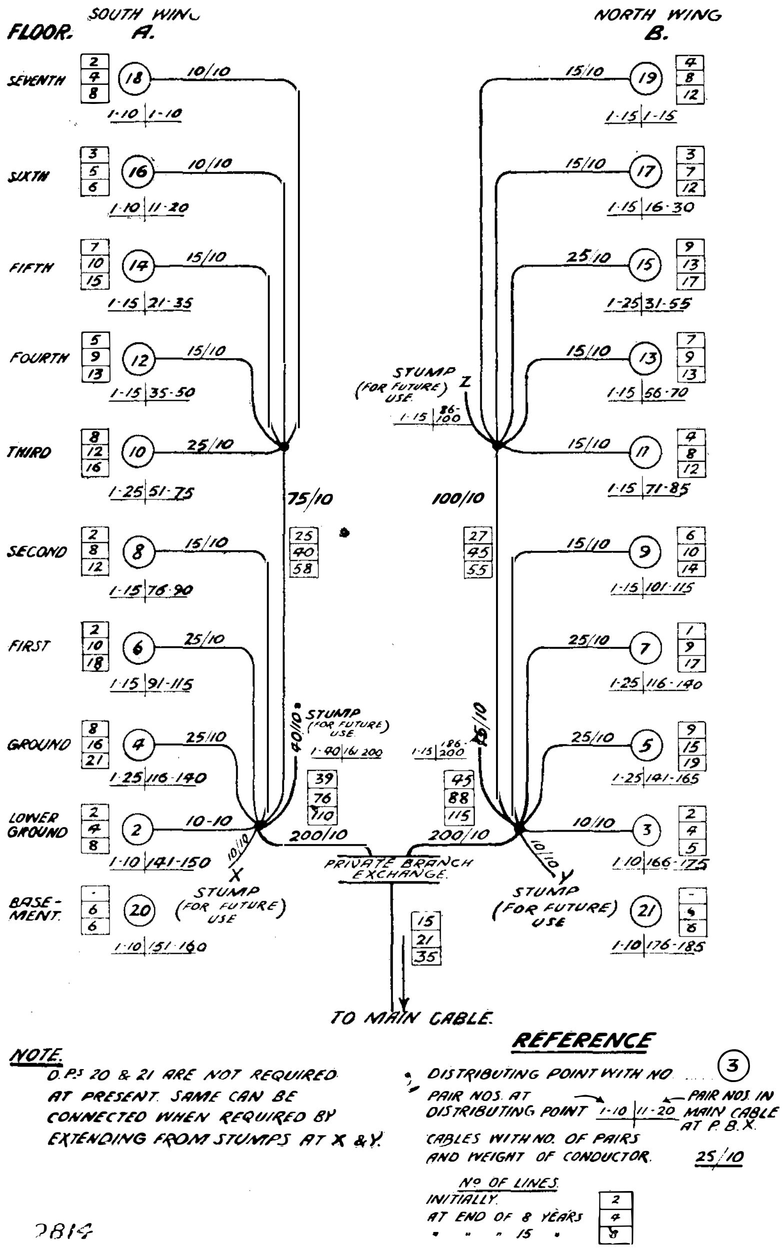


FIG. 7.

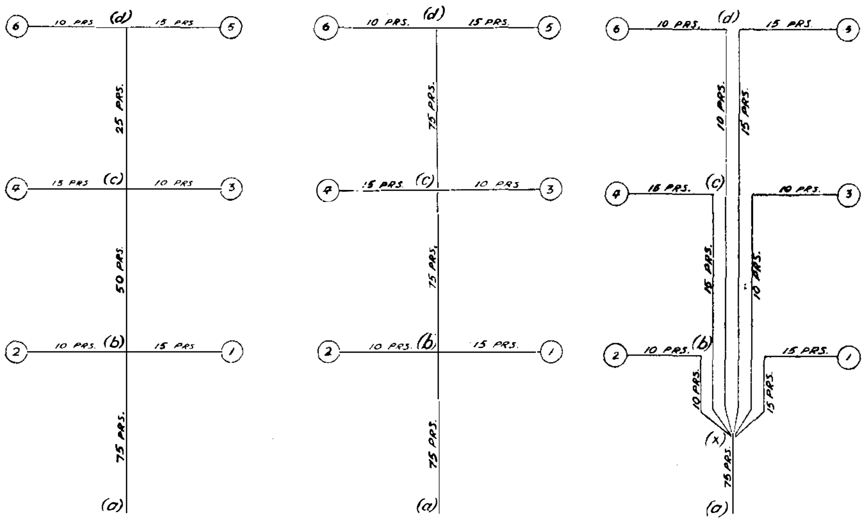
The choice of a course for the main cable run, which is to serve the branches to the distributing points, must in a great measure be made during the determination of the positions for the distributing points, as direct and short a route as possible to the private branch exchange or to the street cable, as the case may be, being chosen. A cable distribution diagram is next prepared, being compiled by reference to the various floor plans previously completed. A cable diagram prepared for an installation at "Asiatic House," Great St.



8.—Private Branch Exchange for Asiatic Petroleum Company, Great St. Helens, London, E.C. Cable Distribution.

Helens, London, is given in 8, which shows the whole of the cable plant to be installed, the distributing points with their numbers, the number of circuits to be accommodated at each distributing point and in each section of cable initially and at the end of the planned period. The weight of conductor, which is also shown, depends upon the transmission requirements. The preparation of plans and diagrams as outlined above is a feature essential to the satisfactory carrying out of the work, and the foreman should be supplied with copies.

As previously stated, distribution may be conveniently effected by the installation of cables rising at one or more points within or upon the external walls of a building. Branches from these vertical cables may then be terminated at suitable points for distribution.



9.—TAPERING SINGLE CABLE. **10.**—SINGLE CABLE WITHOUT TAPER.
11.—PARALLEL CABLES.

The vertical cables may be arranged in one of a number of ways, some of them being exemplified in **9**, **10** and **11**.

9 illustrates the "Taper" system.

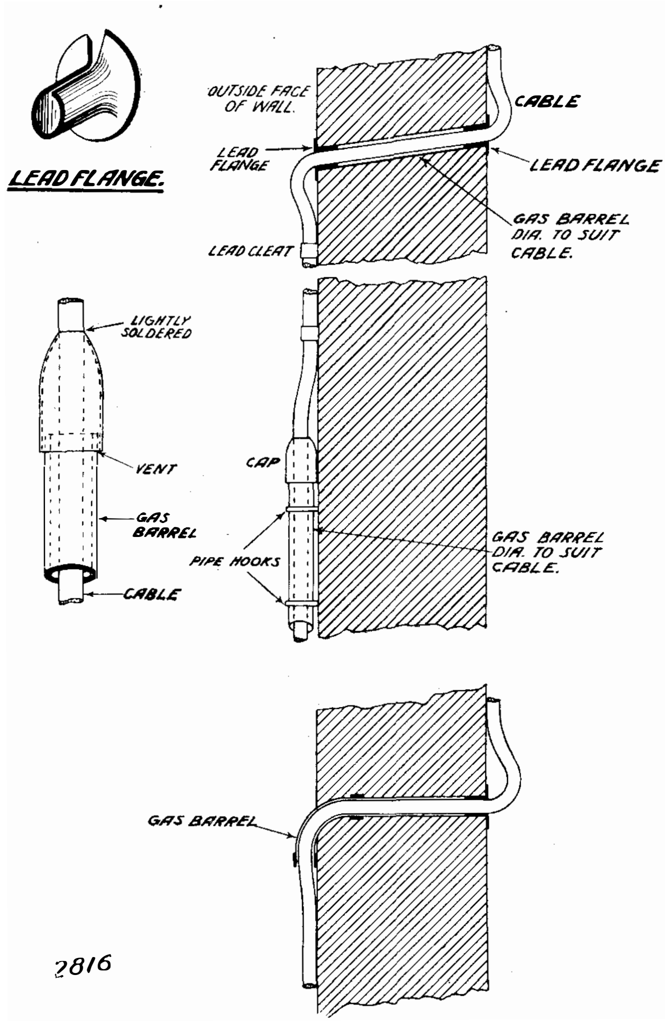
In **10** a single cable of even circuit capacity throughout its length extends as far as the top floor of the building, the branches being tapped off as in the previous system. This method readily lends itself to the provision of teed or interconnected circuits.

In **11** the main feed ends at a suitable point, preferably somewhere near the first branch, and is extended by a number of smaller cables, each serving a particular floor or portion of a floor.

This system lends itself to most cases, and possesses the following advantages over those shown in **9** and **10**:

(*a*) Total number of joints less.

(*b*) Distribution simpler.



12.—Methods of Leading Cables up and into Buildings, etc.

(*c*) The main joint forms a convenient point for re-arrangement of pairs.

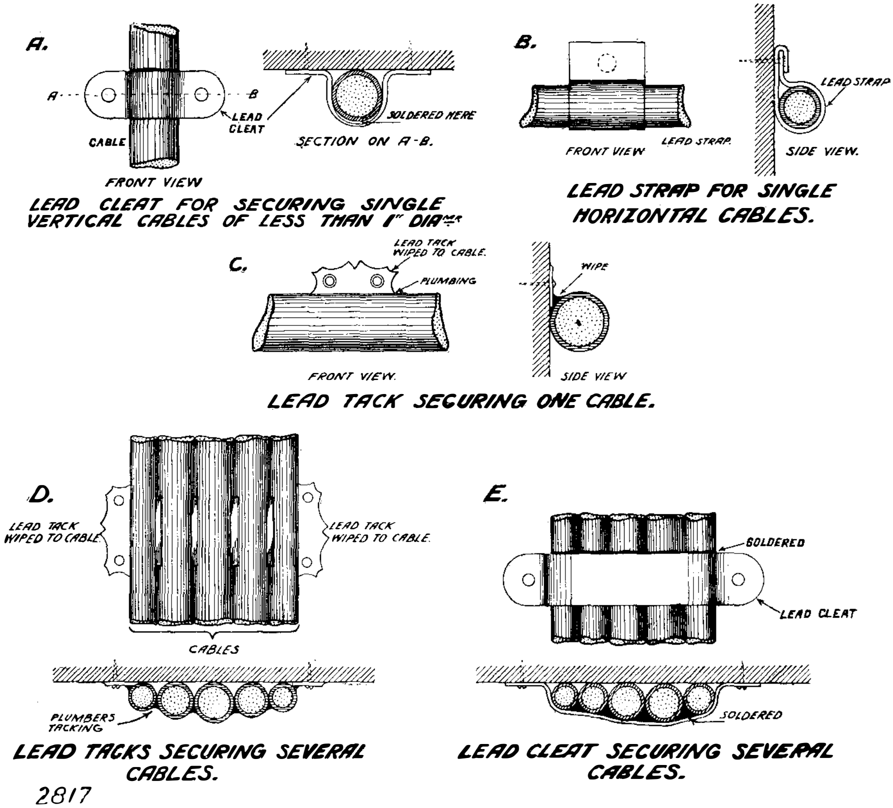
(*d*) The number of different types of cables used is less than in the first system.

(*e*) More readily lends itself to modification without destroying symmetry in cable arrangement.

(*f*) Capital cost less by about 30 per cent., due principally to the saving effected in jointing and its attendant operations, and therefore—

(*g*) Work can be completed more quickly owing to a reduction in the skilled labour required.

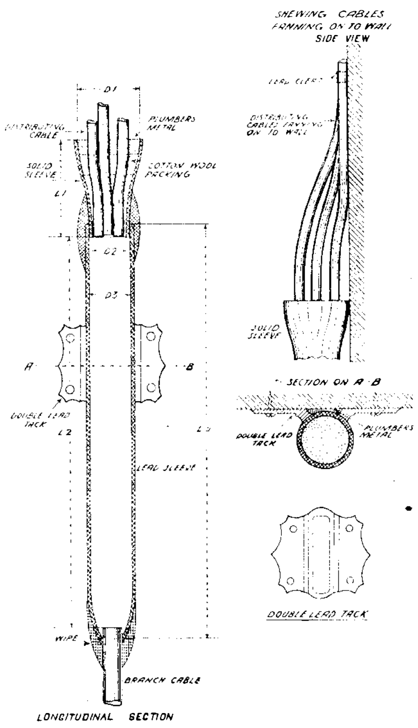
Lead-covered cables are now largely used in the cabling of large buildings. Jointing and its attendant operations are already standardised and need not, therefore, be dealt with. The protection of lead cables from mechanical injury is only required in exceptional



13.—Methods of securing Lead-covered Cables to Flat Surfaces.

cases, as, usually, spacious chutes or large chasings accommodating pipes and cables for general purposes can be utilised. Where, however, cables are led up, or along walls in exposed places, or are fixed in other situations where injury is likely to be occasioned, galvanised iron tubing or other suitable coverings should be provided. **12** illustrates a neat and secure method of leading cables up and through walls and into buildings.

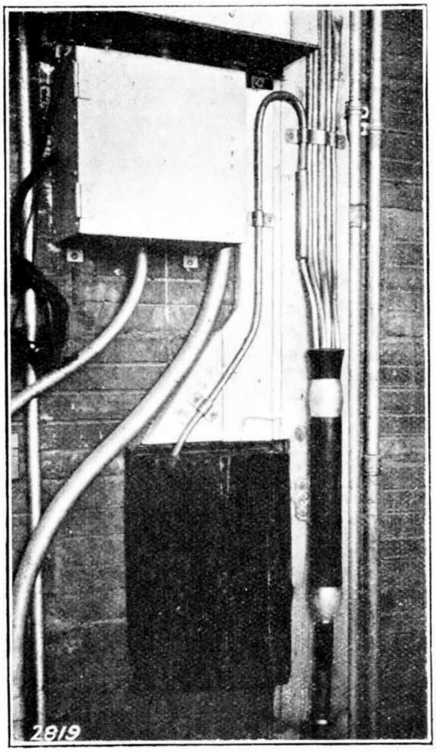
Ledges, cornices and other prominences may frequently be utilised for supporting external cables. Some methods of securing lead-covered cables to the plain surfaces of walls, which may be applied to either internal or external cables, are illustrated in **13**. For vertical cables the plumber's lead tacks shown at *C* may advisedly be placed alternately at the opposite sides of the cable. A method of supporting several heavy parallel vertical cables is shown at *D*. The arrangement shown at *E* is suitable for smaller cables, say of 1 in. diameter and under. To prevent the cables slipping they may be soldered to the top of the lead strap. Care is necessary in order to ensure that the weight of the cables is



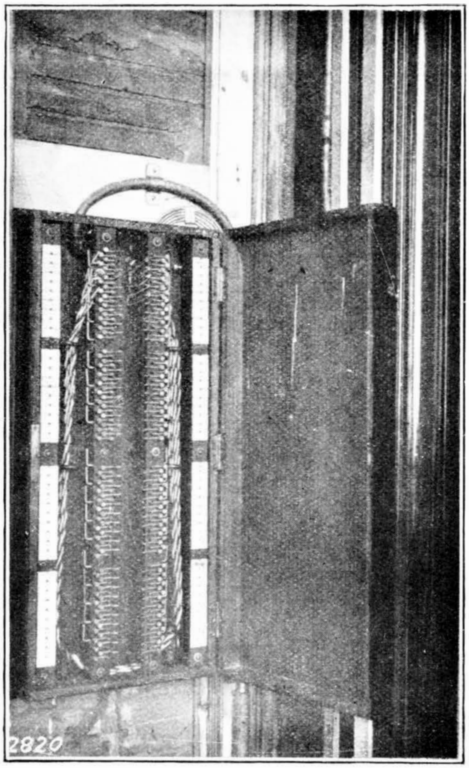
14.—Distributing Joint for P.C. Cables.

distributed equally throughout the several supports. A suitable spacing for the cleats is 2 ft.

For distributing purposes (as in **8** and **11**) it is frequently necessary to connect several small cables to one large cable. A suitable joint for this purpose is illustrated in the drawing reproduced in **14**, which is self-explanatory. These joints have been employed with highly satisfactory results. A prominent feature is the lead collar in which the whole of the distributing cables are symmetrically arranged and secured to form an air-tight joint by flowing in molten plumbers' metal. The collar affords suitable means for plumbing to the lead sleeve of the joint, and provides facilities for the subsequent renewal of the sleeve, in case of necessity, with a minimum disturbance of the existing cables. If it be anticipated that additional cables will be required at a later date, the requisite spare ends or tails may be included in the joint. By means of the joint shown five distributing cables are connected to the single branch cable.



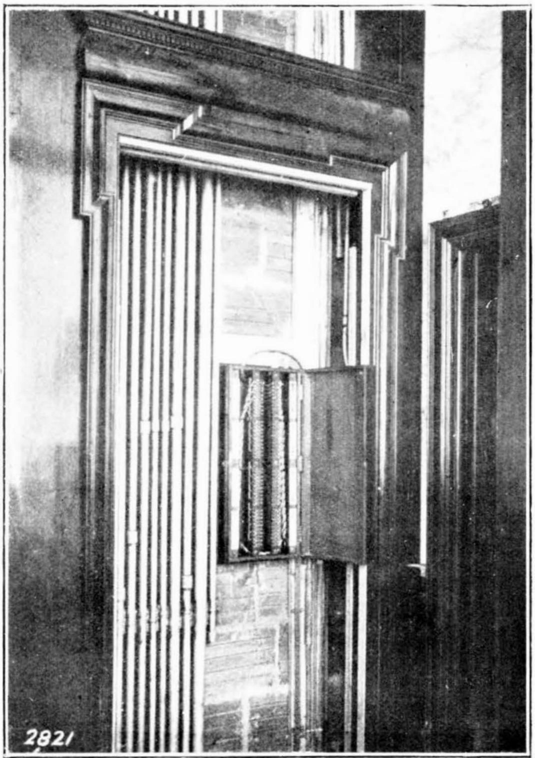
15.—Cable Distribution Joint.



16.—Distribution Case with Cover Open.

15 shows a distributing joint of the above-mentioned type. The distributing cables rising to the upper floors may be seen; one of the distributing cables leads into a distribution case (which forms one of the distributing points for the floor), and a spare tail of cable for future extension is visible on the right-hand side.

Numerous methods and contrivances for terminating paper cables have been devised during the past twenty years, and many of them have been discontinued. The method employed in this country at the present time, involving the use of waxed silk and cotton lead-covered cables, cannot be regarded as entirely satisfactory. The silk and cotton cable requires very great care in handling, and can only be used in situations sheltered from the weather and from a damp atmosphere. Furthermore, silk and cotton insulated cable is expensive. There appears to be a need for a cheap contrivance for terminating the paper-insulated wires without the use of silk and cotton cable, and without the need for a plumbed joint. Experiments in this direction were made in London some time ago. One method tried in an installation consisted in waxing the ends of the paper-insulated wires and connecting them direct to strips of soldering-tabs



17.—Distribution Case in Chase.

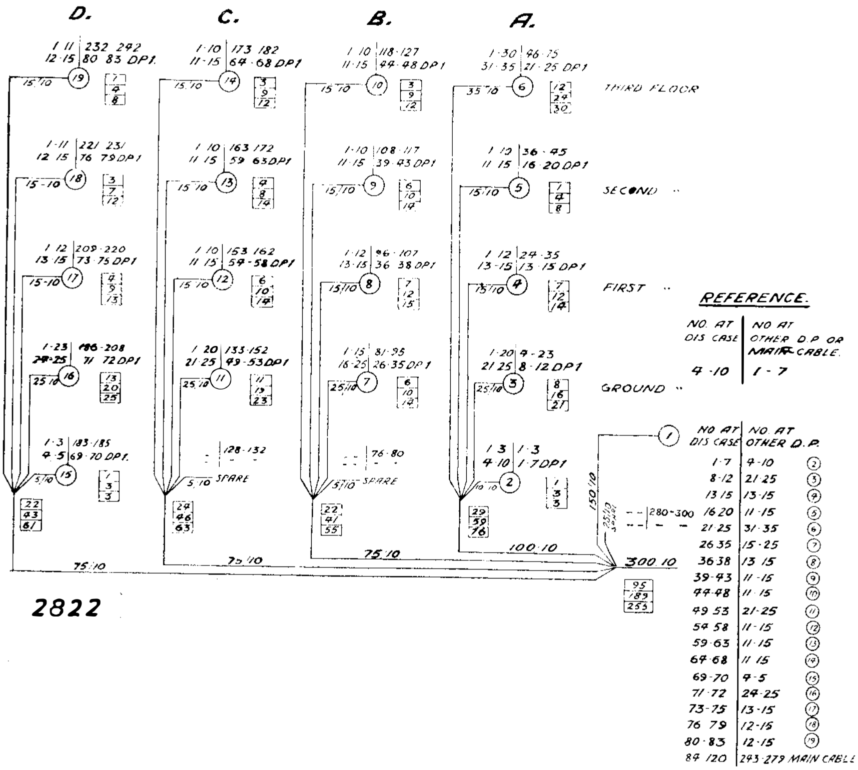
comprising the distributing point. In a second method the wires were terminated on terminals or tabs passing through the back of a specially constructed box, which was afterwards effectually sealed by flowing in molten wax. These experiments were so far successful as to commend the processes for further development.

16 is reproduced from a photograph of a distribution case fitted and wired in connection with the cabling system shown in diagram form in 8. The hinged lid is shown open, and the strips of tabs with cross connecting wires in position can be seen.

17 is a view of the same distribution case, and shows its position

in a large chasing provided for the accommodation of pipes and mains of all classes. This chasing is in the form of a recess or cupboard, which extends from top to bottom of the building. Removable covers are fitted at each floor so that easy access is afforded.

18 is a diagram of an actual cabling scheme in which an attempt has been made to obtain flexibility by the provision of a cross con-



18.—Cabling Scheme Diagram.

necting field fitted in the manner shown in 5, as described previously. The manner in which the pairs are distributed is indicated on the diagram by a system of numbering, and the pairs which are available at the cross connecting field (shown as distributing point No. 1) may be readily followed. The cables providing for each of the four wings of the building are shown under *A*, *B*, *C* and *D*, and these cables are concentrated at a distributing joint in the basement, to which is also connected the cable from the cross connecting field. The number of pairs and weight of conductor of each cable is shown, as also the existing number of working circuits and the anticipated development at the end of the eight- and fifteen-year periods. It will be observed that thirty-seven pairs are connected direct from the cross-connecting medium to the street main, and eighty-three pairs are distributed amongst the eighteen distributing points scattered throughout the building.

LONDON-BIRMINGHAM-LIVERPOOL TELEPHONE CABLE.

By W. J. Hilyer.

In consequence of the great growth of telephone traffic between London, Birmingham, and Liverpool, together with the increasing difficulties encountered in obtaining satisfactory routes for new pole lines for long aërial trunks, it has become necessary to provide an underground telephone channel connecting the three cities. The publication at this stage of a few particulars relating to the scheme will probably be of interest.

Stoneware multi-way ducts of 3⅜ in. internal diameter are being used to form the conduits. 1 and 2 show the route followed and the number of conduits laid down for trunk purposes in the various sections. It will be seen from the amount of pipe space for which provision is made that a large increase in the service along the route is anticipated.

At ordinary cable-jointing points—normally 176 yards apart—the scheme provided for F 2 manholes in the 6-way section of the route, F 1 manholes in the 4-way section, and cast iron couplings (excepting through towns, where double junction boxes or carriage-way jointing chambers are required) in the 2- and 3-way sections.

At the points 2½ miles apart where loading coils will be inserted, F 8 and C 8 special manholes are provided between London and Birmingham, and F 1 and C 1 manholes between Birmingham and Liverpool.

The internal dimensions of the manholes named above are as follows:

Type of Manhole.	Length.	Breadth.	Height.
F 1	4′ 3½″	3′ 0″	3′ 0″ or 4′ 0″
F 2	4′ 3½″	3′ 6″	5′ 0″
F 8 (special)	8′ 0″	5′ 6″	6′ 0″
C 1	4′ 0″	3′ 0″	4′ 0″
C 8 (special)	7′ 0″	7′ 0″	6′ 0″

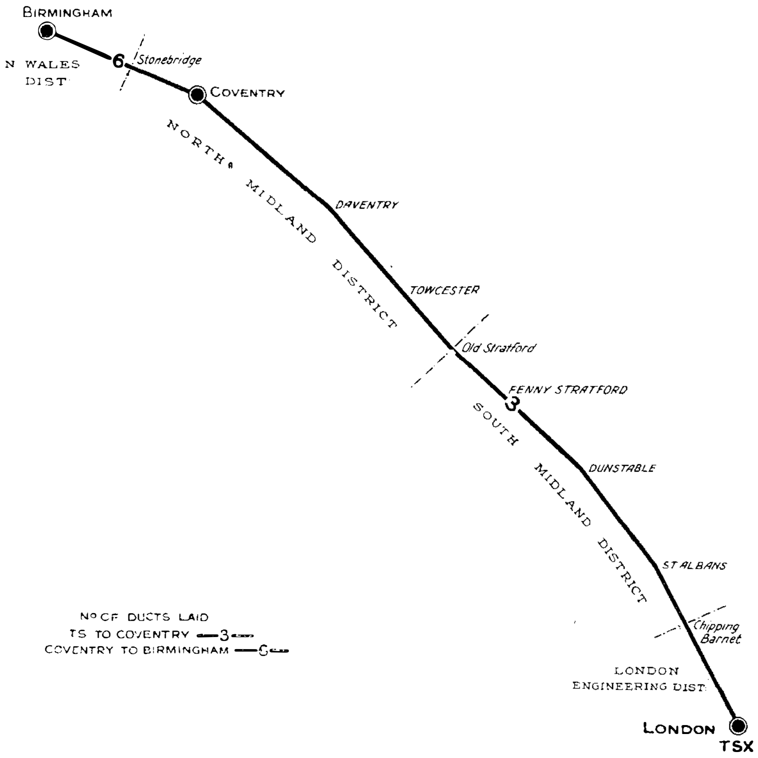
The route length between London and Birmingham is 110½ miles, and between Birmingham and Liverpool 90 miles.

In designing the cable the end in view was to obtain such grades of efficiency as would provide for the following classes of connection:

(*a*) Communication between the telephone areas of the three towns.

(*b*) Communication between the zones of which the towns are zone centres.

(*c*) Long-distance communication, *i. e.* communication between



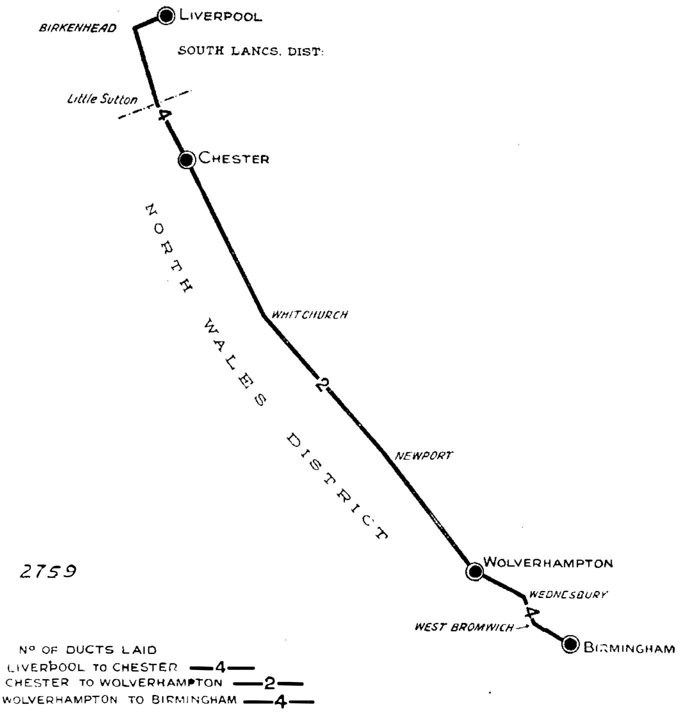
I.—LONDON–BIRMINGHAM ROUTE. LONDON–CHIPPING BARNET, 11·7 MILES; CHIPPING BARNET–OLD STRATFORD, 41·7 MILES; OLD STRATFORD–STONEBRIDGE, 46·9 MILES; STONEBRIDGE–BIRMINGHAM, 10·1 MILES.

places involving longer trains of connections than those considered under (*a*) and (*b*).

The air-space paper-core cable ultimately determined upon contains two 300-lb., fourteen 200-lb., twelve 150-lb. and twenty-four 100-lb. loops made up in multiple twin 4-wire core formation—(stock description 4/300 MT, 28/200 MT, 24/150 MT, 48/100 MT). A diagram showing the section (full size) of the cable is given in **3**, and the theoretical electrical constants of the circuits are given in Table I.

All the loops will be loaded at the outset, as will also twelve superposed circuits formed on 150-lb. and 200-lb. 4-wire cores.

The coils will be of the Western Electric Company's iron-core pattern. At each loading point the following coils will be inserted: fifty type 535 for the 100-, 150-, and 200-lb. circuits; two type 545 for the 300-lb. circuits; and twelve type 536 for the superposed circuits; the whole of the coils will be contained in one cast iron case. A dimensioned drawing of one of the cases of coils is given in 4 and a photograph of a similar case in 5. Electrical data relating to the coils are given in Table II.

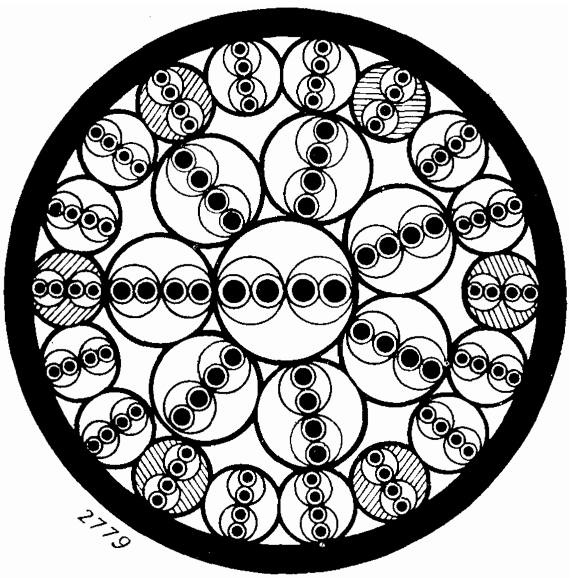


2.—BIRMINGHAM–LIVERPOOL ROUTE. BIRMINGHAM–LITTLE SUTTON, 79·7 MILES; LITTLE SUTTON–LIVERPOOL, 10·2 MILES.

The "leading-out" conductors (for connecting the coils to the main cable) are to be paper-insulated and impregnated, and are contained in two separate cable stubs; one of these will be connected to the "up" side of the main cable and the other to the "down" side. The necessary connection between the side and phantom circuit coils will be made within the case. The paper coverings insulating the leading-out conductors will be coloured; the colour scheme for the cable stubs provides for the identification of the type of coil connected to any pair, and also for the identification of those 4-wire cores in connection with the superposed circuit coils.

The two windings of any coil of types 535 and 545 will be led out on the one side by means of a pair in the one cable stub, and on the other side by means of a pair in the other stub.

Each pair of coils 535 and 545 (and in twelve instances a pair of coils 535 plus a coil 536), which will be inserted in a 4-wire core in the main cable, will be led out on the one side by a 4-wire core in the one stub, and on the other side by a 4-wire core in the other stub. The same colour scheme is to be used for the two stubs, and a pair or core of wires of any particular colour in one stub will be connected



FULL SIZE
CENTRE CORE 300 LBS CONDUCTORS
1ST LAYER 200 LBS "
2ND LAYER {150 LBS " (HATCHED)
{100 LBS "

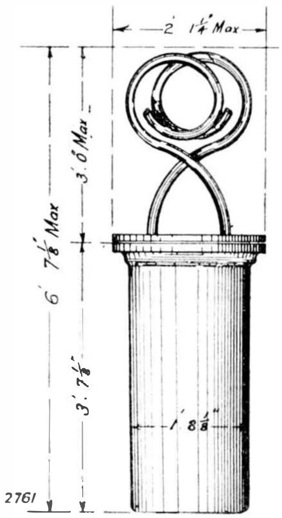
3.

through a coil or pair of coils in the case to another similarly coloured pair or core of wires in the other stub.

6 shows in diagrammatic form the windings of coils of types 535 and 545 and the manner in which these windings are connected to the conductors in the cable stubs. 7 shows similarly coils of types 535 and 536 connected to form a complete side and superposed circuit unit; it will be seen that in this unit the coils 535 act inductively for currents passing round the side circuits to which they are respectively connected, while coil 536 acts non-inductively for such currents, and also that coil 536 acts inductively and coils 535 non-inductively for currents passing round the superposed

circuit. The coils are wound in sections on the iron cores as indicated in order to prevent as far as possible energy losses and cross-talk.

The pipe line is now completed between London and Birmingham and is nearing completion between Birmingham and Liverpool, and cable-laying is proceeding. The cable for the London-Birmingham section is being manufactured and laid by the Western Electric Company, and that for the Birmingham-Liverpool section by the British Insulated and Helsby Cables, Ltd. The Western Electric Company is providing the loading coils for the whole of the work.



Total Weight Complete (with Coils) 1500 lbs.

4.—Loading Coil Case.

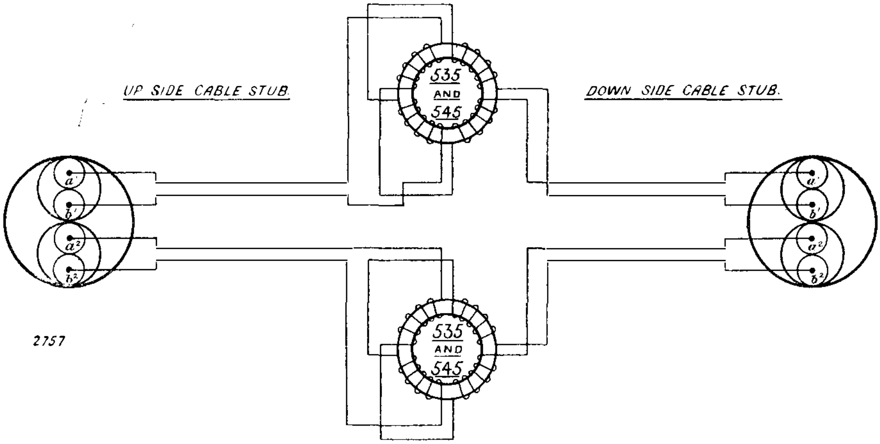
5.—Loading Coil Case.

In order to prevent cross-talk between superposed and side circuits special precautions will be taken to joint together such wires and pairs in successive lengths as will secure the electrical balance of the two wires of a side circuit or of the two pairs of a superposed circuit. (*See page 41 et seq.*)

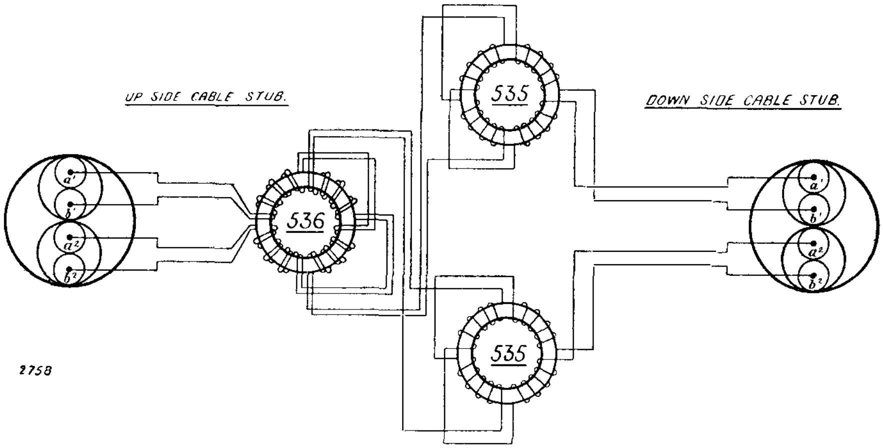
The cases of loading coils will not be placed in the manholes at the loading points, but will be buried horizontally in the ground with the flange of the case and the connecting cable stubs projecting through the wall of the manhole. 8 shows a coil case in position. At each end of the 2½-mile sections air nozzles will be provided in the main cable for desiccating purposes.

As indicated above, the loading spaces are $2\frac{1}{2}$ miles with half spaces at the London and Liverpool ends and on either side of Birmingham.

Table I shows in addition to the electrical constants of the lines the equated lengths for the different gauges. These are such that



6.—Windings and Connections of Coils 535 and 545 for Ordinary Circuits.

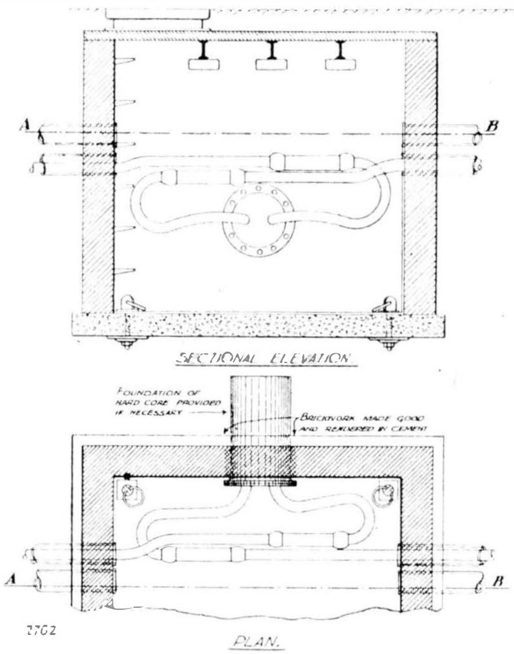


7.—Windings and Connections of Coils 535 and 536 for Side and Superposed Circuits.

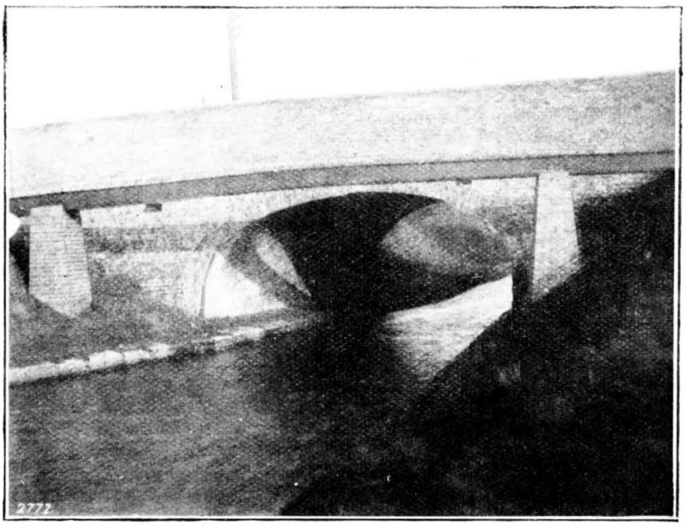
the services referred to on page 33 are provided by the conductors indicated below.

Conductors.

ce a) { Between London and Birmingham } 100 lbs.
Between Birmingham and Liverpool }
Between London and Liverpool { 150 lbs. superposed and 200 lbs.



8.—Loading Coil Case in Position and Coils Jointed to Main Cable.



9.—London-Birmingham-Liverpool Telephone Cable. A Point on the Route. Cables carried alongside Stowe Bridge, Weedon.

TABLE I.—*Data Relating to Loaded Loops.*

Weight per mile lbs. (single wire).	Steady current values.		Values when $2\pi n = 5000$.				Equated length (standard miles) of section.		
	Line resistance, ohms per mile loop.	Wire-to-wire capacity. Mfds. per mile.*	Inductance henries per mile.	Attenuation constant per mile.	Wave-length (miles).	Characteristic impedance.	London-B'gham.	B'gham.-L'pool.	London-L'pool.
100	17·56	·065	·055	·01161	21	$922/\underline{2^\circ}$	12·1	9·9	22·0
150	11·71	·070	·055	·00875	20·2	$886/\underline{1^\circ\ 23'}$	9·1	7·4	16·5
150 (superposed)	5·85	·100	·034	·00759	21·5	$583/\underline{1^\circ\ 15'}$	7·9	6·4	14·3
200	8·78	·065	·055	·00684	21	$920/\underline{1^\circ\ 5'}$	7·1	5·8	12·9
200 (superposed)	4·39	·090	·034	·00601	22·7	$615/\underline{1^\circ\ 1'}$	6·3	5·1	11·4
300	5·85	·065	·055	·00480	21	$920/\underline{0^\circ\ 42'}$	5·0	4·1	9·1

* Pair-to-pair in the case of superposed circuits.

The insulation resistance between any wire and the remaining wires and earth will not be less than 5000 Ω per mile.

The ratio S/K (leakance/capacity) will not exceed 20 when $2\pi n = 5000$.

		Conductors.
Service (*b*)	Between London and Birmingham	150 lbs.
	Between Birmingham and Liverpool	100 lbs.
	Between London and Liverpool	200 lbs. superposed
Service (*c*)	Between London and Birmingham	200 lbs.
	Between Birmingham and Liverpool	150 lbs. superposed and 200 lbs.
	Between London and Liverpool	300 lbs.

The cable will not be led into any office or testing point between London and Birmingham or between Birmingham and Liverpool. It is anticipated that the whole of the work will be completed and the circuits working by July.

When completed the London–Liverpool circuits will be among the longest of the loaded subterranean telephone lines of the world, and the 300-lbs. circuits will be unique in the fact that the conductors are heavier than those of any subterranean telephone lines hitherto laid in Great Britain.

In concluding I have to thank the Western Electric Company for the drawing and photograph in 4 and 5.

TABLE II.—*Electrical Data relating to Loading Coils.*

Type of coil.	Windings in series.			Maximum electro-static capacity between windings (mfds.).	Minimum insulation resistance. (megohms.)
	Inductance (henries)	Maximum effective resistance at 800 p.p.s. (ohms).	Maximum ohmic resistance.		
535	·135	6·75	3·4	·0035	1000
536	·082	4·10	2·0	·0007	1000
545	·135	4·72	2·6	·0035	1000

The insulation resistance is measured with 100 volts direct between any one winding and all the other windings and the containing case. In this Table the term "winding" includes the leading-out conductors in the cable stubs.

BALANCING OF TELEPHONE CABLES WHICH REQUIRE TO BE LOADED FOR SUPERIMPOSED WORKING.

By S. A. POLLOCK, M.I.E.E.

THOSE readers of the JOURNAL who are not already acquainted with the Department's method of balancing telephone cables intended to be loaded and superimposed may be interested in a description of the system of testing and selection of wires for jointing, which has resulted in a very high standard of balance being obtained on the new multiple twin cable completed in November last between Leeds and Hull. The first part of this article will be devoted to the simple theory upon which the system of selection is based, and the second part to the results obtainable and some observations upon the organisation of the work on the road.

Since the principle of inserting crosses in telephone lines for the elimination of inductive disturbances has been dealt with in the various technical instructions issued by the Post Office from time to time, I need not recapitulate all that has been published in the matter already, but it may be interesting to refer to the work of Messrs. F. Tremain and A. W. Martin, who investigated in 1900 the causes of cross-talk and disturbances between circuits on the London–Birmingham underground cable immediately after laying. In their joint reports to the Engineer-in-Chief they submitted schedules showing the out-of-balance of capacity resistance and insulation for the various wires in the cable, and the crosses which were put into the wires as the result of these tests. The crosses had the effect of eliminating not only the cross-talk between telephone circuits, but the disturbance previously caused by Wheatstone telegraph circuits in the cable.

The results obtained in this case were doubtless responsible for the introduction of systematic crossing of wires which was required in later published instructions, but the use of multiple twin cable and the adoption of the jointing scheme of colour rotation rendered the scheduling of crosses upon the results of out-of-balance tests unnecessary for this description of cable in the unloaded condition. The extension of loading has, however, revived the necessity for obtaining a better balance than the colour-jointing scheme provides in practice, and this article deals with the latest developments in this direction.

A description of the method may conveniently be divided into :

TESTING A SECTION OF THE LEEDS-HULL CABLE. TENT REMOVED TO SHOW CABLE ENDS AND TESTING LEADS.

I. Consideration of the conditions governing interference between the circuits.

II. Description of the apparatus used and method of measurement.

III. Method of selecting wires to be joined together.

I. Conditions governing Interference between the Circuits.

There are three conditions to be considered, viz.:

(1) Interference between side and side circuit.

(2) Interference between side and superimposed circuits.

(3) Interference between both side and superimposed circuits.

(1) *Conditions for no interference between side and side circuit.*—1 is a diagram of the usual arrangement of circuits connected together for providing a superimposed circuit upon two loops. Considering only electrostatic induction, if an alternating current is flowing in the circuit AB there will be an alternating difference of potential between A and B, and because the two loops are connected together at the middle points of the transformers the wires CD will be intermediate in potential between A and B if the capacities between the wires of the loops are symmetrical. In practice the capacities are not quite symmetrical, and the magnitude of the effect of want of symmetry will depend upon the potential to which the wires are raised by the alternating current. For the same power at any point the potential in loaded circuits is higher than in unloaded circuits whilst the current strength is less. Taking the effects of A and B separately upon C and D, if the capacities W and Z are equal, the charges induced on C and D by A will be equal to each other and will produce no current round the side circuit CD; similarly if the capacities X and Y are equal, the charges induced by B will be equal to each other and will produce no current round the side circuit CD. But these are not the only conditions which give freedom from interference between the two side circuits.

1a gives the superimposing connections in another form, the four wires of one core of a cable being shown in cross section with the capacities between them as before. Taking again a difference of potential between the wires AB and calling it $Va—Vb$, where Va and Vb are the potentials of A and B respectively, we shall find the conditions required in order that there shall be no difference of potential between C and D. Let Vw, Vx, Vy, Vz represent the potential differences between the wires AC, CB, BD, DA respectively, and W, X, Y, Z the corresponding capacities, and let there be no

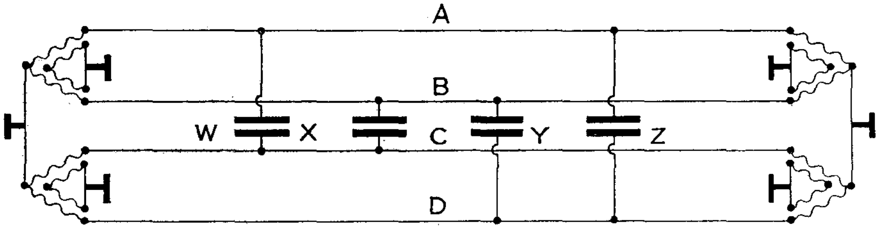


FIG: 1

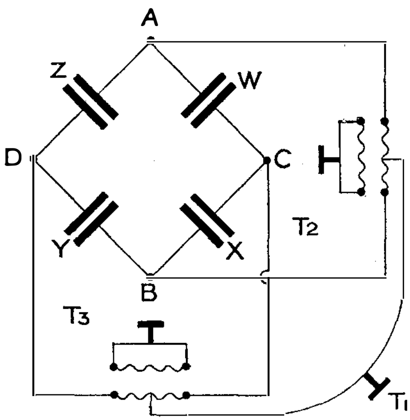


FIG: 1a.

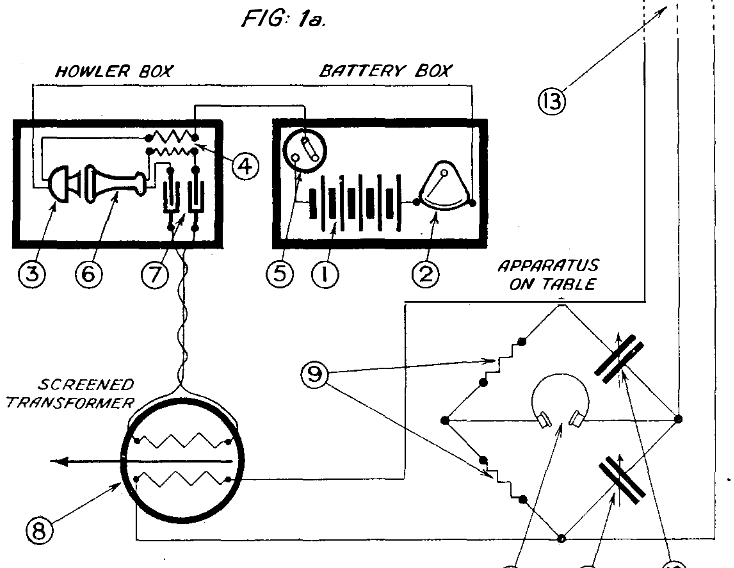


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FIG: 2

difference of potential between C and D. Then because the same quantity flows into W and X—

$$VwW = VxX \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Also for the same reason—

$$VzZ = VyY \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The potential of $C = Va - Vw$ and the potential of $D = Va - Vz$.

Therefore in order that there shall be no difference of potential between C and D, Vw must be equal to Vz and likewise Vx must be equal to Vy. If we make these equal then (1) and (2) become—

$$\frac{W}{Z} = \frac{X}{Y} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Similarly if we apply a difference of potential between CD, a balance is obtained between AB when—

$$\frac{W}{X} = \frac{Z}{Y} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The same result will be obtained by taking W, X, Y, Z as the capacity arms of a Wheatstone bridge and calculating their values from impedances to alternating currents. The last result is identical with (3), which therefore represents the only conditions for no interference between side and side circuits.

(2) *Conditions for no interference between the superimposed and side circuits.*—Referring again to 1a, the wires AB together form one side of the superimposed circuit while the wires CD form the other. Consider the influence of the wires A and B forming one side of the superimposed circuit upon the side circuit composed of the wires C and D. In this instance there is no difference of potential between A and B, but there is a difference between these wires and CD. In order that there shall be no difference of potential between C and D, the same quantity must flow from A and B into C as into D. Let the difference of potential between A and C, B and C, A and D, B and D, be $Vab - Vcd$, then $(W + X)(Vab - Vcd) = (Z + Y)(Vab - Vcd) = Q$, that is—

$$W + X = Z + Y \quad . \quad . \quad . \quad . \quad (5)$$

Next consider the splitting of the current from T_1 into the two wires AB through the differential transformer. In order that T_2 may not be affected by T_1 the currents must divide equally between A and B, and this is only obtained when the two capacities—

$$W + Z = X + Y \quad . \quad . \quad . \quad . \quad (6)$$

Similarly it can be shown that for balance between the wires CD forming one side of the superimposed circuit and the side circuit AB the condition is—

$$W + Z = X + Y,$$

and when we take the splitting of the current from T_1 into the wires CD we must have for T_3 not to be affected—

$$W + X = Z + Y.$$

Equations (5) and (6) are therefore the conditions for no interference between the superimposed and side circuits.

(3) *Conditions for no interference between side and side circuits and between superimposed and side circuits simultaneously.*—These conditions are deduced from the preceding equations as follows:

From (5) $W - Z = Y - X$

,, (6) $W + Z = X + Y$

By addition $2W = 2Y$

$$W = Y \quad (7)$$

By substitution in (6) $X = Z$ . . . . . . (8)

Dividing (7) by (8) we get—

$$\frac{W}{X} = \frac{Y}{Z}$$

but from (4)

$$\frac{W}{X} = \frac{Z}{Y}$$

Therefore

$$\frac{Y}{Z} = \frac{Z}{Y}, \text{ and therefore } Y = Z \quad (9)$$

Hence from (7), (8) and (9) we get:

$$W = Z = Y = Z \quad (10)$$

as the condition for perfect balance between side and side and between side and plus circuits.

When testing the cable the following measurements are made on each core:

(i) $p = W - X$
(ii) $q = Z - Y$
(iii) $r = W - Z$
(iv) $s = X - Y$

where W, X, Y, Z are wire-to-wire capacities in the presence of other conductors and the sheath.

Now if we select from the test results wires which when jointed together make $p - q = o$ and $r - s = o$ (these are termed the side characteristics) and also $p + q = o$ and $r + s = o$ (these are termed the plus characteristics),

Then $p = o$, $q = o$, $r = o$, and $s = o$, *i.e.*

$$W - X = O$$
$$Z - Y = O$$
$$W - Z = O$$
$$X - Y = O$$

or $W = X = Y = Z$, which satisfies the condition for perfect balance.

In practice it is found better and easier to select wires for jointing so as to reduce the "side" and "plus" characteristics to zero than to select for the reduction of the values p, q, r, and s to zero. This is because (1) $p - q$ and $r - s$ are identities, hence there are only three values to consider instead of four, and moreover $p - q$ and $r - s$ are often so small that there are usually only two values to consider. (2) The changes which the side and plus characteristics undergo when wires are crossed are simpler than those which take place when we are dealing with p, q, r, and s. For example, suppose we cross the wires AB and the wires CD also. Then the new values of p, q, r, and s are $-q$, $-p$, $-s$, $-r$, *i.e.* both the signs and the order of sequence change, whereas $(p - q)$ $(p + q)$ and $(r + s)$ become $+ (p - q) - (p + q)$ and $- (r + s)$, *i. e.* a change only occurs in the signs. (3) $(b - q)$ and $(r - s)$ indicate the magnitude of the side to side out of balance, whilst $(p + q)$ and $(r + s)$ are a measure of the side to plus out of balance. Hence when we are dealing with these values instead of with p, q, r, and s, we can see more clearly to what extent we are reducing the "side" out of balance and the "plus" out of balance respectively. The method of selecting wires is dealt with in (III), but a description of the apparatus used for testing will be given first.

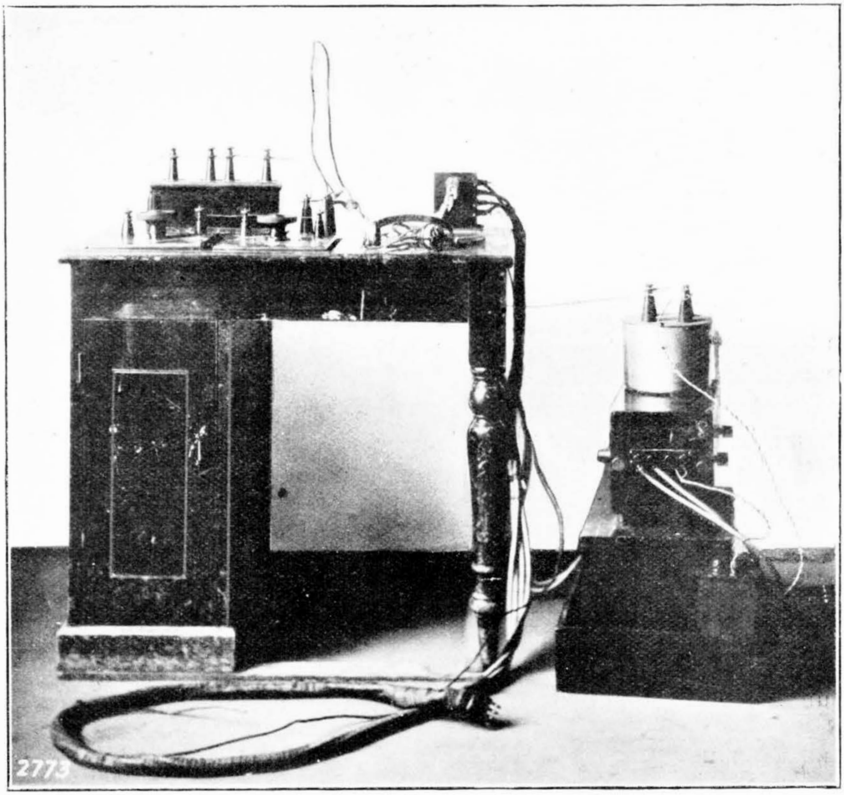
II. Description of Apparatus used and Method of Testing.

The tests are performed with a portable equipment contained in a table measuring 2 ft. 9 in. × 2 ft. × 2 ft. 6 in. high and two boxes containing the generator and batteries respectively. Alternating current of speech frequencies is provided by a generator consisting of an inset transmitter (*3*) (**2**) connected through a No. 2 induction coil (1$^{\omega}$ primary and 150$^{\omega}$ secondary) (*4*). In the primary circuit of the induction coil are the battery (*1*), consisting of six dry cells of size *Z*, milliammeter (*2*), transmitter (*3*), induction coil primary (*4*), switch (*5*).

In the secondary circuit of the induction coil are the telephone receiver (*6*) tuned to a high note by being nearly filled with wax and placed opposite to the transmitter at a suitable distance away, a tuning condenser of ·04 mfd. on one wire *or* preferably two condensers of ·08 mfd., one in each wire between the generator box and the specially screened transformer (*8*), the secondary of which feeds the capacity bridge.

The action of the generator is as follows: Closing the battery switch (*5*) causes current to flow in the transmitter circuit through battery (*1*), milliammeter (*2*), transmitter (*3*), induction coil primary (*4*); the current flowing in the primary induces current in the secondary circuit *viâ* condensers (*7*), special transformer (*8*), and receiver (*6*). This causes the diaphragm to move and transmit sound to the transmitter, which reacts again on the telephone receiver thus setting up a continuous complex sound or howl; hence the name "howler" by which this apparatus is usually known.

The measuring instrument is a Wheatstone bridge suitable for alternating current containing non-reactive ratio arms of 1000 + 1000 ohms (*9*) and two continuously graduated air condensers. Instead of the non-reactive resistances the secondary of a transformer No. 2 which has been specially balanced for the work may be used, the primary being insulated. This arrangement is more sensitive than the 1000-ohm arms for testing short lengths of cable owing to the mutual induction between the windings making it non-inductive to the telephone current and highly inductive to the power current.



TESTING TABLE WITH APPARATUS.

On the other hand, great care must be taken in the selection to see that only an accurately balanced transformer is used and that its accuracy is frequently checked. If accurate the ratio arms will bear reversal without altering the reading of the condensers. The wires of a pair in the cable are joined to the ends of the bridge as in diagram 2 and two variable air condensers (*11* and *12*) are bridged across in series. One of the wires of the other pair in the same core is brought to the centre point of the two condensers, and the telephone (*10*) is bridged from this point to the middle of the ratio arms.

A wireless headgear telephone receiver providing maximum sensitivity is used for this work. The specially balanced transformer

(*8*) has an electrostatic screen between the primary and secondary windings. The capacities of both these windings are balanced to the screen in such a manner that when the screen is connected to earth the transformer feeding the bridge can be reversed with respect to the bridge without affecting the zero of the bridge or the balance obtained. This is essential to accuracy of measurement.

Let *A B C D* be the wires respectively of a four-wire core, *A* and *B* forming one pair and *C* and *D* forming the other pair.

A four-way clip, 3 (*17*) is placed on these wires, and a connecting plug (*18*) terminating four heavy rubber insulated and earth screened leads (*14*) is connected to the clip (*17*), the other end of the leads being connected to a special plug and switch (*16*) and (*15*).

The function of this plug and switch is to perform the following operations:

Connect *A* and *B* to the bridge, and *C* to the telephone for test *p*.

Connect *A* and *B* to the bridge, and *D* to the telephone for test *q*.

Connect *C* and *D* to the bridge, and *A* to the telephone for test *r*.

Connect *C* and *D* to the bridge, and *B* to the telephone for test *s*.

Plugging into the four positions marked *P Q R S* with the plug (*16*) makes the necessary connections. A few notes upon the practical handling of the testing set are necessary.

The middle pin of the plug is shorter than the other two, in order that the telephone connection may be made last. If this is not done the current through the telephone on plugging in will be excessive and somewhat annoying to the ear. Especially is this the case when testing lengths of cable of half a mile and upwards and using mutual induction in the arms of the bridge (when a repeating coil is used instead of non-inductive arms). It is essential that all the springs and plugs in circuit should make good and reliable contact. If they do not, endless trouble will be caused and it will be impossible to balance the bridge in the majority of cases. Long lengths of cable are very exacting in this particular.

The variable condensers should be connected so that the terminal which is joined up to the moving arm is also connected to the telephone. In making the test the variable condenser connected to the *A* or *C* wire is moved, the other remaining fixed. Before starting to test, set the (*A*) condenser to its middle or other fixed point, usually 100, and set the *B* condenser to balance. Now reverse the two condensers with respect to the bridge arms; they should absolutely balance without alteration if the bridge arms are accurately adjusted. If they are not they ought not to be used.

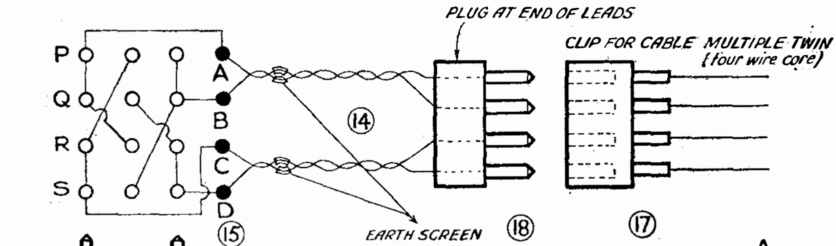
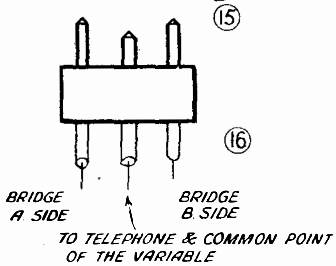



FIG: 3.

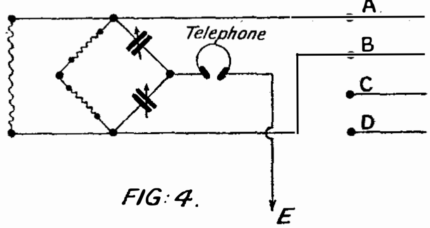


FIG: 4.

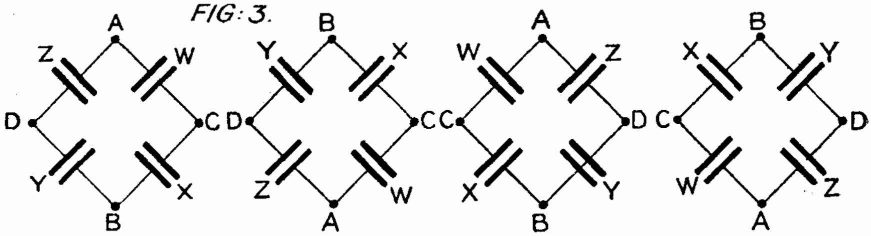


FIG: 5

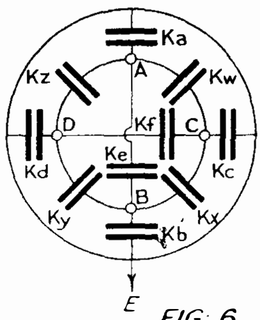


FIG: 6

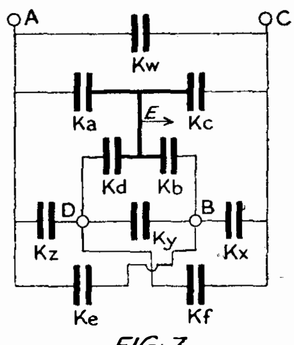


FIG: 7

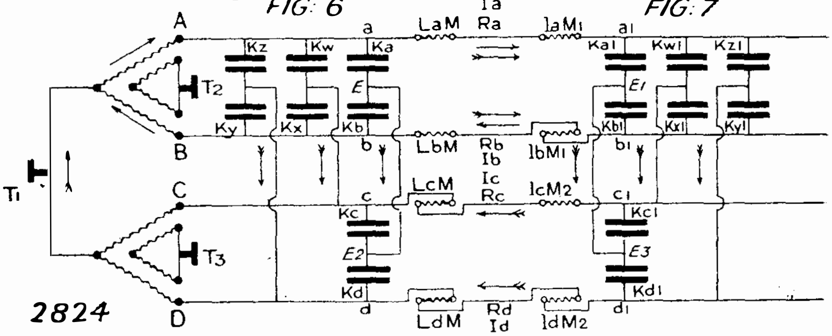


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FIG: 8.

During this preliminary check the plug switch is not in use and the leads are therefore disconnected. Place the 3-way plug in the (*p*) position, balance on the air condenser, reverse the plug and balance again. Both the readings should be at the same point as the zero. If they are not it means that the capacity of the *A* lead to the *C* lead is greater or less than that of the *B* lead to the *C* lead, according as the reading of the condenser is smaller or greater than the zero or middle point.

The middle point or zero is usually taken at 100, and below 100 is taken as positive. Thus 90 is called + 10, while 110 is negative and is called − 10. The reason is that the capacities of the variable condensers are put in to *add* to the capacities of the cable in order to make the total capacities equal; thus, if a smaller capacity is added on one side, it means that the wire of the cable on that side has a greater capacity to the wire on the telephone than its companion wire in the same pair.

In order to test the leads up to the connecting plug (*18*) (3) and balance them the telephone may be placed between the middle point of the condensers and earth (4). A small capacity to earth is connected with *A* or *B* and the value of the capacity varied by small steps until a balance is obtained. Usually the amount required is very small, and can be readily provided by taking a few inches of the special copper braided thick rubber-insulated wire used for the leads, and sealing up the disconnected end with Chatterton compound to ensure good insulation between the conductor and the braid. The balance may be checked by interchanging the two air-condensers, which, if the balance is correct, will not require readjustment. The leads *C* and *D* may be balanced in like manner. If earth is now removed from the telephone and *C* and *D* connected to the telephone instead, the leads *A* and *B* will now be found to be balanced. This method only holds good if the leads are properly screened by an earth-connected metallic braid all along their length, but is a very accurate one. The bridge arrangement shown in 2 may also be used for balancing the leads to earth, the middle point of condensers in that case being earthed. The zero of the condensers may always be checked by reversing the 3-plug switch. After reversal the reading should be as much on one side of zero as it was before on the other (This also checks whether the value, say, of 30 division above zero is equal to 30 division below zero.)

To make the test of the cable both the ends are opened and the wires fanned out. Two or more clips are used to expedite the work, the ones not in use being put on the cable in readiness for the next core to be tested, so that the testing leads may be transferred without loss of time.

Care is taken to see that the wires are placed on the clip properly and the clip on the leads properly, according to the following scheme:

Leads.	Wires.	Pairs.	Core.	Pairs.	Core.
A	connected to *a* wire red string	red	red	blue	white
B	connected to *b* wire white string		or		or
C	connected to *a* wire red string	white	blue	green	green
D	connected to *b* wire white string				

Readings are then taken with the 3-way plug in the four positions of the switch. These represent the differences *p*, *q*, *r* and *s* mentioned previously, and are read directly to the nearest division of the air-condensers above (minus) or below (plus) zero. The maximum value of the air condensers is approximately 0·0012 mf. The scale is divided into 180 divisions. Each division represents approximately 0·1 per cent. error in capacity in the case of 175 yds. of a 108-wire 100-lb. multiple twin cable. It is possible with the 1000-ohm ratio arms to read to 0·5 division, and with higher arms to about 0·2 division when testing the single lengths with the ordinary equipment. On longer lengths the sensitivity is much greater. For instance, on two and a half miles of cable measuring 0·15 mf. wire-to-wire capacity one division on the air condenser represents about 6 parts in 150,000 of the cable, and the sensitivity of the arrangement with an efficient "howler" and mutual inductive ratio arms is sufficient to read to one-sixth division if a perfect zero of sound is obtainable when balanced. To obtain this great sensitivity it is necessary to balance the conductor resistance and leakance discrepancies of the wires under test if such discrepancies exist by introducing a small slide wire of 1 ohm or less into one or other wire of the pair. But a better though more expensive arrangement is the use of a 100-ohm slide wire between the two air condensers with the sliding contact connected to the telephone and the middle wire. The latter arrangement eliminates possible trouble with the contact resistance of the slider. This refinement is not required in practice so long as imperfect contacts do not exist in the switch and plugs between the bridge and the cable, and the resistances of the wires in the pair under test are reasonably matched and the cable dry. Failure to obtain absolute zero of sound on attempting to balance usually indicates one or more of these defects if the accessory apparatus has been properly designed and constructed in the first instance. For purposes of selection it is not necessary to record fractions of a division; the nearest division is ample for the purpose.

The actual equipment used with each testing set consists of a table fitted up with the apparatus described in the foregoing, the connections being made by means of highly insulated leads. All terminals are mounted on ebonite pillars.

A light furniture van may be conveniently used to carry the apparatus from section to section. The tests can then be carried out from the van in wet weather. The vans should be fitted with dumpy stoves in order to keep the atmosphere as dry as possible in bad weather. In fine weather the tests may be made in jointer's tents.

But where expedition is a matter of great importance and the lengths can be got ready for testing quickly enough the testing set can be more permanently installed in a light motor van. The most economical procedure is to arrange for the testing van to follow closely behind the gang or gangs drawing in the cable lengths. This saves the expense and time of opening up the ground again for testing the ends, but limits the rate of testing. It has been found that where holes had already been filled in each testing van accompanied by seven men to open up the ground, prepare the cable ends, connect the testing clips, and to close and re-cap the cable after test could deal with sixteen cable lengths per day.

This rate of progress, however, is difficult to maintain, and twelve cable lengths per day may be considered a good average in favourable weather. A second testing set is employed to test the longer sections of four or five lengths after the single lengths have been joined up by the jointers.

III. Method of Selecting Wires to be Joined together.

As already explained, the object of the system is to join adjacent sections of cable together in such a way that the capacities between the wires of each core should as nearly as possible fulfil the conditions for balance both between the side circuits and between the side and superimposed circuits. The principles upon which selection of the wires is based will first be explained and the actual procedure will be described afterwards.

There are two steps in the selection of suitable wires to be joined together: first, the selection of the cores; secondly, the method of joining up the selected cores.

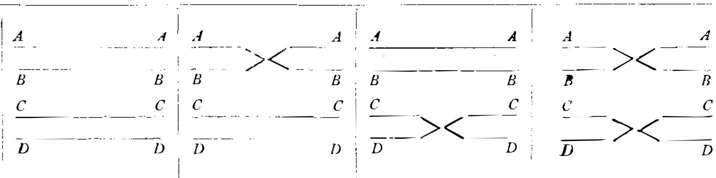
It will simplify the explanation if the second of these steps is considered first.

The cable dealt with is a multiple twin type composed of four-wire cores. It is essential that complete cores should be joined together; that is, the two pairs forming one core in a length of cable cannot be joined through to two pairs in different cores in the adjacent length of cable. Hence, supposing that the two cores to be joined together have been chosen there are eight ways of connecting the wires of the cores. If one length is imagined straight, *i. e.* as represented by the order of the wires in 1A, the adjacent length may be joined to it in any of the orders shown in **5**, *i. e.* (1) straight, (2) wires AB reversed, (3) wires CD reversed, (4) both AB and CD reversed. Combinations (5), (6), (7) and (8) are obtained by crossing the two pairs and connecting the wires of the pairs as in (1), (2), (3) and (4).

It is necessary to find the effect of these operations on the values of the measured quantities p, q, r and s. This can best be seen by reference to the diagrammatic representation of the core sections shown in **5**.

It will be seen that by reversing AB, p or $(w - x)$ becomes $-p$ or $(x - w)$; q becomes $-q$, while r and s are interchanged. Similarly upon reversing CD, p and q are interchanged and the signs of r and s become negative. Upon reversing both AB and CD the signs of p, q, r and s become negative; p and q are interchanged and r and s are interchanged. These effects may be tabulated as shown in Table I.

TABLE I.



	Straight.	AB crossed.	CD crossed.	AB, CD crossed.
P, Q, R, S become .	P, Q, R, S	$-P, -Q, S, R$	$Q, P, -R, -S$	$-P, -Q, -S, -R$
$(P - Q)$ becomes .	$(P - Q)$	$-(P - Q)$	$-(P - Q)$	$(P - Q)$
$(R - S)$ becomes .	$(R - S)$	$-(R - S)$	$-(R - S)$	$(R - S)$
$(P + Q)$ becomes .	$(P + Q)$	$-(P + Q)$	$(P + Q)$	$-(P + Q)$
$(R + S)$ becomes .	$(R + S)$	$(R + S)$	$-(R + S)$	$-(R + S)$

If the pairs are crossed P and Q are interchanged with R and S, the signs remaining as shown in the above table. These changes are also shown in another form in Table II.

It is clear that the cores, which have been assumed chosen, should be joined together in such a way as to reduce the "side" and "plus" circuit characteristics to as near zero as possible. That is, the values of $(p - q)$ $(p + q)$ and $(r + s)$ should be opposite in sign and of the same magnitude for the two cores. The magnitude is that which governs the choice of cores and will be dealt with later. The sign can be regulated by crossing the wires as shown in the above table. That combination should be chosen which reduces each of the characteristics. A numerical example will make this clear.

TABLE II.—*Values which must be Added Together for the Calculation of Residual Balance Differences when Crosses are made.*

Crosses made.	Equivalent arrangement of wires and capacities in core.	Values in top line are to be added to the values in the same vertical columns corresponding to the cross made.			
None	A $z \quad w$ $D \qquad C$ $y \quad x$ B	$w - x = p$	$z - y = q$	$w - z = r$	$x - y = s$
Pairs and CD	D $y \quad z$ $B \qquad A$ $x \quad w$ C	$z - w = -r$	$y - x = -s$	$z - y = q$	$w - x = p$
AB and CD	B $x \quad y$ $C \qquad D$ $w \quad z$ A	$y - z = -q$	$x - w = -p$	$y - x = -s$	$z - w = -r$
Pairs and AB	C $w \quad x$ $A \qquad B$ $z \quad y$ D	$x - y = s$	$w - z = r$	$z - w = -p$	$y - z = -q$
Pairs	C $x \quad w$ $B \qquad A$ $y \quad z$ D	$w - z = r$	$x - y = s$	$w - x = p$	$z - y = q$
CD	A $w \quad z$ $C \qquad D$ $x \quad y$ B	$z - y = q$	$w - z = p$	$z - w = -r$	$y - x = -s$
Pairs and AB and CD	D $z \quad y$ $A \qquad B$ $w \quad x$ C	$y - x = -s$	$z - w - -r$	$y - z = -q$	$x - w = -p$
AB	B $y \quad x$ $D \qquad C$ $w \quad w$ A	$x - w = -p$	$y - z = -q$	$x - y = s$	$w - z = r$

Example I.

Two cores have the following measured values:

Core A. $p = +2, q = +4, r = +24, s = +26.$
Core B. $p' = -7, q' = -6, r' = +30, s' = +31.$

The core characteristics are deduced as follows:

Core A. $(p - q) = (r - s) = -2$; $(p + q) = +6$; $(r + s) = +50.$
Core B. $(p' - q') = (r' - s') = -1$; $(p' + q') = -13$; $(r' + s') = +61.$

The following points should be noticed:

(1) The large values of the plus circuit characteristics occur in the case of the same quantity, namely $(r + s)$ in both cases. We do not require to interchange the values $(p + q)$ and $(r + s)$, therefore we do not cross the pairs.

(2) The characteristics $(p + q)$ and $(p' + q')$ are opposite in sign, whilst $(r + s)$ and $(r' + s')$ are of the same sign. It is therefore necessary to cross the wires of pair *CD vide* Table I, *AB* remaining straight. This alters the sign of $(p' - q')$ and $(r' - s')$ as well as the sign of $(r' + s')$, as the foregoing table shows. The resulting characteristics of the two lengths then become:

$$(p - q) + (p' - q') = -2 + 1 = -1,$$
$$(p + q) + (p' + q') = +6 - 13 = -7$$
$$(r + s) + (r' + s') = +50 - 61 = -11.$$

Similarly the new values of P, Q, R, and S resulting from the combination of the two cores when the wires *CD* are crossed become (*vide* Table II):

$$P = p + q' = +2 - 6 = -4$$
$$Q = q + p' = +4 - 7 = -3$$
$$R = r + (-r') = +24 - 30 = -6$$
$$S = s + (-s') = +26 - 31 = -5$$

Example 2.

Core A. $p = -5, q = -7, r = +15, s = +13.$
Core B. $p' = +11, q' = +11, r' = -8, s' = -8.$

Here the characteristics are:

$$(p - q) = (r - s) = +2;\ (p + q) = -12;\ (r + s) = +28$$
$$(p' - q') = (r' - s') = 0;\ (p' + q') = +22;\ (r' + s') = -16.$$

Inspection of the plus circuit characteristics shows that pairs must be crossed in order to interchange the quantities $(p' + q')$ and $(r' + s')$, and also that the wires *AB* must be crossed to change the sign of $(p' + q')$, and the wires *CD* must be crossed to change the sign of $(r' + s')$, *vide* Table I. The resulting characteristics of the two lengths then become—

$$(P - Q) = (R - S) = (p - q) + (p' - q') = (r - s) + (r' - s') = +2 + 0 = +2.$$
$$(P + Q) = (p + q) + (-(r' + s')) = -12 + 16 = +4$$
$$(R + S) = (r + s) + (-(p' + q')) = +28 - 22 = +6$$

Similarly, the new values of P, Q, R, and S (*vide* Table II), become—

$$P = p + (-s') = -5 + (-(-8)) = +3.$$
$$Q = q + (-r') = -7 + (-(-8)) = +1.$$
$$R = r + (-q') = +15 + (-11) = +4.$$
$$S = s + (-p') = +13 + (-11) = +2.$$

The choice of suitable cores to be joined together is governed by two considerations. The first has been already mentioned, *i. e.* the numerical magnitude of the side and plus circuit characteristics should be of the same order, so that the resultant differences may be small.

The second consideration is that which ensures the reduction of both the side and phantom circuit characteristics. Referring to Table I, showing the change of signs of the characteristics resulting from crossing the wires, it will be seen that any one operation of crossing the wires of a pair changes the signs of three of the characteristics. It will be found upon trial that the signs of the characteristics of a core all of which are measured as positive, can be changed as shown in Table III in the group marked Type A, whilst those which are all measured as negative can be changed as shown in the group marked Type B.

TABLE III.

	$(P-Q)=(R-S)$	$(P+Q)$	$(R+S)$	
Straight	+	+	+	Type A
Cross *AB*	–	–	+	
Cross *CD*	–	+	–	
Cross *AB*, *CD*	+	–	–	
Straight	–	–	–	Type B.
Cross *AB*	+	+	–	
Cross *CD*	+	–	+	
Cross *AB*, *CD*	–	+	+	

It will be noticed that in the four possible arrangements of wires in group A the signs of the three characteristics of one arrangement in no case are all opposite to the signs of the three characteristics in any of the other arrangements. That is, if two cores, both possessing characteristics of the signs shown in the first group, are joined together, it is impossible to reduce both the side and plus characteristics. The same is true of the second group. If, however, a core with characteristics belonging in sign to the first group is joined to one of the second group, both the side and plus characteristics can be reduced. For convenience of reference cores belonging to these two groups are referred to as type A and type B cores respectively. All cores belong either to type A or type B, and wherever possible cores of opposite types should be chosen for joining together. The following numerical example will make the method of choosing cores clear:

Two sections of 6-core cable are to be joined together. The measurements are as shown under p, q, r, s.

Cable length.	Core number.	p	q	r	s	$p - q$	$r - s$	$p + q$	$r + s$	Type.
A	1	− 14	− 14	+ 3	+ 3	0	0	− 28	+ 6	*A* or *B*
	2	− 16	− 18	+ 7	+ 6	+ 2	+ 1	− 34	+ 13	*B*
	3	− 10	− 8	+ 9	+ 11	− 2	− 2	− 18	+ 20	*A*
	4	+ 6	+ 7	− 6	− 6	− 1	0	+ 13	− 12	*A*
	5	+ 1	+ 3	− 3	− 1	− 2	− 2	+ 4	− 4	*A*
	6	+ 10	+ 10	− 8	− 8	0	0	+ 20	− 16	*A* or *B*
B	1	− 15	− 13	+ 7	+ 9	− 2	− 2	− 28	+ 16	*A*
	2	+ 9	+ 10	+ 8	+ 9	− 1	− 1	+ 19	+ 17	*B*
	3	− 14	− 13	+ 5	+ 6	− 1	− 1	− 27	+ 11	*A*
	4	− 4	− 2	− 5	− 3	− 2	− 2	− 6	− 8	*B*
	5	− 10	− 9	− 4	− 3	− 1	− 1	− 19	− 7	*B*
	6	+ 8	+ 7	+ 7	+ 6	+ 1	+ 1	+ 15	+ 13	*A*

Taking core 1A, it is required to find a suitable core in cable Section B to which to join it. Since the side characteristics are zero, the type is immaterial, but the side characteristics of the chosen core should be small. Core 3B is the most suitable as regards magnitude of the characteristics.

Core 2A requires a type A core in cable Section B. Core 1B has characteristics of the same order of magnitude and is of the right type.

Similarly the other selections are made as shown in the table below, the necessary crosses being deduced from inspection of the core characteristics as previously explained.

Core number.		Cross.
Section A.	Section B.	
1	3	*A*, *B*, and *C*, *D*.
2	1	*A*, *B*, and *C*, *D*.
3	2	*A*, *B*, and pairs.
4	5	*C*, *D*.
5	4	*C*, *D*.
6	6	*A*, *B*.

Method of Procedure in Selecting.—In order to deduce the best combinations of cores from the test results, the following operations are carried out:

(1) The values of the core characteristics $(p - q)$, $(r - s)$, $(p + q)$ and $(r + s)$ are deduced from the test values of p, q, r, and s, and filled in on the test sheets.

(2) The core characteristics are tabulated for each cable section in descending order of magnitude of the plus circuit characteristics, the maximum value being taken in each core.

The four characteristics and the types are filled in on this schedule.

(3) The selections are made and tabulated from this schedule, starting with cores having high values. The cores of one cable section are written in order of rotation as they are laid up in the cable, the effect of all crosses being calculated on the other cable section.

(4) The values of the residual differences p, q, r and s are calculated. This step is a check upon the previous calculations and also upon the crosses made in operation (3).

(5) Jointing schedules are made out for use by the jointers.

The above procedure applies to two lengths of cable only. In practice certain modifications are made which give much better results. In the case of a cable which it is proposed to load, the cable is divided up into sections corresponding to those between loading coils.

Each loading coil section is balanced in itself as regards capacity as nearly as possible. There are usually twenty-five cable sections between each loading coil. These sections are grouped into three, two containing eight and one nine sections. The eight section length is tested in the order indicated by the letters T1, T2, etc., in the diagram :

T1		T2	T5	T3		T4	
——	——	——	——	——	——	——	——
1	2	3	4	5	6	7	8

The joints between sections 2 and 3 and between 6 and 7 are deduced from the results of combining 1 + 2 and 3 + 4, etc. In practice better results are obtained by selecting lengths 1, 2, 3 and 4 together, so that the resultant characteristics of 1 + 2 suit those of 3 + 4.

When there are five sections to be joined, the joint between Nos. 1 and 2 or that between Nos. 4 and 5 is selected first in the usual way. The four lengths made up of 1 + 2, 3, 4 and 5 are then selected, the resultant of two of the lengths being made to cancel out with the other three sections.

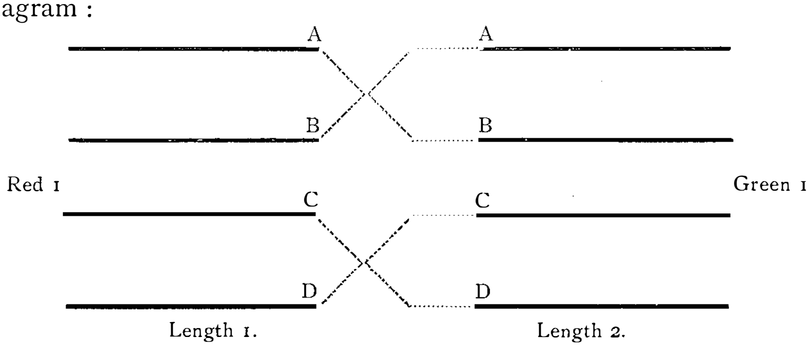
When joints Nos. 1–2, 2–3, 3–4, 5–6, 6–7 and 7–8 have been made, a test is made at the junction of 4 and 5 and the joint is selected from the results of this test.

Finally, tests are made at the junctions of the three component sections of each loading coil section and the two joints selected from these results.

Referring to operation (3) it is important to remember that the calculated values of the residual differences refer to the cable section which has been kept straight.

For example, suppose we are joining together two lengths, 1 and 2, keeping 2 straight and calculating the effect of all crosses on 1. Then the calculated residual differences will refer to the end of length 2—that is to say, the calculated residual differences are those which would be obtained if we tested the two lengths from the end of length 2. Obviously, since the wires of the cable when tested are always connected up to the testing leads in a particular order, these residual differences are not the same as those which would be obtained if we tested from the end of length 1.

An example will perhaps make this clear. Suppose we have joined core Red 1 to core Green 1, as shown in the following diagram :



And suppose when we test from the end of length 2, the residual differences are $+P$, $+Q$, $+R$, $+S$.

If we had tested from the end of length 1, the residual differences would have been $-Q$, $-P$, $-S$, $-R$; and, moreover, these differences would refer to core Red 1, whereas when we tested from the end of length 2, the differences referred to core Green 1.

In order to decide which length to keep straight when joining two lengths together it must be borne in mind where the "deduced" joint is to be made. For example, if we are joining together lengths 1, 2, 3 and 4, we first test the differences p, q, r and s on each of the four lengths. We then join 1 and 2 together, and also 3 and 4 together, and calculate the residual differences for 1 and 2, and 3 and 4. The next thing is to select joint 2–3 (termed the "deduced" joint) from these calculated residual differences. Therefore the residual differences for lengths 1 and 2 should refer to length 2, and the residual differences for lengths 3 and 4 should refer to length 3.

Hence when joining 1 and 2 we should keep length 2 straight, and when joining 3 and 4 together we should keep length 3 straight.

Degree of accuracy obtainable.—The residual out-of-balance of capacity obtained on the various lengths of a loading-coil section of 2·5 miles approximate length depends largely on the number of cores in the cable. In the case of a cable in which the selections are confined to twelve cores in the same layer the out-of-balance occurring at each stage is shown in Appendices I and II. On analysis the results are approximately as follows :

Single	lengths, 4 per cent. maximum.		
Four	,,	0·275 per cent. maximum,	·04 average.
Eight	,,	0·070 ,, ,,	·0156 ,,
Twenty-six	,,	0·022 ,, ,,	·0045 ,,

The above quantities represent the percentage out-of-balance in the capacities *W*, *X*, *Y*, *Z*, and are measured values. The deduced results are usually slightly smaller. This means that many cores are obtained in practice between loading-coil points which are practically perfect, the out-of-balance not exceeding 1 in 100,000 parts.

It will probably have been noticed that the capacities balanced by the method described are only resultant wire-to-wire capacities in the presence of other conductors and the sheath, and do not include the wire-to-earth capacities as would be measured by connecting the corner of the bridge to earth, which in **2** is connected to *D*. On referring to **1** it will be seen that so long as the source of current is not connected to earth it cannot supply current to charge a capacity to earth except in series with other capacities. **6** shows the complex arrangement of capacities which correspond to the resultants *W*, *X*, *Y*, *Z*, and **7** the resultant between *A* and *C*. The true wire-to-wire capacities are represented by *Kw*, *Kx*, *Ky*, *Kz*, *Ke*, *Kf*, and the true wire-to-earth capacities by *Ka*, *Kb*, *Kc*, *Kd*. The theory so far has been developed upon the assumption that the capacities which should be balanced are the resultant capacities as measured with no earth on the testing apparatus, and the results observed by speech confirm this assumption on lengths tested before loading coils have been inserted. But the question naturally arises : How do the earth capacities which may be out of balance on either side of loading coils affect cross-talk ? The conclusion arrived at is that so long as the source of current for speaking has no out-of-balance capacity or leakage to earth before it reaches the cable, earth balances are not required, or when well insulated transformers having balanced electro-static screens between primary and secondary windings are interposed between such defective circuits and the loaded cable, earth balances are not required. But the arguments for this conclusion will now be discussed.

8 represents the connections at one end of a circuit *T*1, superimposed upon two loops *T*2 and *T*3, including plus and side loading coils inserted between the first two sections of the line.

The self-inductances of the four windings of the plus coil are shown as *La*, *Lb*, *Lc*, *Ld* ; of the two windings of the side coils in *T*2 as *la* and *lb*, and of the side coil in *T*3 as *lc* and *ld*. The mutual inductance of the windings in the plus coil is shown as *M*, and of the windings of the side coils as *M*1 and *M*2 respectively. *Ra* represents the sum of the resistances of the windings between *a* and *a*1; similarly *Rb, Rc, Rd,* the resistances between the other corresponding points in *B, C* and *D*. The wire-to-earth capacities in the first loading coil section are represented by *Ka, Kb, Kc* and *Kd,* whilst corresponding wire-to-earth capacities in the second section are represented by *Ka* 1, *Kb* 1, *Kc* 1 and *Kd* 1.

It was shown at an earlier stage that one of the conditions for no overhearing on *T*2 when speaking on *T*1 was an exact division of the current from *T*1 through the differential transformer, and that this was obtained when the resultant capacities between *A* and *CD* were made equal to the resultant capacities between *B* and *CD*, assuming that the conductor resistances and leakances were already balanced. The resultant capacities as measured are made up of a complex combination of wire-to-wire and wire-to-earth capacities as indicated in 6 and 7. The resultant capacity between *A* and *C* is made up of ten capacities as in 7, and a similar diagram would represent the capacities between *B* and *C*. To obtain the resultant capacity in terms of all the capacities shown is extremely laborious, and the result contains too many terms for simple application. But, by making certain assumptions which are approximately true, the capacities shown in 6 can be divided into two symmetrical groups representing the two resultant capacities *W* and *X* as measured on the testing apparatus. When these two groups are equated it can be seen how the balancing of the resultant capacities *W, X, Y, Z,* affect the individual capacities of which they are made up.

If we assume that the wire-to-wire capacities, *Kw, Kx, Ky, Kz, Kf* are equal to each other and *Ka, Kb, Kc, Kd* are also equal to each other, then, from the symmetry of 6 we may say:

$$Kw + \frac{1}{\frac{1}{K\,a}+\frac{1}{K\,c}} + \frac{1}{\frac{1}{\frac{1}{\frac{1}{K\,d}+\frac{1}{K\,c}}+Kf}+\frac{1}{K\,z}} =$$

$$= Kx + \frac{1}{\frac{1}{K\,b}+\frac{1}{K\,c}} + \frac{1}{\frac{1}{\frac{1}{\frac{1}{K\,d}+\frac{1}{K\,c}}+Kf}+\frac{1}{K\,y}}.$$

If we further assume that the wire-to-wire capacities are 70 per cent. of the wire-to-earth capacities and substitute relative numerical values we obtain for the first term ·7, for the second term ·5, and for the third term ·44. The capacities which are not common to both sides are *Kw, Ka, Kz, Kx, Kb* and *Ky*. If we give small equal increments to *Kw, Ka* and *Kz,* one at a time, and observe the effect upon the sum of the series we see that the balance is very sensitive to a change in *Kw,* and much less sensitive to a change in *Ka* or *Kz*. In other words, the second term is less variable than either the first or the third term. Consequently, in balancing the resultant capacities, we are principally balancing the wire-to-wire capacities and to a much less extent the wire-to-earth capacities. This has been proved by actual measurements of the wire-to-earth capacities after the resultant capacities have been balanced. Referring to **8**: For silence to be obtained on the side circuit *AB* when speaking on the plus, the current *Ia* in one of the windings of the side coil must be equal to the current *Ib* in the other winding of the same side coil, for, if not, an E.M.F. will be impressed round the loop, of which the windings form portions of the sides according to the equation :

$$E = M1 \frac{d}{dt} (Ia - Ib).$$

These currents will be equal to each other if the following conditions are fulfilled: (1) The impedances between points in *C* and corresponding points in *A* and *B* (such as *c*, *a*, *b*, and *c*1, *a*1, *b*1) are equal to each other and also those between *D* and corresponding points in *A* and *B* before the coils are inserted; (2) the E.M.F. absorbed between the points *a* and *a*1 is equal to the E.M.F. absorbed between *b* and *b*1, according to the following equations:

$$Ea = Ra\, Ia + La \frac{d}{dt} (Ia) + M \frac{d}{dt} (Ib) + la \frac{d}{dt} (Ia) + M1 \frac{d}{dt} (Ib),$$

$$Eb = Rb\, Ib + Lb \frac{d}{dt} (Ib) + M \frac{d}{dt} (Ia) + lb \frac{d}{dt} (Ib) + M1 \frac{d}{dt} (Ia).$$

The first condition may be obtained by balancing the impedances of the various sections of *A* and *B* to *C* and *D*, and the second condition by balancing the windings in each loading coil during construction for inductance and resistance. In **8** the unfeathered arrows represent at a given instant the flow of current in the side circuit when speaking on *T*2, and the feathered arrows represent the current when speaking on *T*1. Take first the case of speaking on *T*1; a difference of potential will exist between the pair *AB* and the pair *CD*, and if the wire-to-earth capacities *Ka*, *Kb*, *Kc*, *Kd* are approximately equal, the points *E* and *E*1 will be intermediate in potential between the pairs *AB* and *CD*. Let *AB* be above *E* at a given instant, then the feathered arrows show the direction of current from the higher to the lower potential. It will be observed that no interchange of current can take place between *a* and *a*1 or *b* and *b*1 *viâ* the points *E* and *E*1, for that would mean a flow of current back into the line from a lower to a higher potential. Similarly, no interchange can take place between *C* and *C*1 or *d* and *d*1 *viâ* *E*2 and *E*3, for that would mean a flow from the pair *CD* to earth from a lower to a higher potential. If there be no interchange of current *viâ* *E* and *E*1, or *viâ* *E*2 and *E*3, then the wire-to-earth out-of-balance capacity taken by itself cannot interfere with a proper division of current through the

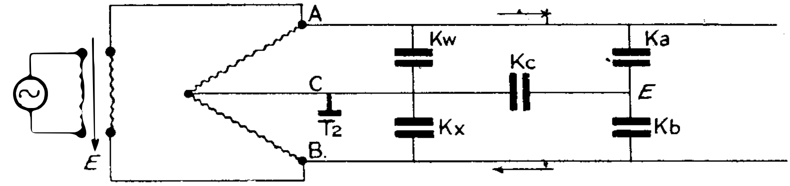


FIG: 9.

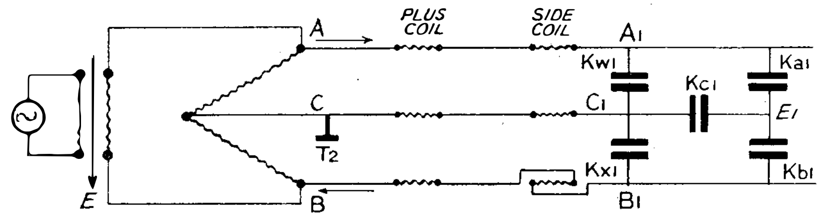


FIG: 10

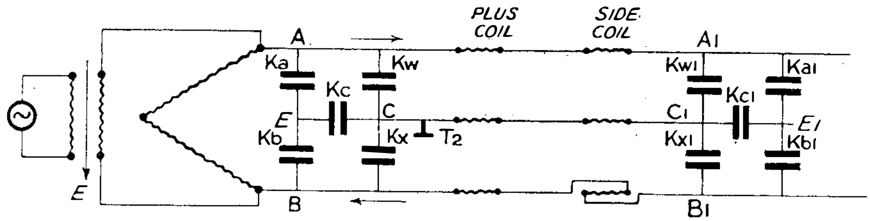


FIG: 11

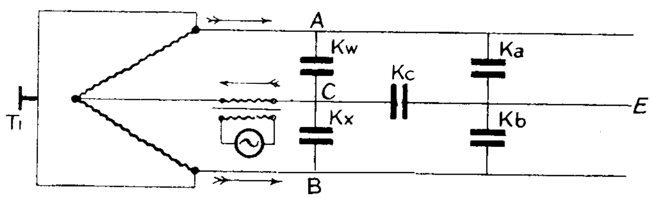


FIG: 12

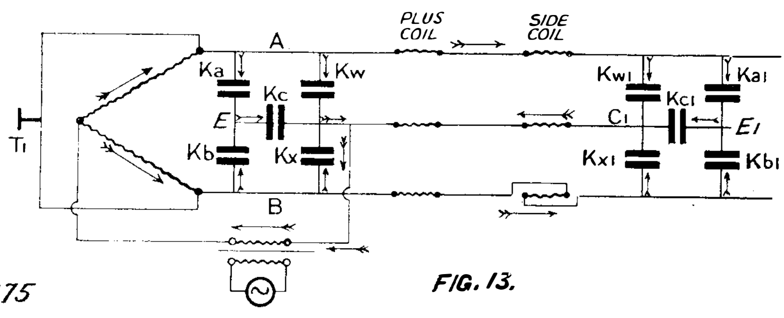


FIG. 13.

loading coils. This may be seen more clearly by following the arguments based on **9**, **10**, **11**, **12** and **13**, which have been prepared to settle this point. **9** illustrates the conditions which obtain when the wires *A B* are on the testing-bridge and the telephone is connected to *C*. The power is applied between *A* and *B*. Under this condition balance is obtained when—

$$Kw + \frac{1}{\frac{1}{Kc} + \frac{1}{Ka}} = Kx + \frac{1}{\frac{1}{Kc} + \frac{1}{Kb}}$$

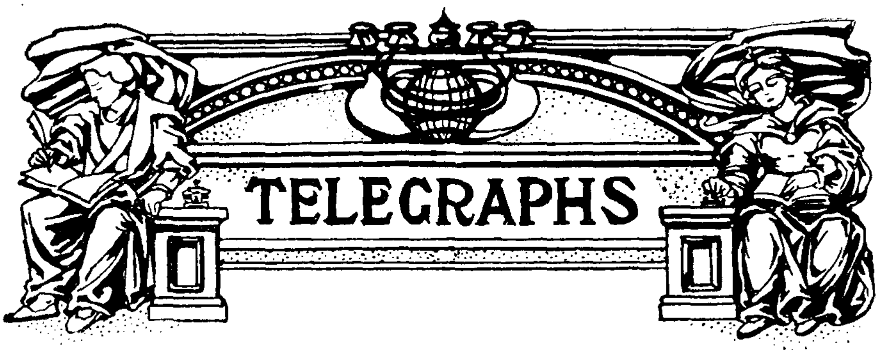
These may be regarded approximately as the resultant capacities *W* and *X* of the first loading coil section. **10** shows the conditions under which balance would be obtained if a test were made of the second loading coil section with the coils inserted between the section and the testing apparatus. **11** combines **9** and **10**, but shows the telephone connecting the two neutral points of the capacity systems in each section, *i. e.* in circuit on the *C* wire. It is evident from this figure, if absolute potentials are neglected, that when the resultant capacity system of the pair *A B* is balanced to the wire *C* on both sides of the loading coils no current will flow along the wire *C* due to earth capacities being out of balance on either side of the loading coils. But we can determine also the relative potentials of the points *C* and *C*1 with respect to each other by comparison with the potential of the ratio arms. The potentials of the ends of the ratio arms will be governed by the capacity to earth of the wires *A* and *B*. The point *C* will be midway between these two potentials when the first loading coil section is balanced. If the previously balanced second loading-coil section has a different wire to earth balance, and is now added to the first loading coil section, the absolute potentials of the ratio arms will be altered, but the point *C* will still remain midway between these new absolute potentials. As the point *C*1 is also midway between the points *A* and *B*, the points *C* and *C*1 must be at the same absolute potential. This matter has been dwelt upon at some length, because it is a matter of great importance to determine whether selections must be made for earth balancing as well as for balancing the resultant capacities. Referring to **11** again and the equation—

$$Kw + \frac{1}{\frac{1}{Kc} + \frac{1}{Ka}} = Kx + \frac{1}{\frac{1}{Kc} + \frac{1}{Kb}}$$

it is evident that unless $Kw = Kx$ the capacity *Kc* will receive a charge. In that event the points *C* and *C*1 cannot be at the same potential as *E* or *E*1. In practice they are, of course, never far away from earth potential. **12** illustrates the interchange in position between the source of testing power and listening telephone and represents speaking on the plus. **13** is an extension of the last diagram to include two sections with loading coils between them. The arrows indicate the path of the currents and the wire *D* is omitted for the sake of clearness, it being understood that *D* is always when balanced at the same potential as *C* with respect to the plus source. Current cannot flow from *E* or *E* 1 into *A* or *B* under the assumption that *A B* at the moment is above earth potential; therefore the wire-to-earth capacities *Ka*, *Kb*, *Ka* 1, *Kb* 1 cannot unbalance the currents through the loading coils so long as the resultant capacities are balanced as previously stated.

We have now arrived at the conclusion that balancing the wire-to-earth capacities as distinguished from resultant capacities made up partly from wire-to-wire and partly wire-to-earth are not necessary from the theoretical point of view, and this is borne out by actual experiment where the source of current has no appreciable capacity to earth or no appreciable leakage to earth. But where the source has capacity or leakage to earth it may easily be shown that capacity to earth must be balanced to avoid interference from such circuits, or as an alternative a well insulated and balanced transformer having an electrostatic screen between the primary and secondary windings may be interposed between the cable and the faulty circuit. In practice unbalanced circuits are liable to be connected to a balanced cable unless the latter is operated through special transformers. For these reasons it is desirable to balance the earth capacities, and the following procedure should be adopted as a modification of the method already described. If the loading coil section contains 25 lengths of cable, tests should be made at the joints 1–2, 3–4, 5–6, and 7–8 for resultant capacities only. Select joints 1–2, 2–3, 3–4, together, and 5–6, 6–7, 7–8 together. Test 1–4 and 5–8 for earth capacities and resultant capacities, the latter being as a check only upon the accuracy of the previous testing and jointing. Select joint between 4 and 5 for earth capacities only. Lengths 9 to 17 will be treated similarly except that five sections will require to be selected together. Lengths 18 to 25 will be treated like lengths 1 to 8. The Sections 1–8, 9–17, 18–25 will be measured for resultant and earth capacities, and selections will be made for the former except in cases where the latter are large, in which case they should be taken into account. The earth capacities are measured by connecting the telephone to earth when the pair under test is connected to the bridge. The changes which the test values undergo when crosses are made are very simple. Crossing the wires of a pair merely changes the sign of the reading, and crossing pairs interchanges the magnitudes without affecting the signs. If the reading of *AB* is *U* and *CD* is *V*, then crossing *AB* and *CD* changes *U* into $-U$ and *V* into $-V$, whilst crossing pairs changes *U* into *V* and *V* into *U*.

(To be continued.)



SOME NOTES ON AMERICAN TELEGRAPHS.

By JOHN HUME BELL,
Late of the Telegraph Section, E.-in-C.O., and Secretary of the I.P.O.E.E. before entering the service of the Western Electric Company, New York.

IN the first issue of this JOURNAL Mr. Donald Murray stated that "if some magic carpet suddenly transported a British telegraph engineer into a large New York telegraph office he would at first be dazed by the extraordinary clatter of the sounders." Although no magic carpet was employed in the transportation of the writer, the effect produced upon him on his first visit to the New York head office of the Western Union Telegraph Company was akin to that described above.

The public telegraph traffic of the United States is handled almost entirely by two large companies, the "Postal Telegraph" and the "Western Union." The latter is the older and larger concern, having about 25,000 offices in 21,000 separate cities, towns, and villages, and a wire mileage of approximately 1,500,000. According to the latest records over 90 per cent. of the entire revenue of this company is obtained from less than 2000 of the 21,000 places, and nearly 17,000 offices have an average monthly revenue of about £2 each, with a maximum of £10. Clearly the small offices have very little traffic, and it is only by co-operation with the various railroad and telephone companies, in whose premises many of such offices are located and by whose staffs the traffic is handled, that the existing telegraph facilities can be economically provided over so wide an area of country.

Small offices are linked up, sometimes as many as forty, in series on one circuit, termed a "way wire," and operated on the closed circuit system, as shown in 1. The necessary energy, usually drawn from dynamos, is provided at one or both of the terminal offices. On long circuits the total voltage may be as high as 350. At each intermediate office a few primary cells are required to operate the local sounder circuit.

Duplex circuits do not differ in principle from those used in Britain.

The line signals are sent out by an electrically operated pole-changer, the coils of which are joined in series with two operating keys and a low-resistance sounder. The second key is placed near the receiving operator, who uses it to ask any corrections he may require. The sounder is provided to enable the sending operator to hear his own signals. American operators have become so accustomed to send in this manner that the abolition of the practice would now be difficult. Nearly all operators have spent the first few years of their service in some small office where they were accus-

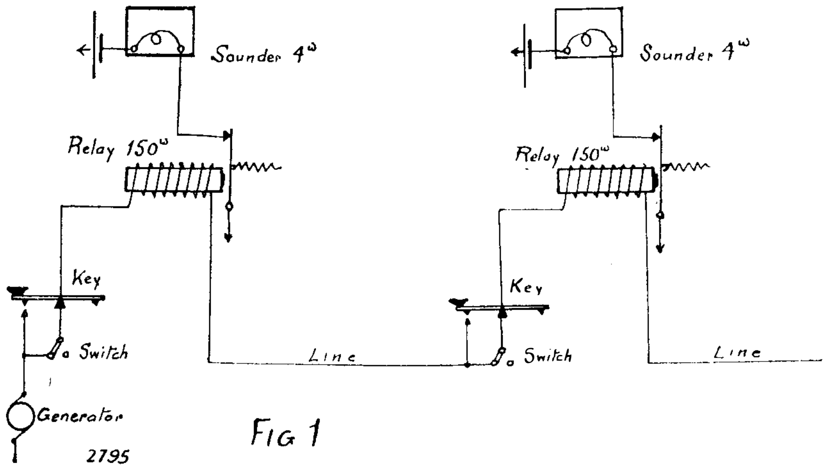


FIG 1

tomed to hear their own signals when working the local "way circuits," and this is probably the origin of the practice. It is to be regretted, however, that no steps were taken to prevent the general use of sending sounders in large offices, where they are responsible for half the clatter referred to by Mr. Murray. Their provision involves considerable capital outlay and somewhat hampers simplification of local circuit connections.

In the quadruplex system used by the Western Union Company two voltages only are needed, change in current strength being obtained by the insertion of resistance in the line circuit, and a leak path to ground, as shown in **2.** A definite ratio must exist between resistances A, B, and C in order to produce a current ratio of 1 : 3, 1 : 3·5, or 1 : 4, as may be required, and also that the total resistance to incoming signals may remain unchanged.

The following table, in conjunction with the lettering in **2,** shows the ratios which should exist :

Ratio of current strengths.

1 : 3	$A = 2C$	$A + C = 2B$
1 : 3·5	$2A = 5C$	$2(A + C) = 5B$
1 : 4	$A = 3C$	$A + C = 3B.$

Correction of the "B" side signals is effected by the use of an extra coil on the non-polarised relay, termed the "holding coil," connected in series with a condenser of suitable capacity as shown in 3. In the case of quadruplex repeaters this arrangement appears

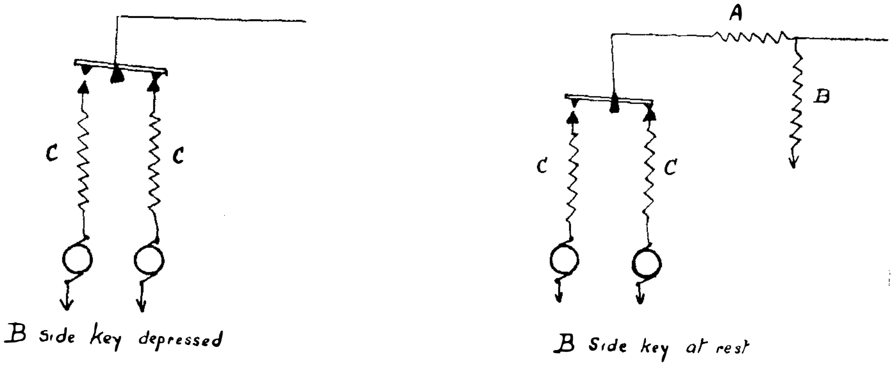


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Fig 2

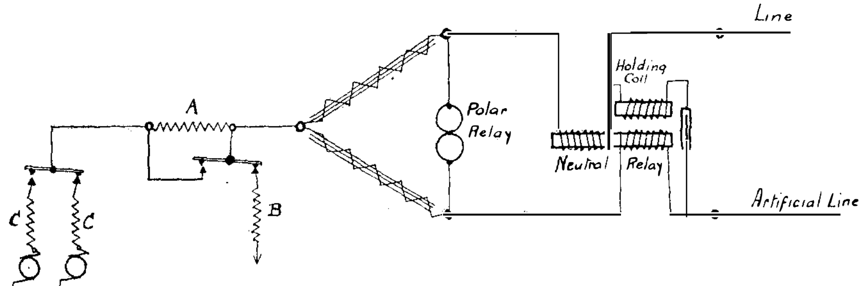

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Fig 3

to offer an advantage over the British method of rectifying the signals at the "B" side sounder itself, as it obviates the need for two relays with their battery connections and resistance coils. A further advantage claimed for it is that it permits of uniformity in the local circuit connections (termed receiving legs) of both "A" and "B" sides of quadruplex and of duplex circuits. The desirability of securing such uniformity will be shown later.

The pole-changer and the transmitter, which take the place of the reversing and incrementing keys, are operated electrically in the same manner as the pole-changer of the duplex. The electrical connections between these instruments and the keys and sounders at the operating tables are termed "sending legs."

The lay-out of the apparatus in large offices differs considerably from that usually followed in European offices. The main line relays, pole-changers, and duplex balancing apparatus are concentrated in one section of the office, and are attended to by a staff of specially trained men. In the Western Union New York office energy is drawn from dynamos located in the basement. The power leads

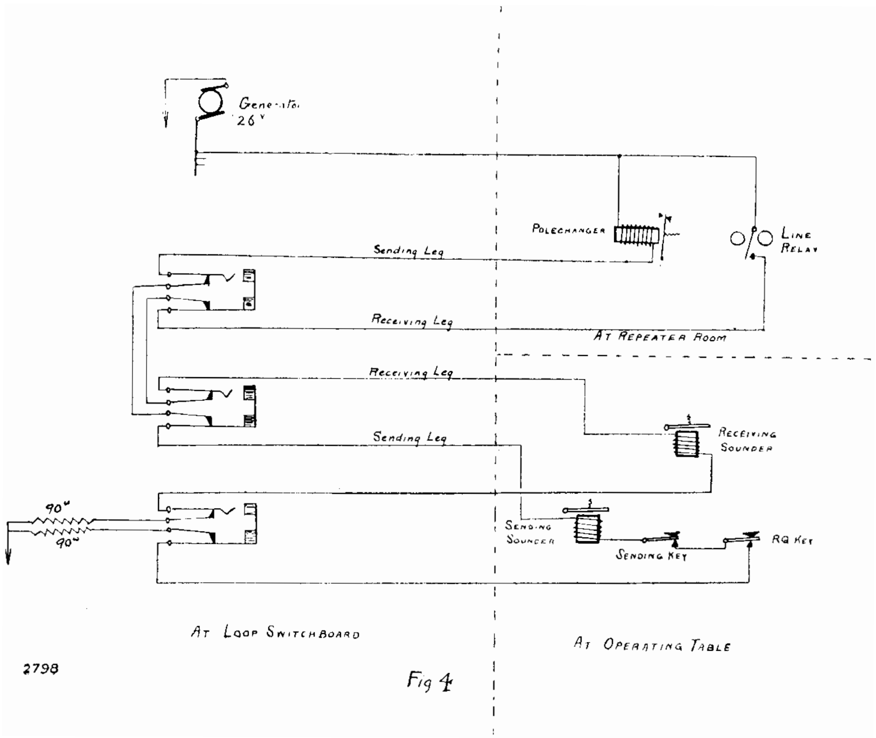


Fig 4

come up to a series of busbars mounted on a mezzanine floor in one of the operating rooms. From these busbars taps are taken off through suitable lamp resistances to the various apparatus sets in the "balancing" room.

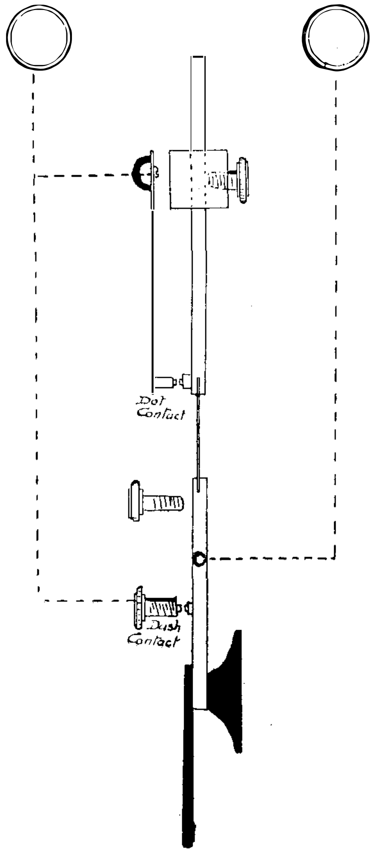
The sending and receiving legs of each duplex and quadruplex are led to a switchboard termed the "loop switchboard" and terminate on the outer springs of break jacks. To this switchboard are also connected the leads from the operating sets in the instrument room, terminating on the outer springs of another series of jacks, the inner springs of each corresponding pair of jacks being connected together as shown in 4. Circuit conditions are normal when no pegs and cords are in use. Any rearrangement of circuits in the operating room can be made by cross-connections at the loop switchboard.

A number of sending and receiving legs are provided between the head office and certain important branch offices within about one mile radius, and these "legs" also terminate at the loop switchboard so that any of these branch offices may readily be put in direct connection with any long-distance circuit. By means of what is termed a double loop repeater, several branch offices can be connected on the sending and receiving legs of a duplex circuit, and this is the general method employed for giving such important branch offices as the Stock Exchange, Cotton Exchange, and Sugar Exchange, direct communication with distant cities such as Galveston, Chicago, New Orleans, or Savannah. None of these branch offices separately may have sufficient traffic to warrant the exclusive use of a long-distance circuit, but for the joint use of several branch offices in the manner described, its provision is justified both on the score of economy and efficient service. The sending operator at each branch office has a listening sounder in series with his key which enables him to tell whether or not the line is being used by one of the other offices. Obviously there must be no squabbling as to priority amongst the sending operators, and none occurs. Operating regulations, which need not be enumerated here, govern the working of these circuits. The operators are specially selected men, and the records of traffic passing over these circuits show that a high standard of working efficiency is maintained.

Leased circuits are made up in similar manner to the main office circuits, *i. e.* by connecting up sending and receiving legs through the loop switchboard, the duty of maintaining balances and adjusting relays being performed at the head office.

The reason for having the connections of the "B" side of quadruplex circuits uniform with the local circuits of ordinary duplex and "A" side quadruplex is perhaps now apparent. Should a long distance circuit become faulty, communication can be promptly restored by transferring the sending and receiving legs to another circuit which is already balanced. Operators are not advised whether they are working on a duplex or the "A" or "B" side of a quadruplex, and it is to be hoped that the quality of "B" side signals is such as to enable the operators to remain in blissful ignorance.

An increasing number of operators make use of auto-dot keys, or, as they are more generally termed, "wig-wags" or "bug-senders." There is no doubt that by using these semi-automatic sending devices many men afflicted with cramp who would otherwise have been compelled to retire from the telegraph service have been able to continue as expert operators. 5 shows in diagrammatic form one type of "wig-wag" key. The key lever has affixed to it a flat spring upon which a sliding weight may be fixed at any position. In this manner the natural frequency of vibration of the flat spring can be altered to correspond to the speed at which the dots are to be made. Normally the lever occupies a central position, and the circuit through it is broken. Pressure on the key at one side causes a permanent contact to be made, and a dash signal of any desired length is thus made.



2799 Fig 5

Pressure from the other side causes the spring to vibrate and to close a contact at each vibration, the number of dots thus made being determined by the operator.

Another machine which has helped to ease the lot of the American telegraphist is the typewriter. Even with the aid of an auto-dot key adjusted for rapid working a sending operator is unable to "run down" a receiving operator who makes use of a typewriter. The ease with which the typing is performed is in striking contrast to the concentration of attention which must be given by an operator transcribing in longhand with pen or pencil at a high speed.

It was customary in the past for operators to supply their own typewriters, and many devices were resorted to to render a machine unusable by anyone but the owner. One operator learnt to type on a machine with blank keys, another had the position of the letters on the keyboard considerably altered from the universal keyboard setting, whilst another went still further and had the position of the type characters altered, the keyboard remaining unchanged. Needless to say such freak machines were left undisturbed by unauthorised persons.

Some time ago the Western Union Company decided to furnish type-writing machines specially adapted for telegraph work, and thus relieve the operators of the cost of providing them. An order for

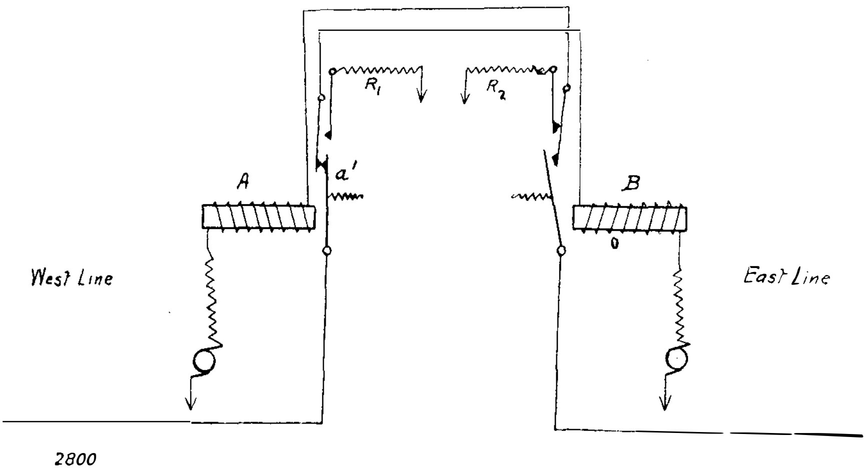


Fig 6

ten thousand machines was placed with the Underwood Company, and most of these are now in service.

Some "way" circuits are so long as to necessitate the use of a repeater, whilst long leased lines and special newspaper circuits have frequently as many as three and four repeaters in circuit. Of closed circuit repeaters there is a large variety, and new types are still being designed.

6 shows the principle of one type of closed circuit repeater, of which there are several modifications. This may be classed as the "make-before-break" type. Normally both line relays are energised, the circuits on either side being closed. When any key on the west line is opened relay B is de-energised, its armature falls back and so breaks the circuit of the east line.

Assuming now that the resistances R_1 and R_2 did not exist, then as soon as the armature of relay *B* left its front contact the circuit through the winding of relay A would be broken, the armature a^1 would fall back and so produce a disconnection on both lines. The function of the make-before-break contacts on the relays and the resistances R_1 and R_2 is to ensure that during the release of one line

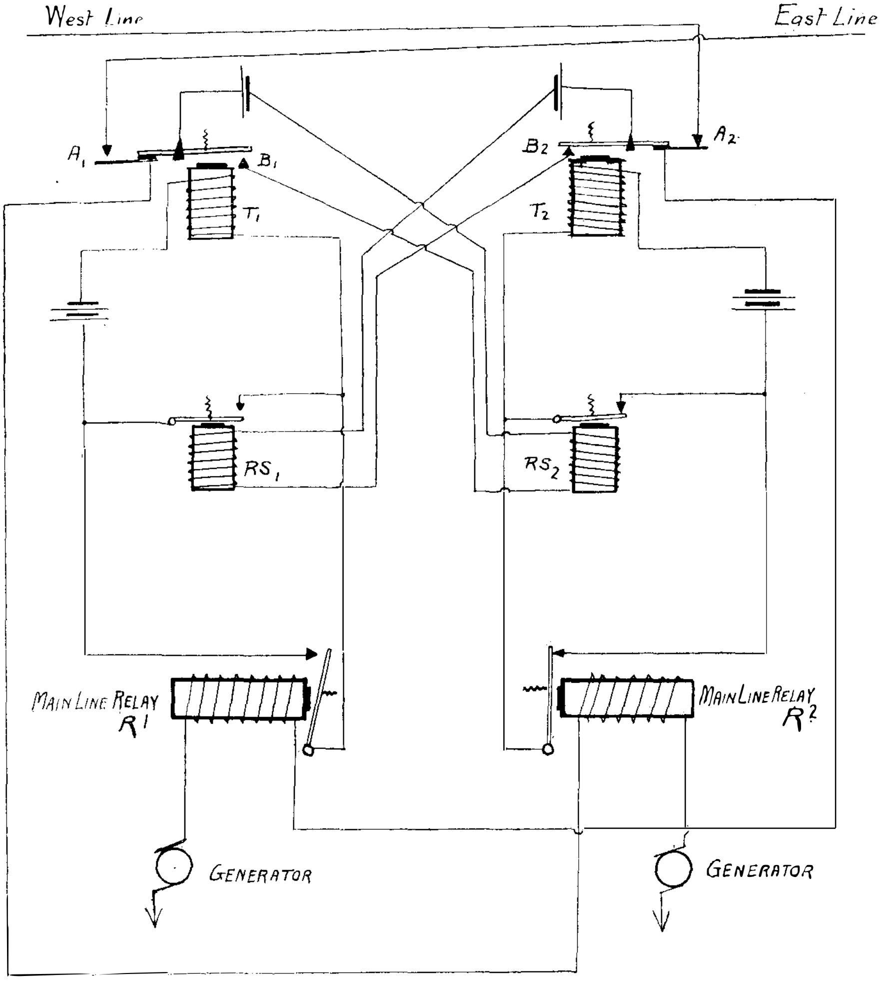


Fig 7

relay a current of suitable strength will continue to flow through the other line relay, and by retaining its armature in the attracted position will prevent opening the line on which the incoming signals are being received.

Such a repeater as that shown in 6 would work efficiently on a circuit having a good working margin, but it is doubtful if it would meet the severe requirements of a long line during periods of low insulation. On a long line disconnected at the distant end the leakage current passing through the line relay at the repeater may amount to 40 milliampères, whilst earthing the line at the distant end may increase the current to 45 milliampères only. Obviously the line relay at the repeater must be adjustable to pull up with 45 milliampères and to fall back when the current drops to 40 milliampères. Relays of the "make-before-break" type cannot meet such requirements so well as those with fixed contacts where the distance of travel of the armature is less. Consequently a repeater of this simple design has to give place to one which is somewhat more complicated.

One of the best known closed circuit repeaters in use to-day is that known as the Atkinson repeater. **7** shows the connections when the west line has been opened, thus allowing the armature of main line relay R_1 to fall back and open the local circuit which existed through transmitter T_1 and the front contact of relay R_1. Transmitter T_1 is thus de-energised and its armature is released. The contact at B_1, however, is broken before that at A_1, which has a flexible spring extension on the armature, thus permitting the release of the armature of RS_2 before the armature of main line relay R_2 falls back. In this manner the local circuit through transmitter T_2 is not disturbed by the operation of transmitter T_1.

It will be seen that in this repeater the line relay has a simple armature to actuate against a fixed contact. The transmitter with spring contact is operated in local circuit where sufficient energy is available to produce positive action. The operating margin is secured by the slight time lag which exists between the opening of two contacts, one fixed, the other a spring contact. The correct adjustment of these contacts and of the repeating sounders RS_1, RS_2, once obtained, the only adjustments required to meet varying line conditions are those of the line relays R_1 and R_2.

One noticeable feature of American conditions is the remarkably high insulation of aërial lines which exists throughout the greater portion of the year. During some experiments in which the writer was interested, an aërial circuit of nearly 500 miles in length showed practically no loss of current, the current at the receiving end being within 99·5 per cent. of that sent out.

ON DOCTORS' PRESCRIPTIONS.

By John Lee.

The story is told of a certain eminent bishop who wrote a villainous hand. On one occasion he dropped a little note to a friend in London, who, in turn, was unable to make head or tail of it. In sheer despair, the friend detached the episcopal heading from the note-paper, and took the remainder to the chemist round the corner. The chemist forthwith went behind the mystic fluted glass, mixed up a suitable bottle, coloured the contents an appropriate shade of scarlet, and charged him one shilling and eightpence. It was before the days of the so-called Drug Stores. When the bishop received the scarlet bottle, in due course, he was surprised. He remonstrated with his friend, who replied: "Your note was so hard to understand that I felt sure it was scientific."

Nowadays the medical profession shows some signs of changing its methods. It takes the lay people a little more frankly into its confidence. It has less faith than formerly it had in the efficacy of cryptic language as a cure for human ills. Consequently we all know a little more about ourselves, and our confidence has increased. We are less thrilled than we were at the sight of a prescription. The fluted glass has lost its terrors. "Potass." to us nowadays is "potassium," whereas once it seemed to be a personal reflection. The little curly things at the end of the lines, which once we dreaded as some sort of medico-artistic caricature of the shape of our pitiful legs, are known to be "grains" and "pennyweights" and other stages in the social scale of drugs. Indeed, so have we developed that even a Harley Street specialist has been known to write his injunctions in English, and to speak of "headache," an Anglo-Saxon word which has now found a secure place in medical language. It frequently appears even in learned medical journals.

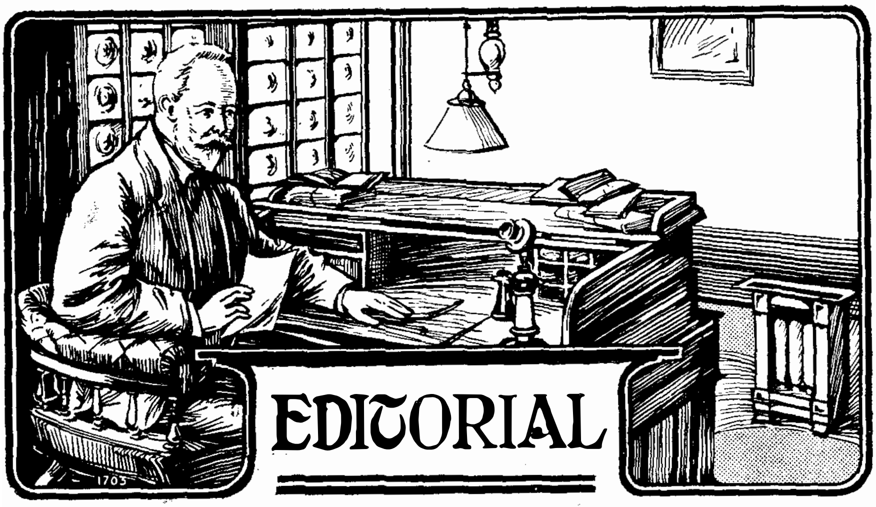
Lay people are well aware of their indebtedness to the medical profession. That profession is the most beautiful section of the Civil Service; whether or not it ever becomes a State medical service is a smaller question. High and low, rich and poor, owe to its research, its tenderness, its enthusiasm, the soothing of the brow of pain and the softening of the blows from the hand of Fate. But as the use of technical language has been modified our indebtedness has increased. Our medical adviser comes to be our friend and teacher. He is not now called in only at the crisis point. We visit him to talk things over. We consult him that we may continue in health. No longer do we divide our ailments into two classes, one to be treated by homely remedies, the other to be treated in Latin.

All the remedies are homely, frank, undisguised. There is now a less rigid demarcation between the professional and the lay mind. He knows more than we do, but in the application of his knowledge he asks for our co-operation. He advises; we administrate. He gathers from the store of medical knowledge of the world and puts it, in plain language, at our disposal. He does not resent our attempts at understanding; rather he explains at length. No professional jealousy bids him hide his thoughts in the language of mediæval monasteries, a tradition from the days when learning had secrecy for its main characteristic. He is not the less exalted, rather he is the more exalted, because he makes things quite clear to humbler and trusting minds.

To this greater frankness we respond eagerly. Ah, so *that* is the cause of our headache? Yes, we admit not his diagnosis merely, but his essay into causation. We have burned the candle at both ends, exactly as this our friend has stated. His grandfather would have handled our grandfather differently. In that age of mystery, the Victorian epoch, the medical ancestor would have beheld the lay ancestor with benevolence in his eye. With due pomposity—also Victorian—he would take to himself his pen of hardened steel and with its aid would have hidden bicarbonate of soda under hieroglyphics. And the trembling hand would have taken it to the Victorian druggist. So far all is deceit—well-intentioned and kindly and even affectionate. The real truth would only come out on the death certificate, which was a poor consolation to the man who once bore worthily the name of Patient. Nowadays the patient may suffer, but he does not suffer so acutely from *Ignoratio Causæ*. He knows. He is intimately acquainted with the organs and ducts and channels which have called loudly for treatment. He knows of his appendix—or, more accurately, he did know of it. The sacred secrecy has gone and we are all the better for it. We have burned the boats of our Victorian hypocrisy. Even in drawing-rooms "legs" and "livers" are mentioned, and we are unashamed.

So is Science the better for it. There is a missionary side to Science. It is not merely that knowledge should "grow from more to more" and that "more of reverence" may in us dwell, but that our lay reverence shall be based upon closer intimacy with research. Intensively all branches of science are developing, but there is a danger lest this intensive growth should be at the cost of extensive application. It is true that scientists need a language of their own for readiness of communication, a shorthand *ad hoc*. But in the communications—the missionary communications—to the wider arena of lay people, for whose behoof, after all, science is advancing, there is great need for simple direct language, for the sparing use of technical forms of thought and of technological expressions. The days of fluted glass and mystification are over, because our indebtedness is becoming so great that the common mind is irked and distressed by its failure to comprehend the fulness of meaning of contributions to its knowledge.

So, perhaps, in these pages, the lowly lay mind may make its appeal. Deep lies it in debt to those minds which give to it generously the rich fruit of patient research. But sometimes the fruit is over-rich, and mental digestion calls out for a similarly simple diet to that which the modern physician kindly gives to the sister digestion. The prescriptions which come to the awe-stricken mind are sometimes even more appalling than the prescriptions which came, a decade ago, to the shivering body. A reviewer said of Mr. Henry James's 'The Wings of a Dove' that it was so difficult to understand as to demand from the reader the contribution of a mind equally subtle and alert with that of the writer. No doubt such reading is exhilarating; no doubt, too, there is some sense of gratification in co-operating with a giant mind. But we are not all giants. Some of us are dwarfs, and we would fain be content to look upwards and to hear from below. Too frequently we are asked to jump upwards in order that we may meet the golden words halfway. If only those who have the knowledge and who have the generous temper which bids them disseminate that knowledge would bear our limitations in their minds, we should be even more appreciative than before, and the extensive application of science to the work of to-day would be facilitated and furthered.



EDITORIAL NOTES AND COMMENTS.

THE King has been pleased by Letters Patent under the Great Seal, bearing date the 12th inst., to appoint the Right Hon. Charles Edward Henry Hobhouse to be His Majesty's Postmaster-General during His Majesty's pleasure.—*London Gazette*, February 20th, 1914.

Mr. Hobhouse, who is a son of Sir Charles Parry Hobhouse, Bart., was born on June 30th, 1862, and is therefore in his fifty-second year. He was educated at Eton and Oxford. From 1892 to 1895 he sat for East Wilts, and since 1900 he has represented East Bristol. He was appointed a Church Estates Commissioner in 1906, Under-Secretary to the Indian Office in 1907, Financial Secretary to the Treasury in 1908, Privy Councillor in 1909, and Chancellor of the Duchy of Lancaster in 1911.

He is best known to the Post Office staff as Chairman of the Select Committee of the House of Commons which, in 1907, was appointed to inquire into the conditions of employment, etc., in the Post Office.

Mr. Hobhouse has assumed control of the Post Office at a time when two matters of importance are occupying considerable attention—we refer to the staff reorganisation arising out of the report of the Holt Committee, and to the revision of the telephone tariff. He is to be congratulated on the fact that, in dealing with the former, he will have the benefit of his experience as Chairman of the previous Committee, and also that, in attempting to solve the other problem—equally complex—he will be fully cognisant of the Treasury aspect of the matter.

As representing in some degree the Engineering Department of the Post Office we extend to Mr. Hobhcuse a very hearty welcome, and in doing so we venture to express the hope that his term of office at St. Martin's-le-Grand—whether short or long—will be one upon which in due course we shall be able to look back with pride

THE RT. HON. C. E. H. HOBHOUSE.

as having contributed both to the convenience of the public and to the welfare of all grades of the staff.

While feeling pleasure at the announcement of Mr. Samuel's promotion to the Presidency of the Local Government Board, Post Office Engineers—in whose operations and investigations Mr. Samuel has evinced considerable interest—are exceedingly sorry that the parting of the ways has come. Mr. Samuel came to the Post Office on February 15th, 1910, with a great reputation as an administrator, and he lost no time in enhancing it. During his period of rule as Postmaster-General many important developments and reforms took place, and a dozen are cited as being of especial interest to readers of this JOURNAL:

(1) Two new telephone cables laid between England and France.

(2) New telegraph cable laid between England and Germany.

(3) New telephone cable laid between England and Belgium.

(4) New telephone cable laid between England and Ireland.

(5) £6,500,000 spent on the development of the telephone system and a further sum of £10,000,000 voted.

(6) About 500 new exchanges opened.

(7) Automatic telephone exchanges introduced into Great Britain.

(8) Electric tube railway for the conveyance of mails in London authorised and about to be constructed.

(9) Erection of the Imperial wireless chain of stations authorised and commenced.

(10) The National Telephone Co.'s undertaking transferred to the State. Arbitration award of £12,500,000 as against £21,000,000 claimed.

(11) Engineering staff (all grades) increased from 7000 to 24,000.

(12) Engineering staff re-organised.

That so many important developments and changes should have come to pass in the short space of four years is indeed striking, and it is gratifying to be able to include in the list a revision of the engineering grades of the Post Office, which embodied a recognition by the late Postmaster-General of the value of the work done by Post Office engineers.

Mr. Samuel leaves the Post Office with the best wishes of the Engineering Staff.

The United States Post Office Department has followed the example set by the home administration, and the Postmaster-General has appointed a committee, similar to our Awards Committee, to adjudicate upon suggestions submitted to it by employees for improvements in the service. To obtain an award the suggestion or invention must be one that will clearly effect a material economy or increase efficiency. The sum of 10,000 dollars has been appropriated annually for this purpose; the maximum amount to be paid in any one month, or for any single suggestion, will not exceed 1000 dollars.

In our last issue Mr. Addey, in his valuable series of papers on "Alternating Current Calculations," described on p. 344 a method of measuring resistance and inductance which was devised by Mr. C. E. Hay, of the Research Section, Engineer-in-Chief's Office. As Mr. Addey had already gone into the details of the method and ascribed its authorship in an article on "Telephone Transmission," which appeared in vol. 5, he did not consider it essential to his purpose to indicate the source of the test in his later paper. We take this opportunity of awarding due credit to our versatile colleague, who, as everybody knows, is one of the greatest authorities on Wheatstone bridge measurements.

The Sixth Annual Conference of the Society of Post Office Engineers was held in London on February 7th, 1914, and following day.

On the eve of the Conference, a very enjoyable Re-union and Smoking Concert was held at the Tavistock Hotel, W.C. Nearly 200 Engineers and friends in the Service assembled, and proved that, although always busy men and oft overworked, Post Office Engineers are not yet incapable of thoroughly enjoying a concert remarkable for its rousing choruses.

FROM WITHOUT AND WITHIN.

TRADITIONS die hard, and a popular delusion lives not infrequently to a green old age unless or until some exasperated sceptic, with a kick of reason, tumbles it—a spent scarecrow—into a convenient furrow; at which some rooks will still caw.

It is nearly half a century since Dickens died, and most of the evils of the day which he satirised have followed him. Schools of the Yorkshire type are no more; imprisonment for debt has been abolished, body-snatching is extinct, and electioneering methods have wholly changed. But the Circumlocution Office perennially blooms in the fancies of the severely facetious, visioning enough of red tape "to stretch in graceful festoons from Hyde Park Corner to the General Post Office"; the quip passing us innocuously by reason of the great novelist having particularised our own little sphere of public service as the end and not the originating point of this decorative scheme.

Still, we of the Telephone Branch cannot but be conscious of the winging of more modern shafts, from many quarters, which being meant, at least, to sting, do here and there occasion us some inconvenience or chagrin.

With scarcely more than two years of Post Office life behind me and a receding background of twenty-nine in the National Telephone Company's service, I may perhaps still claim to possess a fresh mind as to the newer conditions, while retaining undimmed the recollections of former experience. It may not, therefore, be out of place at this juncture to review some actual facts as one has found them in comparison with one's preconceived notions of life in a State Department. And at the outset I have to express entire concurrence in the view of the wise man who once said that if we were all stripped we should be found to be very much alike.

To clear the ground, one or two propositions have to be accepted —as, for example: Both the Post Office and the Telephone Company had, formerly, extensive telephone systems in London; each execrable according to some; to others endurable; superlative praise only to be conferred posthumously. Given equality in worth of raw material, it follows that any flaw in the manufactured article must be purely a personal matter, *i. e.* it must be the result of want of skill, or defects in organisation or apathy or carelessness, what you will. Now, prior to the amalgamation of the two systems, complaints by subscribers (and they ought to know) of the service were about equal on both sides, and it may therefore be assumed that the management and staff were equally good, or, if it be preferred, equally bad.

After these premises comes the puzzle. Since those halcyon days, if we are to believe the newspapers (and, like Mr. Crummles, I can't think who puts these things in), the Service has not steadily, but by leaps and bounds, deteriorated; although, be it remarked, the commercial world seems to have rubbed along as though nothing had happened. How is this downfall to be accounted for? Can it be possible that the two staffs, lost in contemplation of each other's virtues, have forgotten their first duty, or that in chivalrous emulation of the Black Prince each has clamoured to bestride the humble pony to allow the other to shine resplendent on the full-grown steed; and thus between the two both have come to the ground? Mere suggestions, of course, but possible.

I can think of one more explanation, and a plausible one. While the "National" flock changed their pasture the shepherds remained behind; the shepherdless sheep, therefore, bringing plenty of wool with them but no brains; straying into the company of other sheep, whose shepherds with this additional charge had an insufficiency of brain to go round; reminding one of the miller with two windmills, who dismantled one because there was not wind enough for both.

I am not quite certain whether some of us of the transferred staff were not, prior to our migration, fearful that in the Post Office we should find no further scope for our bounding vitality, and that all we could hope for was that, in due time, we too might learn to take our ease without qualms; howbeit, the more sanguine may have aspired to infuse somewhat of their enthusiasm into the body of that effete and hoary institution.

But, if so, our nightmare was brief, and we awoke relieved and sobered. For, speaking for myself and others of my old colleagues with whom I have discussed the subject, it took very little time to realise—some of us, I fear, with mixed feelings—that the standard of work demanded, and prevalent, in the Post Office is far higher, man for man, pay for pay, and age for age, than that formerly expected of us—the more limited scope of the Company not providing so many outlets for promotion nor for interchanges of duties, and thus men might, and did, go on for years ploughing and re-ploughing the same furrow, narrowing their utility, and learning little of what was going on around them. The judgment and reliability, the initiative and sense of responsibility displayed in the work of comparative juniors with whom I have come into contact during the past two years have been to me a continual source of wonder. It is not a case of abnormal ability here and there, but of an all-round plane of efficiency; and what is in the green wood is at least to be found in the dry.

There are many reasons for this high level, but possibly that which outweighs all others is that a critical public expect it, perhaps unconsciously, and what the public want they usually get. What, of course, the public do not always recognise is that thoroughness is costly, and that as time is usually the essence of value, we must be allowed enough of it in which to deal adequately with their requirements. Speaking of my particular sphere, I have been very much impressed with the complete sifting which takes place every time the complaint of a telephone subscriber has to be investigated. Those, and they are many, who imagine that these things are treated lightly or with indifference, would be astonished at the immense pains taken to get at the core of every difficulty or irregularity. Nothing is slurred over or evaded, and the stamp of finality is not affixed to the accumulated documents until a first-hand confession of the original sin appears among them in all its bare simplicity. Then all else is brushed aside, and the public are made acquainted with the plain unvarnished truth.

All this spells individuality, and creates that feeling of personal responsibility which seems to me to have so marked an effect on the tone of work in the Post Office.

With all the ramifications of such an enormous business as ours, investigations of any importance are necessarily prolonged; but to show that even such well-regulated concerns as railway companies (where Time would surely expect to be well served) are not exempt from what the man in the street might mistake for dilatoriness, a little example may give us a crumb of encouragement. A year or two ago a piece of old furniture was delivered to me damaged in such a way as to completely destroy its value. I submitted a modest claim with full particulars, and went about my ordinary affairs. Two months afterwards the station-master presented me with half a sovereign, and I wondered what had happened in those two months, how many officials and employees had been concerned, among what great company this atom had wandered, through what machinery it had passed to emerge refined gold, and how relieved everyone must have been to be rid of it at last.

Soon after my entry into the Post Office the need for a new kind of care was forcibly brought home to me by a dreadful apparition in one of the daily papers, namely, the publication of a letter of my own drafting. Careful scanning fortunately revealed nothing to blush at; but for some time after my daily repast of correspondence possessed me with a feeling something akin to the man who, dining in unaccustomed company, is embarrassed with a fear of committing himself by the mismanagement of an unwonted profusion of knives and forks. I merely mention this incident as emblematic of habits, striking to a newcomer, and peculiar to a public department, which one has to acquire to preserve the expectant tone and avoid obloquy. It is a small matter in itself, but indicative of the wariness with which every branch of the Service, in full publicity, has to tread its way, whether in correspondence, pole-planting, or stores-purchasing; and circumspection in walking is not conducive to speed.

It seems a little unreasonable to imagine that men—and women, too—having stepped on to the lowest rung of the ladder through the exercise of their brains, should suddenly abandon that medium of success, and embark for evermore on a system of *laisser faire.* And yet this is no uncommon view from outside, as ridiculous as it is unfounded, because it carries with it the theory that a qualifying examination is promulgated merely to satisfy the curiosity of the authorities on the subject of the competitor's past educational history, and not as an earnest of what may be expected of him or her hereafter. I have even heard it said that as amateur horticulturists, artists, musicians and writers we leave nothing to be desired, but that from a business point of view the real goal of the civil servant is his pension; this being the great secret why the Post Office is crowded with mediocrity, while every commercial concern around it puffs with energy. All I can say is, that I have never yet met the youth or maiden who, at the age of seventeen or thereabouts, worried or troubled themselves as to what is looming ahead for them at the age of sixty or sixty-five.

But I can also say this: that coming into the Post Office, a matured outsider, I have discovered by degrees that there is as much zeal, as much earnestness, as much devotion to duty and pride in good work among both sexes within as without. I find the same sacrifice of private leisure, the same individuality with at least as much recognition thereof as in my former experience. And so far as I have come into contact with other branches of the Service than my own, the same conditions appear to prevail. Wherever and whenever two or three officers foregather, whether in hotels or railway carriages, or even for social enjoyment, business topics are pursued with almost disgusting persistency.

A reproach frequently levelled at the Telephone Service is that the business is not run on commercial lines, and the generally adduced reason is that the *personnel* has had no commercial experience or training; but I have never been able to discover exactly what those "lines" are. Now, the vulgar acceptance of the meaning of the word "commerce" is, I believe, to buy in the cheapest market and sell in the dearest, and as my earliest experience in business life was not wholly unconnected with ship-broking and the coal trade, with a seasoning of the Custom House (where the cashier evinced a very commercial abhorrence of light gold), I may lay claim to have fitted myself to an unusual degree for a telephone career, and whatever modicum of success I have achieved in that quarter was no doubt presaged in my three years' sojourn in a strictly commercial concern in the neighbourhood of Billingsgate.

Strange to say, the knowledge I then gleaned of tonnage, freightage and pit and market prices seemed to have no bearing whatsoever on the easy-going system of twenty-pounds-a-year-or-no-telephone method with which I became subsequently acquainted. And, stranger still, I find no essential difference in the means employed by honourable men in providing a public service, whether shareholders, ratepayers or taxpayers have to be considered. Outside an unalterable tariff, which in our case is identical with that of a railway or gas company, I find the same spirit and elasticity of concession and fair-dealing prevalent in a Government Department as under a Board of Directors. If to run a business on commercial lines is to extort the uttermost farthing without remorse, we are a long way from the ideal, but if it mean the welfare of the community, then my poor powers of observation are utterly at fault if I have not discerned that our whole course moves continually in that direction.

Besides, I cannot, for the life of me, see what special commercial apprenticeship is undergone by the officers and employees of such public services as gas, electric light, tramways, railways, etc. (some of them run with conspicuous success) which is not attainable in the Post Office. For two years I have been trying to discover whence and how comes that benumbing blight which hearsay fastens upon the intelligences and business consciences of every man and woman whose misfortune it is to become a civil servant, and, so far, I am baffled; though at times a shudder passes through me when my ill-success suggests the horrible thought that I, too, may have taken the insidious disease without knowing it. Especially when I recall the expressions of condolence and commiseration showered upon me by sympathetic friends on hearing that my talents would henceforth lie buried in the precincts of St. Martin's-le-Grand—possibly associating that saint with his neighbouring brother, Bartholomew, and viewing the institution named after him as a Home for Incurables.

Before the days of motor traction, one might often see a heavily laden 'bus lumbering laboriously up Ludgate Hill. The horses who drew it were not fiery thoroughbreds, but with their necks well in the collar, and encouraged by the judicious urging of a driver mindful of passengers of varying temperaments, they did their best. And they usually got to the top.

EUSTACE HARE.

HEADQUARTERS NOTES.

COMMITTEE ON HIGH-SPEED TELEGRAPHY.

THE Postmaster-General has appointed a Committee to inquire into the systems of high-speed telegraphy and to report thereon. It consists of: Captain Norton, M.P., Assistant Postmaster-General (Chairman); Sir John Gavey, C.B., past president of the Institute of Electrical Engineers; Mr. John Lee, Traffic Manager, Post Office Telegraphs; Mr. W. M. Mordey, past president of I.E.E.; Mr. A. M. Ogilvie, C.B., Third Secretary, G.P.O.; Mr. W. Slingo, M.I.E.E., Engineer-in-Chief, G.P.O.; Mr. A. B. Walkley, Assistant Secretary, G.P.O.

Anyone desirous of giving evidence before the Committee should communicate with Mr. G. O. Wood, Secretary's Office, G.P.O., who has been appointed Secretary to the Committee.

TELEPHONE EXCHANGE DEVELOPMENTS: C.B. MANUAL.

Since the last issue of the JOURNAL, orders have been placed for the equipment of new manual exchanges at Truro, 260 lines; Weybridge, 1380 lines; Wrexham, 460 lines.

Installation of equipment has been commenced at Altrincham, extension, 300 lines; Birmingham (Central), extension, 4600 lines; Birmingham (Midland), extension, 460 lines; Birmingham (Victoria), extension, 140 lines; Worcester, extension, 320 lines.

Installation of the following equipments has been completed at: Mansfield (New Exchange), 640 lines; Chester, extension, 840 lines; Doncaster, extension, 280 lines; Ealing, extension, 900 lines; Harrods' (P.B.X.), extension, 180 lines; Kingston, extension, 540 lines.

The following new exchanges have been opened:

Exchange.	Date of opening.	Number of subscribers' lines.	
		Exchange equipped for	At date of opening.
Helensburgh	6 : 12 : 13	480	371
Attercliffe	6 : 12 : 13	480	160
Llanelly	17 : 12 : 13	400	310
Victoria (London) . . .	24 : 1 : 14	8100	5285

AUTOMATIC TELEPHONE DEVELOPMENT.

Paddington Exchange.—An order has been placed with Messrs. Siemens Bros. for automatic traffic distribution to twelve "A" positions, Nos. 104 to 126, for originating calls from 1000 subscribers,

Official Switch.—An extension of 150 lines has been completed. bringing the fitted capacity up to 650 lines.

PROTECTION FROM ELECTRIC LIGHT AND POWER CIRCUITS.

Important modifications have recently been made in the Department's requirements for the guarding of overhead electric lighting and power circuits. Hitherto these power circuits have been guarded by means of independent guard wires, earthed at each end, and the arrangement of the wires in respect of overlap and vertical distance has followed exactly the requirements of the Board of Trade for guard wires on electric tramways.

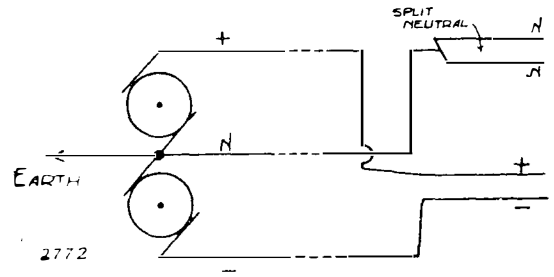
The Department is now prepared to accept an arrangement of the *current-carrying* wires of any electrical power system not exceeding 650 volts, continuous current, or 250 volts to earth, alternating current, provided that the earthed or earthed neutral wires of the electrical system act as guard wires.

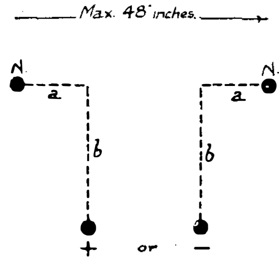
For instance, in a 3-wire continuous current system, the neutral conductor would consist of two wires, *i.e.* split neutral, and for a guarding arrangement to protect telegraphs crossing above the power wires the arrangement would be as depicted in the figure.

The vertical distance *b* must be not less than 8 inches, and the overlap *a* must be not less than half the vertical distance *b*, whilst the maximum separating distance between any two earthed wires must not be greater than 48 inches.

For example, if *b* is 24 inches, then *a* must be not less than 12 inches.

The use of the neutral or earthed conductors, as guarding, has two advantages:





(1) If a telegraph wire falls across the neutral wire and an outer, the short-circuit conditions seem reasonably certain, and the present difficulty in regard to the value of independent earth connections for guard wires is overcome.

(2) The neutral wires, being part of the current-carrying system, will probably be efficiently maintained.

DISTRICT NOTES.

LONDON.

VICTORIA TRANSFER.—Many months of patient work were brought to a climax at two o'clock on the afternoon of Saturday, January 24th, when the transfer of some 9000 junctions and subscribers' lines, serving 14,000 stations, including the House of Commons, the War Office, Admiralty, and all the principal Government offices, was effected in the space of some fifteen seconds. The new switching plant is in a new building which has been erected by the Office of Works in Greencoat Place, near Vauxhall Bridge Road, and not far from Victoria Station. The new plant has been provided by the Peel Conner Telephone Works, Ltd., and is of the 40-volt No. 1 Common Battery type, similar to that provided at the Avenue Exchange, but in this case without ancillary lamps and jacks. In accordance with the usual practice in such cases all the working circuits had been "T'd" to the new Exchange at points outside the old Exchange. The connection to the apparatus at the new Exchange was complete except for the fact that the springs of the cut-off relays were held apart by small insulators. These insulators were connected together by short lengths of string, and the lengths of string were yoked together by tens and by hundreds and brought to suitable points, where string handles were provided so that one pull would remove a large number simultaneously. At the old Exchange broad tapes had been run down behind the heat coils on the main distributing frame, and these also were yoked together and provided with handles so that when the critical moment arrived they could be pulled out, and thus simultaneously the disconnection from the old Exchange and the connection to the new Exchange might be effected. Half of the junction circuits were transferred at 1.30 p.m., and at the same time half of the operators took up their positions in the new Exchange. At 2 p.m. the officers in charge of the transfer work were in communication by telephone and each gave the word "pull." At the old Exchange fifteen men stood in readiness along the M.D.F., and at the word they pulled vigorously, producing a Maxim-gun fusillade as the heat-coils flew out of the retaining springs. At the new Exchange six men served for the quieter operation of withdrawing the insulators, and the transfer had been effected.

The new building is in the form of a hollow square with one side missing, and the switch-room has the same conformation. Although it is a vast improvement upon its predecessor and boasts a polished parquetry flooring, the existence of two right-angles prevents one obtaining a clear view of it at any point, and the line of sight in every direction is unfortunately broken up by centre pillars. In this respect, therefore, the Victoria switch-room is inferior to Gerrard, Regent, Paddington, and Park, in all of which a clear, unimpeded view is obtainable. On the other hand the lighting is exceptionally good, and the clerestory roof provided at Victoria is a considerable improvement on the arrangement at Park, which has frequently been referred to as being of the swimming-bath variety.

It is pleasing to be able to state that the new Exchange has, during the week succeeding the transfer, taken up the functions of its predecessor with the utmost smoothness, and the successful completion of the work was recognised by the then Postmaster-General, Mr. Herbert Samuel, who issued to all concerned an expression of his satisfaction.

An official inspection by the Westminster City Councillors took place on Friday, February 27th, and a copy of a condensed description of the Exchange was given to each visitor.

Exchange Extensions.—The work of converting the cord circuits on the "B" positions at Central Exchange for keyless working is now completed.

Museum Exchange is nearing completion. The bulk of the construction work is finished, and the lengthy process of testing out is in hand.

Extensions to the equipment are in hand at Brixton North, Palmer's Green, Stratford, Streatham, and Wanstead.

Information desks are being installed at Finchley, Mayfair, Park, and Willesden.

A private branch exchange of eight sections for the War Office is being provided.

New Telephone Lines.—During the thirteen weeks ended January 27th, 1914, 4967 exchange lines, 3194 internal extensions, and 253 external extensions were completed. In the same period 3083 exchange lines, 1989 internal extensions, and 209 external extensions were recovered, making a net increase of 1884 direct lines, 1205 internal extensions, and 44 external extensions; approximately 5196 removals of exchange circuits were carried out for subscribers.

New London Engineering District Headquarters.—Building operations were commenced on the new Denman Street offices on February 3rd, and rapid progress on the excavation work is now being made. The contractors are Messrs. James Smith and Son, of Norwood.

Notes from the London Sections.

Central Telegraph Office.—The installation of house tubes referred to in a previous issue is nearing completion, and five of the eleven tube tables in the galleries will be brought into use by the time this is in print. Two tubes which have been in use for some months have given great satisfaction. The displacement of the old lead tubes has resulted in the recovery from under the floors of about 80 tons of scrap lead. It will be remembered that the new brass house tubes are being run in parallel lines under the ceilings.

On completion of the house tube portion of the work, all the tubes in the Central Hall will have to be re-arranged and double slide switches substituted for the present old-form valves. This work will be attended with some difficulty, as the tubes must be kept working during the transition stage.

Official automatic switch.—The original capacity of the automatic switch has been exhausted, and an extension of 200 lines is nearing completion. In order to obtain space for this extension it has been necessary to re-arrange the rooms in the basement, part of the linemen's room being appropriated, and this entailed the removal of a wall which formed one of the main supports of the building. The manual portion of the automatic equipment is about to be removed from the G.P.O. West to the Central Exchange. Extensive re-wiring in connection with the house bell system in the G.P.O. North and G.P.O. West is in progress. Some 300 circuits are involved. The old system was installed by the Office of Works when the building was originally erected.

North section (external).—The laying of duct work from Harwar

Street to Broxbourne in connection with the London to Ware trunks and the fitting of several new pattern loading coils for the proposed trunk cable has been commenced.

South section (internal).—A spring wire message-carrier has been installed by the Lamson Company at Sydenham for the purpose of conveying fault dockets between the switch-room and the test-room, the object in view being the reduction of the duration time of faults.

Centre section (internal).—A new three-position multiple private branch exchange has just been completed and brought into use at the House of Commons.

West section (internal).—This section has now the honour of including the largest private branch exchange in London, and therefore in the United Kingdom. It is situated in the gigantic stores of Messrs. Harrods, Brompton Road, S.W. A recent extension has increased the installation, so that it now consists of 10 sections of the C.B. No. 10 type equipped for 480 extensions and 120 exchange lines. At present 84 exchange lines—47 in-coming and 37 out-going—and 314 extension lines are working. The power plant recently renewed consists of two batteries, each of 22 volts with initial capacity of 420 amp. hours, 1 D.C. motor and 1 power switchboard. Orders are received both day and night, and on December 24th, 1913, the traffic broke all previous records, the total number of calls in-coming, out-going and internal exceeding 10,000.

A Lamson wire-carrier similar to that referred to in connection with Sydenham has been installed at the Ealing Exchange. The cost of these carriers is, of course, much less than that of the pneumatic tubes, and their performances will be carefully observed.

Our Annual Gathering.

The second annual gathering of the staff and friends will take place on April 4th, at the Holborn Restaurant, and, as on the previous occasion, it will consist of a tripartite function, including a dinner, a concert, and a dance. After the dinner the dance and the concert will proceed simultaneously in the King's Hall and the Throne Room respectively, and in this way an effort is made to cater for all tastes. So signal was the success achieved in connection with the 1913 re-union that there are already indications of a very large attendance on this occasion. A hearty welcome is extended to officers in sister-branches of the service, and tickets at 4*s*. 6*d*. (single) and 8*s*. (lady and gentleman, or two ladies) can be obtained from the Hon. Secretary, Mr. A. Wright, Battersea Exchange, Lavender Hill, S.W.

South Lancs. District.

Since the last issue of the Journal, 23 miles of duct and 16 miles of cable have been laid for local lines, and 24 miles of duct for main lines.

Contracts have been placed as follows:

	Ducts.			Cables.		
	£	s.	d.	£	s.	d.
Manchester, Bolton	8000	0	0	14900	0	0
,, Burnley	10000	0	0	16000	0	0
,, Rochdale	4500	0	0	6000	0	0
Liverpool, St. Helens	——			10500	0	0
Atherton (local)	1000	0	0	——		
Liscard ,,	1200	0	0	——		

The work at Manchester City Exchange which was being done by contract has been completed.

A number of local development schemes have been authorised under the Annual Contracts for underground works to completion; this will amount to some thousands of pounds. This work is being carried out by the British Insulated & Helsby Co.

South Midland District.

Since the formation of the District on October 1st, 1912, we have had to face the erection of over 6000 poles and over 7000 miles of wire. These figures represent main works only. The following summary shows roughly the work which has been performed in twelve months, *i. e.* from October 1st, 1912, to September 30th, 1913.

Miles of wire erected	4600
Number of poles	3600
Exchanges fitted and opened	14
Rental (P. W.) installations	90
P. W. stations	300
Fire-alarm installations	15
Exchange line stations	2600
Call-office stations	110

The mileage of wire and the number of poles is exclusive of work done in connection with the ordinary increase of subscribers' stations, removals, etc.

In addition to this about 41 miles of pipework and 25 miles of cabling in short sections have been carried out. This is, of course, apart from Main Cabling Schemes and Development Scheme Underground Works. Of the latter 22 schemes have been put in hand and are in an advanced state, comprising roughly the laying of 99 miles of pipe and 187 miles of cable containing 6500 miles of wire.

In connection with main cabling schemes, the trench mileage assumes the large total of 133 miles, with a pipe mileage of about 170 miles and a cable mileage of 25,000 wire miles.

The trench work has been completed. These figures include the portion in this District of the following schemes :

London, Watford, St. Albans, Aylesbury.
London, Slough.
London, Coventry, Birmingham.
London, Weybridge, Guildford.

There is little doubt that further extensions will be required in the very near future.

INSTITUTION NOTES.

COUNCIL MEETING.

A MEETING of the Council was held in Bristol on February 24th and 25th.

MEMBERSHIP.

The Secretary reported that during the present Session the following increases in the membership had taken place : 100 engineering, 32 clerical, 17 foreign and colonial.

In addition to the above, 254 associates had been enrolled, and the South Midland, South Lancs., North Midland, North-Western and Irish Centres were to be congratulated on their share in this excellent result of the Session's work.

PAPERS SUBMITTED FOR PRINTING.

The Secretary reported that the following papers had been printed and would be issued immediately :

"Directive Wireless Telegraphy." F. Addey, B.Sc.
"Parallel Distribution." E. A. Pink.
"Manchester Fire-Alarm System." R. Nimmo.
"Low-Pressure Hot-Water Heating Systems." T. Monaghan.
"Correct Time." H. Myles Hook.
"Overhead Wire Construction." A. P. Trotter.

In addition to the above it has been decided to print the following :

"Alternating Current Measurement." C. E. Hay.
"Stone-Throwing Prosecutions." W. H. Powning.

Other papers were under consideration by the Council.

MEDAL AWARDS—SESSION 1912–13.

The Council awarded the following Institution Medals for papers read during the Session 1912–13.

Senior Silver Medal to Mr. C. E. Hay for his paper entitled "Alternating Current Measurement."

Senior Bronze Medal to Mr. F. Addey, B.Sc., for his paper entitled "Directive Wireless Telegraphy."

Junior Silver Medal to Mr. H. Myles Hook for his paper entitled "Correct Time."

Junior Bronze Medal to Mr. T. Monaghan for his paper entitled "Low-Pressure Hot-Water Systems."

The Council attended a meeting of the South-Western Centre at Bristol, at which Mr. Tremain read an interesting paper relating to his early experiments with loading coils.

The Chairman, Mr. W. Noble, presented Institution Medals, 1911–12, to Mr. R. Nimmo and Mr. E. A. Pink for their papers on the "Manchester Fire-Alarm System" and "Parallel Distribution" respectively.

T. SMERDON (*Secretary*).

LOCAL CENTRE NOTES.

LONDON CENTRE.

CONSIDERABLE interest was manifested by members of the Traffic Branch in the reading of Mr. B. O. Anson's paper, "The Elimination of Waste in Telephone Plant and Operating," which took place at the December meeting. Mr. A. M. Ogilvie honoured the meeting with his presence, and was accompanied by Mr. L. T. Horne.

Mr. Ogilvie took part in the discussion, as did also Mr. J. Stuart Jones and Messrs. Pink and Dives, of the General Manager's staff.

In January Mr. Hill gave his paper on "The Loading of Aërial Lines," and the discussion which followed proved so interesting that it became necessary to adjourn the same until the next ordinary meeting in February.

On January 20th a special meeting was held to hear Mr. A. P. Trotter, of the Board of Trade, on the "Erection of Overhead Wires for Medium and Low Pressures." Several gentlemen well known in the commercial world accepted the Committee's invitation to be present, and took part in the discussion. Mr. Trotter's paper has already been set up in type, and should be in the hands of members by the time they receive this number of the JOURNAL. Mr. Trotter read his paper subsequently at a joint meeting of the Institution and the Yorkshire Local Centre of the Institution of Electrical Engineers at Leeds.

The President occupied the chair at Mr. Trotter's meeting, and presented the Senior Silver Medal of the Institution to Mr. B. O. Anson for his paper on "Machine Switching in Telephony."

The arrangements for the reading of Mr. L. B. Turner's paper, which was to have taken place at the February meeting, not having been completed in time, the reading of the paper has been postponed to a future date, probably one in April. The meeting, however, was taken by Mr. F. Addey, who gave a lecture on "A Modern P. O. Wireless Station," illustrated by lantern-slides. The station described is the one just recently erected at Malin Head in Ireland. Mr. J. G. Hill occupied the first portion of the meeting with a reply to the criticism on his paper. The Controller of Stores, Mr. Morgan, and the Assistant Controller, Mr. Allen, were present.

In December a very interesting visit to the Neasdon Power Station took place by the courtesy of the Metropolitan Railway Co.

The Committee has much pleasure in acknowledging on behalf of the Institution a presentation by Sir John Gavey to the Central Library of a series of 'Journals of the Franklin Institute' and a series of the 'Royal Engineers' Journal.' W. G. O.

SOUTH MIDLAND CENTRE, READING.

With pleasure we have to record a very successful Session. At our first meeting two representatives of the Engineer-in-Chief, Messrs. Sinnott and Reid, were present; at the second meeting Mr. H. Brown; at the third meeting the whole of the Council; and at the fourth meeting the President.

From causes over which we have no control the published programme had to be slightly modified, and the following are the particulars of the meetings held since the Centre was formed :

First meeting, April 29th, Mr. Whitehead : " London–Aylesbury Duct Scheme ; Sykes Ducts, and Laying thereof." Present, 86 members.

Second meeting, September 30th, Mr. Atkins : " Faults." Present, 64 members.

Third meeting, November 18th, Mr. Beasley : " Development Schemes." Present, 66 members.

Fourth meeting, December 15th, Mr. Hall : " Works Orders"; Mr. Shorter: "Organisation of a Sectional Engineer's Office." Present, 59 members.

Fifth meeting, January 20th, Mr. Moody : " Organisation of Maintenance Work." Present, 35 members.

Sixth meeting, February 25th, Mr. Macpherson : " Workmen's Classes" ; Mr. Eaton : " Messenger Boys' Classes." Present, 38 members.

The discussions were particularly exhaustive and well maintained at each meeting, and on three occasions had to be curtailed owing to the room being wanted.

It is interesting to note the keenness of the transferred Staff in all matters affecting the Institute, and it is hoped the few eligibles who are not now members or associates will become members at a very early date.

We may congratulate ourselves on the fact that practically every member of the Inspector's Class has enrolled.

SOUTH LANCS. CENTRE.

The fourth meeting of the Session was held at Manchester at 5.30 p.m. on January 5th ; seventy members and visitors present. Mr. G. H. Vaughan delivered a lecture on the " Experiences of a Telegraph Engineer in South America." A large number of excellent lantern-slides were shown, and the lecture was highly appreciated. The fifth general meeting was held on February 2nd, when Mr. T. Cornfoot read a paper on " Traffic." The paper was well received, and an interesting discussion followed.

NORTH-MIDLAND CENTRE.

The following meetings of the Institute have been held this year :

January 19th : Paper by Mr. J. Cooke on " Cash Accounts."

February 16th : Paper by Mr. G. J. Morris on " Stores Accounts."

After the meeting on January 19th the usual " smoker " was held and much enjoyed, but on February 16th a new departure was made, and a grand Bohemian Concert—to which the ladies were invited—was held at the Welbeck Hotel. The ladies turned up in sufficiently good numbers to out-nnmber the gentlemen, and with a capital musical programme a very enjoyable evening was spent, all voting the experiment a huge success.

The President of the Centre (Mr. E. J. Eldridge) presided at all the functions.

SCOTLAND (EAST) CENTRE.

In spite of the extraordinary pressure of work which is being felt on all sides, we have been able to secure a full programme of papers for the 1913–14 Session. The details are given below :

October.—" The Ethics of Supervision," Mr. A. S. Renshaw, of E. in C.O.

November.—" Heavy Line Construction," Mr. Jno. Patrick.

December.—" The Training of Men," Mr. R. J. Lawson.

February.—" Undergronnd Experiences," Mr. J. McIntyre.

March.—" Notes on Wireless Telegraphy," Mr. A. Scott.

April.—Subject to be selected, Mr. C. Crompton.

We must express our thanks to Mr. Renshaw for so readily consenting to read his paper to us, a paper which gave evidence of deep insight into the subject chosen. Mr. Patrick, by means of a number of excellent lantern-slides, showed us how to get long poles into apparently impossible positions, and at the same time unconsciously testified his ability to control a large body of men under canvas. Mr. Lawson treated the subject of "The Training of Men" on original lines and so framed his paper as to evoke most useful discussion. Mr. McIntyre's paper on "Underground Experiences" was also much appreciated, and the information he has gathered will be of great service, not only to engineers, but to the clerical staff who have to examine contractors' accounts. We look forward to the papers of Mr. Scott and Mr. Crompton, the recollection of whose previous efforts on behalf of the Institution is well remembered. It has been a real pleasure to us to have been honoured at the meetings by the presence of three former Superintending Engineers, Messrs. Eden, Campbell, and McHugh, who are all resident in "Auld Reekie."

WHIST DRIVE AND DANCE.—A most successful whist drive and dance was held on February 6th at the Carlton Hotel. Mr. and Mrs. J. D. Taylor received the guests to the number of about 100, and it was exceedingly pleasant to the host (and probably a record) to welcome no fewer than three of his predecessors in office, viz. Messrs. Eden, Campbell, and McHugh. For the sake of the young and irresponsible, the whist was not unduly prolonged, and dancing commenced at 9.30. Some of the Sassenachs found the dancing more vigorous than that to which they had been accustomed, but they were not dismayed. The closing hour came all too soon, leaving everyone with a desire for an early repetition.

Will the Editor please start a rumour that a summer picnic should take place ?

SCOTLAND (WEST) CENTRE.

The second meeting of the Session was held on February 9th, when a paper was read by Mr. A. S. Angwin on "Power Supply at Telephone Exchanges."

The lecturer dealt very fully and clearly with the different methods of transforming public supplies to the required voltage, and the conversion from alternating to direct current. Short explanations were given of the principles and use of rotary converters, motor generators, mercury arc rectifiers and Nodon valves. The provision of "stand-by" plant was fully discussed, mention being made of "Boosters," which were considered to be not altogether satisfactory. For lamp-signalling exchanges it was recommended that where a public supply is available, one generator set and duplicate batteries should be provided, and it was mentioned that at Paisley Automatic Exchange it is proposed to duplicate both batteries and machines.

The third paper of the Session was read by Mr. T. Hetherington on February 23rd.

The paper reviewed the growth of the trunk system during the past ten years and the resulting congestion of the main trunk routes, which called for an alternative for open wires to provide for further development in the Service. This development was to be met by providing underground routes, on which the efficiency of the circuits would be augmented by loading. A diagram of the new cables about to be laid to towns within twenty-five miles of Glasgow was given to show the proposals for the district. The principles on which loading is based were next dealt with, and in illustration of the results obtained the case of a Glasgow–Paisley cable was worked out in detail. Finally, the financial side of the question was touched on, local cases being taken to show the approximate relation in cost between open wires and loaded underground circuits.

On February 14th the annual staff dinner of the Engineering Department in the Scotland West District was held in Glasgow. Mr. Weaver (in the unavoidable absence of the Superintending Engineer) presided over a large gathering.

The guests included the Postmaster of Glasgow, the Town Clerk and other prominent officials of the Glasgow Corporation, the Secretary of the Stock Exchange, and colleagues from the Scotland East District.

Mr. Hardie proposed the toast of the guests, and Mr. Lindsay (the Town Clerk), in replying, drew special attention to the cordial relations which existed between the public bodies in the West of Scotland and the Engineering Department.

An excellent programme of music was arranged by Mr. W. G. Robertson, who was supported by Messrs. Hunter, Loudon Hilton, Hewson, Forbes, Kirkpatrick, and Heggie. Mr. F. J. Shadforth presided at the piano for the evening.

POST OFFICE ENGINEERING DEPARTMENT: ANNUAL DINNER.

THE Tenth Annual Dinner of the Engineering Department of the Post Office was held on Tuesday, February 10th, at the Criterion Restaurant, a numerous company being present.

Mr. Slingo, the Engineer-in-Chief, presided, and among the guests present were The Rt. Hon. Herbert Samuel, M.P. (Postmaster-General), Sir Henry Norman, M.P., Mr. R. Elliott Cooper, Dr. Glazebrook, Mr. Duddell, Rear-Admiral Charlton, R.N., Professor Fleming, Mr. F. Gill, Mr. Hugo Hirst, Mr. A. M. Ogilvie, Sir John Gavey, Mr. W. M. Mordey, and Mr. A. B. Walkley.

In proposing the toast of "The Engineering Department," Mr. SAMUEL said:

I have much pleasure in rising to propose the health of the Staff of the Engineering Department coupled with the name of the Engineer-in-Chief. Mr. Slingo and his Staff have all passed through a period of alarums and excursions during the last few years. The Engineering Department is now enjoying an opportunity of settling down.

The efforts are mainly connected, at the present time, with the development of the telephone system, and that development is a steady development, but if steady it is also very certain from certain points of view. We are yet far from the state of telephone development, so far as numbers of subscribers are concerned, that we should reach in this country in comparison with other countries of the world. That our development at the present time should be slow is inevitable, and is perhaps temporary. You are engaged in the task of straightening things out—we have just absorbed the vast system of the National Telephone Company; we have had to amalgamate the organisations of the two systems one with the other. In London in the last year alone we have had to transfer no fewer than 10,000 subscribers to the Exchanges to which they should rightly belong from the Exchanges to which they have wrongly belonged, and also all over the country there has been the necessity for great extensions of the plant. It has been impossible to have simultaneously, both a happy re-organisation of our telephone system and a rapid growth if we are not to outgrow our strength, and perhaps it has been not an unfortunate thing that the adoption of the new tariff rates has inevitably been somewhat postponed. That new tariff is now completed. When it is published, and when it is adopted, it will, I am quite confident, bring to the telephone system of this country the accession of a very large number of additional subscribers, and it is well that the Engineering Department should have an opportunity of digesting what we already have, before seeking outside for a vast increase in the number of members of the public we are called upon to serve. But already this hour-to-hour development has assumed large proportions, not, as I may say, so much in the numbers of subscribers as in the preparations which are being made to deal with a greatly increased mass of business on the most efficient lines.

When I came to the Post Office four years ago the Department was spending two million pounds a year; next year it will be spending eight million pounds, and this last year it has spent nearly six million pounds, which is a simple numerical measure of the enormous increase in the work that has been thrown upon the Engineering Department of the Post Office. That in four years its expenditure could have grown four-fold is indeed a remarkable sign of the vastness of the task you are undertaking.

Of course, I have no doubt that there are many of you who will draw the conclusion that if the work of the Engineers has grown four-fold in four years the salaries should also have grown in the same proportion, but in the presence of a representative of the Treasury that is a conclusion which I should hesitate to draw on the premises.

I should like to congratulate those officers of the Department who have been concerned with the remarkable development which has taken place quite recently in the telephonic communication between Liverpool and Manchester, which, I think, is perhaps the most striking individual thing that has been done since the transfer of the National Telephone Company. To eliminate trouble and to place towns like Liverpool and Manchester on the same footing as adjoining exchanges in the same town has been no small achievement, and the change has apparently worked with absolute smoothness and to the complete satisfaction of the commercial communities of those two great cities, and the Engineering Staff is entitled to high credit for the initiation and the successful accomplishment of this reform.

Equally satisfactory is the transfer, not very long ago, of 5000 subscribers simultaneously—almost in a moment—from the old Victoria Exchange in London to the new Victoria Exchange, a transfer which also appears to have been accomplished practically without a hitch, and which, again, is very creditable to the officers who are concerned.

Then, quite recently, you have the new cable between England and Ireland on the system of loaded cables, in which the British Post Office has been the pioneer, and perhaps it is as well that the conversations between this country and Dublin should not take place —as hitherto—by way of Ulster.

I have not been quite sure that the use of machine telegraphy has been developed as fully in our Service as it might have been. I was rather inclined to suspect that the layman is chary of expressing his opinions on these matters. Possibly more could have been done in the use of machine telegraphy in various directions. As you are aware, a strong Departmental Committee has now been appointed in which we have the advantage of the assistance, once more, of Sir John Gavey to investigate and suggest any improvements that may be possible.

We are also, as no doubt you are fully informed, rapidly developing the use of automatic exchanges for telephone purposes in this country, about which I think I had the pleasure of speaking to you a year ago when I attended a similar function. In nine of the large towns of England automatic telephones are now being installed. If they are successful there, there is no doubt but that automatic telephony will have wide extension in many of our other cities.

Then, again, the Imperial Wireless Chain, about which there has been so much controversy, has at last been set going, and the actual work has now begun with the digging of the holes in the ground with a view to the establishment of the first stations. And not least interesting is the fact that since I last addressed you Parliament has sanctioned the construction of a tube railway in London for the sole use of the Post Office, the plans for which are now completed, and tenders for the work of construction will very shortly be invited.

You, with your Department, not being content with conquering the land, and the æther, and the sea, are now burrowing—efforts more than it has been accustomed to do—in the ground, so that none of this terrestrial globe shall be excluded from your sphere.

In these three matters—automatic telephony, long range wireless telegraphy, and the construction of underground railways for the sole use of the Post Office—our British Post office is once again, as it has so often been in the past, giving a lead to the whole world. In all these respects Britain will be far in advance of any other country.

Well, Gentlemen, this is the third occasion on which I have had the pleasure of attending a dinner of the Post Office Engineering Staff, and it is now four years since I had the honour of becoming Postmaster-General, and I feel quite aged as a Postmaster-General, for I think I have gone far beyond the allotted span of life for those who hold that office. Those four years have been a period of stress and of change, sometimes of difficulty, but the Department has withstood the stress and successfully accomplished the necessary changes and overcome all its difficulties, and I think we are now rapidly sailing into smooth waters. These successes have been accomplished owing to the manner in which the staff, as a whole, and perhaps especially the Engineering Staff, have risen to the occasion and have grappled with the difficulties with which they may have been confronted, and that they have so successfully achieved this is due in no small degree to the energy and efficiency of your Engineer-in-Chief, Mr. Slingo. (Applause.) He has, I know, the loyalty of his staff, the confidence of his chiefs, and I, personally, am most grateful for all that he has done to promote the well-being, efficiency and progress of this great Department of the State, and I ask you to drink the health of the Engineering Department, coupled with the name of the Engineer-in-Chief.

Mr. SLINGO, in replying, said: I can assure you that it is with the greatest sincerity that we wish to express our thanks to the Postmaster-General for his remarks, and our appreciation of the way in which the toast has been received. The Engineering Department is one which lives in hopes of having even higher praise showered upon it in the future than we have heard to-night, but it will have to be something very big indeed in order to justify more than Mr. Samuel has been pleased to say concerning us.

You may remember that when I had the privilege of occupying this chair a year ago I viewed the coming year with a little misgiving because of the anticipated very large growth in our expenditure. It was going up, not by leaps and bounds simply, but by a species of kangaroo leaps, squared and cubed. The expenditure which we had to face was a matter of $5\frac{3}{4}$ millions, and I had a little hesitation as to whether we should be able to get through so much work as that amount of money represents. There was one thing I felt certain was necessary, and that was the loyalty and full co-operation of the whole of the staff right away down to the humblest youth or boy, and I am happy to say that I have had that co-operation, and I have had that support, and we are going to spend by the end of the financial year at least as much as we undertook to do. Now, I think if we can go through such an ordeal as that we have in a very great measure justified our existence, and are entitled to hold a gathering such as we are pleased to have here to-night.

More than that, although we have grown from a matter of two millions expenditure in 1910 to a matter of six millions this year, I have not the slightest fear whatever or the slightest hesitation in approaching an expenditure of eight millions next year, and if the Postmaster-General wants a further extension than that, I think we can be prepared to meet him. In saying that, I cannot give a more solid testimony to the thorough confidence which I have in the whole of the staff.

Now one or two things have happened during the year. We have had the Holt revision. I know it is more particularly applicable to the minor grades, but I would just make this remark—I am quite confident that the scheme propounded and as slightly modified since, is to the advantage of the men, and I am sure of this—that the longer the men study the scheme the more satisfied they will be with it, and those officers who come in contact with the men will be doing the Service a great good by letting them clearly understand that the object of the Postmaster-General and the Department in making these changes is not to penalise the men in any shape or form, but to improve their lot and to increase the efficiency of the Engineering Department.

We have been very largely engaged in straightening out. Well, it was a case of straightening out the two sets of plant or being straightened out ourselves by someone else, and I think we took hold of the stick at the right end by making up our minds that the first thing which was necessary was to weld together the two sets of plant and straighten out unnecessary feeling, and generally to bring the Service into a state of solidarity, uniformity and serviceability. With that operation we are still at work, but we do hope in the very near future we shall see that the Service has been satisfactorily reorganised. I am not speaking now of complaints on the part of subscribers—a lot of these are quite uncalled for, and those which are called for do not affect the Engineering Department. (Laughter.) I have no fear of contradiction in making that statement on this occasion.

I have to thank the Postmaster-General very heartily and you for the very kind way in which this toast has been proposed and received.

The toast of "The Visitors" was proposed by Mr. A. J. Stubbs, Assistant Engineer-in-Chief, who said:

Just as "good wine needs no bush"—whatever that may mean!—a good toast needs no butter. (Applause.) I feel sure that you, gentlemen, for whom I speak, and you, gentlemen, to whom I speak, will be very well content that this toast shall be short and crisp—with little butter.

We have amongst us to-night guests whom we welcome with our whole hearts, as great men and as friends. It does not need that the Postmaster-General be told that we are greatly honoured and greatly delighted to have him with us to-night, that we have listened to his words of congratulation with the greatest possible pleasure and delight; and he knows as well as you do that our whole function depends upon him, for the date upon which it is held is fixed at his dictation.

Amongst those whom we ought to have had as our guests to-night are many to whom our thoughts have turned—perhaps most readily the name of Sir Alexander King comes into your mind; and we are extremely sorry that he and his brother—the Lord of Post Office Finance!—are alike prevented from being with us owing to their not being very well. I dare not suggest, as I look around, that their absence has made you look sad, but I am sure that our regretful thoughts have many times this evening turned to their absence and the absence of others of our invited guests. But we have other great ones and welcome ones amongst us to-night in all directions. We have the "Lord of the Telephones"—Mr. Ogilvie. (Applause.) His name is rapidly becoming a household word throughout the length and breadth of our land. We have many high Post Office servants—great men with us (I am tempted to call them "the great underpaid"); while there are other of our guests of whom we think as by no means "underpaid"—they are rather "lords of commerce" who find it as easy to buy a motor car as we poor Post Office engineers find it difficult to buy a pair of gloves! Then there are men, the highest in our profession, the presidents of the great engineering societies, the principals of great educational institutions, the heads of consulting engineering firms, and many others.

I have been trying to avoid the mention of specific names, but I must mention one or two, because I hardly know in what connection to class them—the great engineers who have been amongst us in the times past, like Sir John Gavey, and who also, in a sense, are amongst us still, like not only Sir John Gavey, but Mr. Gill. (Applause.)

Well, gentlemen, we have not delighted in the company of these friends and great ones because they are great men, but because they are great friends; we are glad to have them in our midst to-night because we recognise that whatever their position in life has been and is, they are our friends; and we want to assure them that we are glad to have them honour our board, humble though it may be.

I will not stand longer between you and those who will respond to this toast. It is my duty to couple with this toast of "Our Guests" the names of Mr. Duddell, the President of the Institution of Electrical Engineers, and Mr. Walkley, who represents Art and Literature, if I may say so, as well as the Post Office, because his name is of world-wide renown. Gentlemen, I give you the toast of "Our Visitors."

The toast was responded to by Mr. A. B. Walkley, Mr. W. Duddell, and Sir Henry Norman, M.P.

Mr. WALKLEY: I am very glad to find that you have divided the honours of replying between two of us, Mr. Duddell and myself, because Mr. Duddell will be able to represent an expert's views, while I am here in the entirely negative character of a layman. I think, if you will allow me to say so, you do well, you engineers, to feast us from time to time—and no doubt the more often the better—because you engineers, if I may put it without offence, in a sense are modern mystery men and miracle-mongers, and that is a character I view like the rest of the world with certain misgivings. The remark applies with peculiar force, I think, to engineers who deal with the strange, still unexhausted force of electricity. One of the strangest things about it is that it has always surprises in store. You are always pursuing the elusive nymph of electricity and she is always fleeing, and just as you think she has escaped you she proves, like other nymphs, unexpectedly prodigal of her favours. And after that you go about "fey" men, a little uncanny. In mediæval times they would have crystallised this in the statement that the Devil was the first engineer. After all, in the progress of the ages the Devil has been credited with so rich and varied an initiative that I think he can very well afford to spare that particular attribute. But that is why I suggest that you do well to entertain us and to let us see that you are not merely engineers—those strange, uncanny beings—but that you are also men and brethren. I think, as I speak, of the song that is now something of a nuisance all round London—"You made me love you: I didn't want to do it." I will not say we didn't want to love you engineers—we have always wanted to love you—but there has been that little difficulty about the mystery of you, and you do well to make us love you by your very charming hospitality.

Gentlemen, on behalf of the lay guests, I return you my very best thanks.

Mr. DUDDELL: It gives me the greatest pleasure to get up and thank you for the very cordial way in which this toast has been proposed, and the way in which you have honoured it. The last speaker seems to have been guilty of responding on the "expert" side. I may tell you that I must plead guilty of being very largely a guest. I think I am thoroughly expert at being a guest. On the subject of guests and how they shall be treated I can tender my services—a very simple thing! Since 1904, when I first had the pleasure of going to the Post Office and meeting Sir John Gavey, I have always felt somehow or other that I was one of you. So many of you I know by sight, and large numbers of you I know so well, that I feel when I am among you that I am among friends. The pleasure I feel at being your guest to-night is enhanced because of what we have heard on the subject of the money that is going to be expended on the telephones next year. During the last few months there have been startling changes appearing, and the extra few millions, and I may have perhaps still more experience of the telephone system. To-night we have heard of 5000 subscribers being transferred at one "go." This transfer is a big one. I was transferred, but after the change people did not know I had been transferred! As a result I was constantly asked, "Are you number so-and-so?" The exchange did not seem to act upon my transfer. Yes, it is a strange thing to effect such success as my transfer.

Well now, gentlemen, I wish to say on behalf of the Institution of Electrical Engineers that you are still the first branch of electrical engineering, and still the most important from many points of view. We are always glad to have you, and hope to have you in our building and to give you every entertainment we can.

On behalf of the guests and on my own behalf in particular I beg to thank you for the very cordial way in which you have drunk this toast.

The CHAIRMAN then said: Mr. Walkley has replied for the laymen! Mr. Duddell has replied for the expert guest! Now, I think, we are really entitled to, and should much appreciate, a little response on behalf of the unofficial guests, and Sir Henry Norman has therefore very kindly consented to respond to the toast.

Sir HENRY NORMAN: I have often, very often, had occasion to feel a sense of my own shortcomings, but I never felt so keen a sympathy with an actual criminal as I do at this moment, because, as you all know, when a French criminal is first sentenced to the guillotine the date of his execution is mercifully withheld from him until the moment arrives, and at that moment the governor of the prison says, "Courage, my friend, the moment has come." Your Chairman has paid me that compliment to-night, because, when I had enjoyed a most excellent dinner, he suddenly said at the last moment, "Courage, my friend, the moment has come for you to make a speech." I am very much honoured to be associated with your other guests, with my old friend Mr. Walkley, whom I have known for more years than I care to remember in his many capacities and multifarious tasks, so that I was not surprised when I read in the papers that he had blossomed forth as an authority on high-speed telegraphy.

Mr. Duddell is among the most eminent of our electrical experts in this country, and he is, rightly so, often chosen to represent us in scientific circles abroad. I gathered from what fell from the Postmaster-General or the Chairman—I forget which—that you gentlemen are responsible for the London Telephone Exchanges. If that is so there may be somebody here present who is responsible for the Regent Exchange. I do not see anyone standing up. (Laughter.) Well, all I want to say is this: that at the Regent Exchange there is a lady. I have not the pleasure of her acquaintance, apart from a familiarity with her voice over the telephone, but if the gentleman who is responsible for the Regent Exchange is here present and is able to convey this suggestion to the lady at the Regent Exchange, can he persuade her not to ask me to drop a penny in the box at my private house when I wish to communicate with another subscriber? (Laughter.)

I will tell you another personal experience.

I was recently in company with an eminent gentleman who with myself was called upon to be present at an official committee, but unfortunately the secretary of that committee had given us a wrong address, and none of our fellow committee-men were there. We were alone, and we knew that the chairman and our fellow-members were awaiting us, and we felt very embarrassed, as we did not know where the committee was meeting.

We thought that we would telephone to some Government headquarters, just to ask where the committee was meeting that day. So we telephoned—I should say we tried to telephone. There were difficulties, and there were some difficulties, and there were many difficulties. I do not propose to tell you them all. At any rate, at last we got through on the telephone, and the gentleman who was with me turned round and said, "You will notice, Sir Henry, that the telephone difficulties in London are all administrative and not engineering." I am not surprised that I heard your Chairman to-night express a similar sentiment. It appears to me to-night that the talents which have been successfully displayed in the administration of the technical and engineering side of the telephone system can be brought to apply to some of the problems of the House of Commons, which might perhaps be to our advantage there. I wanted a seat in the House of Commons to-day in order to hear the speeches on both sides on this historic occasion. In order to [illegible] seat it was necessary for me to be outside the door of the House of Commons this morning at 6.50, and to wait hours before I could go in to claim my seat. [illegible] think that you who have so much to do with automatic selection of the telephone system can surely apply something like that to enable us to get our seats without going through that childish course. Of course you have an automatic selector! It will be necessary to have an automatic gas pressure regulator. You will also have to add an automatic cut-out. (Laughter.) However, I had the privilege of spending a very short time with you—far too short for my happiness as a member of the Post Office staff; and, joking aside and coming to seriousness, I can bear testimony to the fact of my own personal knowledge, that, so far as I am able to judge, the Post Office is the most efficient department of the public service. (Applause.) During the short time I was there it seemed to me that the public were always ringing the front door bell, and had to be answered immediately. I am quite certain that the Post Office has no more efficient staff than the Engineering Staff. Some of you, I am very glad indeed to learn from the Postmaster-General to-night, are connected with the foundations for the building of the first stations of the Imperial chain which are being dug. This, of course, is the beginning, and I am very glad indeed to know that this first step has been taken. I have not always been able to see eye to eye with my friend the Postmaster-General on the matter of the Imperial chain of wireless stations, but I can certainly say that it would have been impossible for the Post Office and the national interests to have been represented in the House of Commons by a man who worked with a more single eye to the public interest, or who devoted so much labour to attain what he believed to be the highest possible results.

Mr. Samuel has spoken to-night in some strange manner of the expiration of the allotted span of the Postmaster-General. I can only say that, speaking as a member of the public, with some opportunity of knowing what is going on, I certainly hope that this is not applied to his own particular case. If it is, I can only say that, in view of the very great number of men in the public service dependent upon the Post Office administration, of which he has given us in his annual statement in the House of Commons year after year such an example, I should think it is an unequalled record of achievement of the Postmaster-General and his staff, and I would add that his successor, whoever he may prove to be, will have a very difficult task to follow along the same lines. During the very brief time I passed at the Post Office, certainly among the most happy and profitable moments of my life, I felt very honoured.

Gentlemen, I thank you for the way in which you have received this toast.

Mr. Moir, in proposing the toast of "The Chairman," said: I have much pleasure in rising to propose the toast of the Chairman, and, lest you should have any misgiving as to the length of time which I am likely to occupy in submitting this important toast for your acceptance, I should like to explain at once that, in official parlance, I have been discreetly reminded that he who undertakes work on behalf of the Engineer-in-Chief does so with a time-limit and a penalty clause attached to his contract. I am glad on your account to have been given this gentle hint, otherwise I might have been tempted to pour upon your innocent heads a perfect deluge of words. For example, Mr. Slingo is the sixth Engineer-in-Chief under whom I have served, and I still survive! In a spirit of gratitude, therefore, I should have been tempted to have spent half an hour or so upon "The Lives of the Engineers-in-Chief," after the manner in which Johnson dealt with the Lives of the Poets, but the penalty clause forbids

Again, some of you in this room have known Mr. Slingo from his youth upwards, so to speak; I have not been so fortunate. I have known him only as Staff Engineer, Superintending Engineer, Assistant Engineer-in-Chief, and in his present position. But, Gentlemen, these are four of the great ages of man in the Engineering Service of the Post Office, and, looking round this room to-night at the brave show made by our young Engineers—the future hopes of the Post Office—with the wave-lengths of their faces not unduly extended; their physical proportions not attenuated to any great extent; their mental installations well-equipped and closely tuned, so as to enable them to deal effectively with the problems in lighter engineering which become more numerous and more complex from day to day; and with their hearts well charged, I make no doubt, with clean and healthy ambition, I should have liked on their behalf to have spent a quarter of an hour or so on "The making of an Engineer-in-Chief" as personified in our Chairman himself—but the penalty clause forbids.

I come, therefore, to Mr. Slingo as we know him to-day—certainly one of the busiest men at the General Post Office. I had intended to have made reference to the manner in which he had undertaken the heavy responsibilities placed upon him since he became Engineer-in-Chief, but after the handsome and well-deserved compliments paid to Mr. Slingo by the Postmaster-General it would be presumption for me to add anything as to his high attainments.

I should like, however, to [illegible] short story about a countryman of my own who entered a chemist's shop and placed an order for two-pennyworth of laudanum. The chemist, having the Poisons Act in his mind, looked his customer up and down, and said, "What do you want it for?" His customer, missing the chemist's point of view, but responding readily to the inward calls of what is popularly believed to be his ruling passion, answered: "What do I want it for? I would like it for a penny!" Well, gentlemen, the question you will now like to ask me is which is the Engineer-in-Chief, and my answer is that neither of these two represents the Engineer-in-Chief. Mr. Slingo does not want two-pennyworth of laudanum for a penny, but he wants two-pennyworth of laudanum for twopence, and he is very well qualified to know when he gets value for his money, and, therefore, you need never on any occasion endeavour to sell the Engineer in-Chief a pennyworth of laudanum for twopence. But, although Mr. Slingo, as this story illustrates, is well qualified to look after the interests of the Department, he is also very familiar with the whole of the conditions of the staff, and has a sympathetic feeling towards any reasonable demand that may be made upon him. After all, gentlemen, what quality more than any other is required to-day by those who are placed over the large Departments of the Post Office, or who occupy, for the time being, the Chairmanship of Committees dealing with Staff matters? It is the quality and the capacity of being able to weigh evenly in the balance the sometimes conflicting claims of employers and employed.

Gentlemen, the toast is "The Engineer-in-Chief."

The CHAIRMAN replied in the following terms: Gentlemen, I am very grateful for the toast proposed. There can be no doubt of what Mr. Moir said that everyone wants two-pennyworth of "mustard" or whatever it was for twopence, and I do hope that it is realised throughout the Service, that no one wants more than two-pennyworth for twopence. But we do want to justify our existence to show that we are what we pretend to be with eyes, ears, brains and thoughts, at the bottom of the whole business. I am very much obliged indeed for the way in which the officers of the Department have responded, not only to this toast to-night, but to the very pressing and great demands which have been made upon them during the past year. I think the organisation which we have been able to set up and develop during the past year will enable us to cope with anything that is likely to occur in the future.

During the evening an excellent musical programme was contributed to by Miss Lillian Burgiss, Miss Margaret Norton, Mr. Murray Ashford, and Mr. Charles Wreford.

The preliminaries in connection with the Dinner were admirably organised by a committee representing the Engineer-in-Chief's Office and the London and South-Eastern Engineering Districts respectively.

To Messrs. R. A. Wells and L. J. Farries, the joint Honorary Secretaries, high praise is due for the carrying through of a most successful function.

THE TELEPHONE AND TELEGRAPH SOCIETY OF LONDON.

The fourth meeting of the current Session took place on January 26th, when Mr. G. F. Mansbridge of the Stores Department, gave an excellent paper on the subject of the "Manufacture and Repair of Telegraph and Telephone Apparatus at the Post Office Factories." Although the paper was longer than usual, interest did not flag in the least. Indeed, most of the audience were disappointed only because the available time did not permit of more than the lifting of the veil which covers the mysteries of the factories. The subject was in fact so wide that one moment we were in spirit at the timber-felling camps in Australia, and the next at a remote local store watching the packing of returnable stores in a thoroughly unique and unorthodox manner.

Mr. Mansbridge, after dealing with the history of the factories and the probable future arrangements, explained in detail the methods of manufacturing wooden arms for telegraph poles from eucalyptus wood, and the need for careful scrutiny of the wood before and during the process of manufacture so as to discover flaws, especially those caused by side-slips across the grain at the time of felling the timber. He described the method of automatically collecting dust and chips as they were produced and conveying them to the furnace.

Apparently they make and repair casks at the factories by sleight of hand, but, although the process was fully described and illustrated on the screen, their subsequent uses were left to the imagination. The description was sandwiched between "arms" and "waste material," but I am informed on high authority that the context was accidental.

Scrap material at the factories seems to be a misnomer, as apparently they never scrap anything, using the material over and over again in different forms. All of us were very proud to hear of the clever methods for separating copper from gutta-percha, of the Lucas battery and the Mansbridge condensers.

Mr. Mansbridge described the method of dismantling, repairing and reassembling instruments and switchboards, and all the system for turning old plant into new, the process of lacquering by aërograph instead of by brush, the devices for constructing Wheatstone chain and the use of automatic and semi-automatic tools. He also described the new factory which is being built at Birmingham, and the arrangements which will be made there to utilise electric power to an unusual extent.

When, later, Mr. Mansbridge discussed the question of piecework *versus* daywork, he expressed himself as strongly in favour of the former. I cannot do better than give the following extracts from his paper, viz.:

"Scamping is encouraged, not by piecework as such, but by slack supervision and inefficient examination. Workmen, being human beings, differ in their characters, but the average workman, if he gets a decent piece-price, takes a genuine pride in turning out a good article, and this pride is none the less if he knows that rejection would certainly be the fate of poor work. Piecework properly managed is an advantage to the workman and an advantage to the employer. It results in increased output, it enlarges the sum over which the overhead charges have to be spread, and thus, by reducing the percentage of establishment charges, enables a reduction in total cost to be effected. Moreover, it is an excellent medium for training young hands and for separating at an early stage those who are suitable for mechanical work from those who are not. The workman who can turn out first-class work, but who requires twice the normal time in which to do it, is not an efficient workman, and the sooner he is brought to realise this the better, and there is nothing like piecework for putting this to the test. In London what is known as plain piecework is in force. Under this system the aim is to fix piecework price at such a figure that a workman of average skill should be able to do a job in about four fifths of the time represented by the piecework price—that is to say, five hours would normally be reckoned as the right time to allow for a job which a man working at piecework speed would accomplish without undue effort in four hours. On this basis he would receive five hours' pay for four hours' work, or, as he would put it, he would earn 25 per cent. profit. If he did the job in less than four hours, the pay would, of course, be the same, but his profit would be greater. If he took longer than four hours, his profit would be less, and if he took more than five hours he would make a loss which might or might not be made good to him, according to the system in force, although the tendency in the best outside factories of late years has been towards making up such losses where they are not the result of laziness or deliberate misconduct on the part of the workman. As a general rule, the profit week in and week out all round the factory ranges from 20 to 25 per cent., but, as with most other things, jobs differ and men differ."

Mr. Mansbridge announced that, for the sake of uniformity, the Nottingham and Birmingham factories would soon be brought under the "plain piecework" system now in force in London.

The fifth meeting took place on February 23rd, when Mr. B. M. Wylie (A.G.D.) read a paper on "Telegraph and Telephone Accounting," which was, I believe, the first serious attempt to give a general survey of the system of accounting for those services. Mr. Wylie, indeed, showed us the "whys" and the "wherefores" of some of those irritating financial details which, as Mr. Waldegrave (A.G.D.) pointed out later, we do not suffer gladly even in private life.

Mr. Wylie, with all his enthusiasm for his subject, complained of difficulty in kindling the spark of life in its dry bones. If the writer of these short notes fails miserably to preserve that spark; the reader must ascribe the failure either to the fitfulness of the original spark or the clumsy use of the bellows.

Mr. Wylie dealt at some length with the financial history of the Telegraph and Telephone Services, and then described the method of Parliamentary control, which, starting with the Treasury Officer of Account (the Comptroller and Accountant-General), and continuing through the Treasury, the Comptroller and Auditor-General and the Committee of Public Accounts to the House of Commons itself, makes it so difficult for a Government Department to conduct its affairs on ordinary commercial lines. Much of the work of the Accountant-General's Department may be said to be directed towards securing the observance of the regulations governing Parliamentary accounting, and towards codifying receipts and expenditure in such a way as to enable accounts to be prepared in a form acceptable to Parliament.

All expenditure on the Telephone and Telegraph Service is provided for either by loan or moneys voted by Parliament. The money so obtained is specially allocated to specific purposes, and the misapplication of the money is a heinous offence. Hence the difficulty at times of obtaining promptly those small articles which are purchasable from the funds of another Department, and which in the commercial world would be bought off-hand from "petty cash."

It is this fear of misapplication (or misappropriation, as Mr. Wylie perhaps more properly but less prettily calls it) which makes it so necessary for the Accountant-General to pay such particular attention to the spending sides of our great organisation. So far as services common to the telegraph and telephone services are concerned, the apportionment is now carried out in the Accountant-General's Department with much accuracy and much less friction.

The annual receipts from the services are paid into the exchequer as revenue after passing through various conduits from the point of collection to the Accountant-General. We are all aware of the method of prepaying telegrams by means of postage stamps; and it appears that the average value of an inland telegram is calculated periodically and multiplied by the total number of telegrams, and the amount so arrived at is deducted from the money received from sales of stamps. In the case of the telephone service, the greater value of the actual fees, etc., paid by postage stamps is calculated.

But apart from the payments by postage stamps, there are some millions of telephone revenue which are collected by District Managers. This revenue is divided into two parts, viz. Exchange and Trunk. Generally speaking, the basis of the Exchange service is the subscriber's agreement, which provides for the payment of rental, etc., at a published tariff. Acceptance of the agreement is followed by the issue of an advice note which is the primary accounting voucher. This advice note is issued to the Superintending Engineer and contains full particulars of the service required. It is returned to the District Office when the engineering work is completed, an entry then being made in the rental register and an account rendered to the subscriber. Any engineering work performed for a subscriber, even though not involving a new agreement, is made the subject of a separate advice note. Local fees are dealt with by means of valued sheets, *i.e.* a printed sheet, one for each subscriber, provided with columns showing consecutive numbers of calls, the corresponding values, and spaces for indicating periodically the number of actual calls made by the subscriber. Without this valuable record it would be practically impossible to secure the prepayment of the charges for local calls. Trunk fees are posted direct to the subscribers' accounts from the trunk tickets.

The District Managers pay all moneys directly received by them, or transmitted to them by Postmasters, into appointed banks, whose acknowledgments called accountable receipts are transmitted to the Accountant-General. They cannot draw cheques on these banks, all payments for wages, etc., at district offices being made through the postmasters. With the limited space at my disposal, I cannot follow Mr. Wylie through the questions of commercial accounts, etc., but I can safely recommend the paper as worth careful study by those concerned.

The sixth paper of the Session was read by Mr. James J. Tyrrell, of the Cable Room, Central Telegraph Office, on March 23rd, and its title was "Some Difficulties of International Telegraphy." Not having had any practical or theoretical experience of the telegraph service, I will apologise at once for any misconceptions of Mr. Tyrrell's paper which I may in ignorance put forward.

Mr. Tyrrell explained fully the methods of working the telegraph channels to the continent. He is strongly of opinion that whatever may be the merits of the "operator output" as a unit of comparison in the case of inland telegraph lines, the special conditions of the international service render such a unit totally inapplicable to the latter. His arguments on this point were cogent; and he urged that, having regard to the capital value of the plant, the proper business proposition was a "circuit output" unit. He pointed this moral by comparing the cost of a little additional staff with the extra revenue which might be earned by the expensive plant. Members of the sister service will appreciate this view when they remember what excellent results attended the provision of ample staff for the long-distance inland telephone trunk wires.

But, as Mr. Tyrrell pointed out, the full advantage of additional staff at the Central Telegraph Office would not be obtained unless the Foreign Administrations concerned were prepared to staff their ends of the channels as generously as this administration. Apparently he is not sanguine of their willingness to do so, and he quoted cases where the foreign ends are at present less adequately staffed than the British ends. In connection with the staff question he pointed out that generally speaking the international wires work less efficiently in the early hours of the day than they do later on, and that consequently there is a certain accumulation of traffic towards the periods when the staff at the Central Telegraph Office is being automatically reduced.

Some interesting reasons were given for the difficulties of working the international service, one being that each nation assumes that its methods of construction and maintenance are superior to all others, and is difficult to convince that a fault in its own territory is not due to a hundred and one other possible causes within the remedy of its neighbour. The national representatives will not first remove the beam from their own eyes before examination of the specks elsewhere. Unfortunately nations are not singular in this respect. Mr. Tyrrell urged that every possible means should be used to convince the foreigner that the interruption of communication is not due to faults in British maintenance, and with this object he considered that repeater stations should invariably be placed as near as possible to the cable ends. Still, even then, if one may judge from the tenour of his paper, he fears the blindness of those that will not see.

Arrangements are being made to print all the papers which have been read before the Telephone and Telegraph Society of London during this Session, and a copy of each paper will be supplied gratuitously to each member of the Society. I hope that each member will derive much benefit from the perusal of the papers, as many points must of necessity be overlooked when one is merely listening to an address for the first time or scanning a hopelessly inadequate summary of it. J. W. W.

BOOK REVIEWS.

'Practical Uses of the Wave-meter in Wireless Telegraphy,' by J. O. Mauborgne, First Lieutenant 24th U. S. Infantry: formerly Instructor Army Signal School, Fort Leavenworth, Kansas. (Published by the Hill Publishing Co., Ltd., 6, Bouverie Street, London, E.C. Price 4*s*. 2*d*. net.)

This work, which in its manuscript form passed through the critical hands o Prof. G. W. Pierce, was written originally by Lieut. Mauborgue for private reference in the Army Signal School at Leavenworth, Kansas. It has now, by order of the Secretary for War, been officially adopted.

No unnecessary preliminaries are indulged in by the author, who goes straight to his subject by a definition of what constitutes a wave-meter passing on to log: decrements, oscillation constant, damping, syntony, etc. Chapters II and III are devoted to various types of wave-meters in use and the manner in which they are used for wave-length determinations.

Chapter IV, which for the practical wireless engineer is perhaps the most important in the book, deals with the tuning of the sending station, and is a lucid exposition of the way in which this all-important operation should be carried out.

In the remaining chapters methods are given for measurement of damping, decrement, inductance, capacity, etc., by means of the wave-meter, and a logarithmic chart is supplied for the purpose of finding the frequency corresponding to any wave-length, the wave-length corresponding to any given capacity and inductance, etc.

Two obvious misprints occur in the book, viz. on p. 30, line 18, λ should be λ_2; and on p. 62, first equation, the ratio in the right-hand member should be multiplied by C, and not the first term in the numerator.

On the whole the book is one that can be heartily recommended to all who are interested in wireless telegraphy. It is excellently printed, and the text is interspersed with many diagrams and illustrations.

'Telephone Erection and Maintenance: A Handbook for the Contractor and Wireman,' by Herbert G. White. (Published by Messrs. S. Rentell & Co., 36, Maiden Lane, W.C. 125 pp. and index. Price 1*s*. 6*d*. net.)

In his preface the author states that his "main object is to explain the principles underlying domestic telephones of the type that the electrical contractor and wireman have to handle," and that "no attempt is made to deal with public telephone service." The book is not, therefore, one which will appeal to Post Office employees generally.

The various types of magneto and battery-ringing direct-circuit installations, secret and non-secret intercommunication systems and switchboard installations in common use are clearly described and the illustrations are adequate and good. Stress is laid on the necessity for carefully planning and executing every detail of any work, and practical directions are given which will well repay observance.

The author recommends the use of two-groove insulators for transposition purposes when open wires are run for any appreciable distance adjacent to a power circuit, but in a damp climate such as ours it is better to provide two independent insulators per wire at each transposition point.

There are a few errors of spelling, etc., which, in the event of a reprint, will doubtless be eliminated.

'Automatic Telephony,' by S. Turner, Engineer-in-Chief's Office. (Published by 'Electricity.' Price 6*d.* net.)

This little pamphlet of thirty-two pages is a reprint of a short series of articles published in 'Electricity,' July 4th, 1913, etc., and outlines in very simple language the mechanical and electrical operations of the automatic circuits used in a "Strowger" Exchange for joining together two automatic subscribers in a three-figure system. For each stage of a connection, a separate circuit with the essential apparatus only is shown. The diagrams are, therefore, simple and easily followed. The manuscript deals with the connections of a local call from first principles, and should be useful as a first step to students of automatic telephony. J. H.

'Practical Electrician's Pocket-Book, 1914.' (Rentell, cloth 1*s.* net; Rexine [with Insurance]. Price 1*s.* 6*d.* net.; postage 3*d.*)

The 1914 edition of the little red book is again before us, and we are pleased to note that the editor and his assistants do their utmost to maintain the up-to-date character of this most useful work in every respect. This year chapters have been added on 'Electric Welding' by Mr. R. J. Wallis-Jones, M.I.C.E., M.I.E.E., and on 'Electric Heating and Cooking' by Mr. 'Tricity Grogan, whose work in this direction is so well known to the majority of our readers. Other important additions deal with Automatic Electric Lighting Plants, Electro-Plating, Electric Cranes and Lifts, Electric Signs and Flashers, and other interesting and practical subjects too numerous to mention, the net result being an increase in size of some fifty-eight pages. We are sure that this little handbook will meet with the reception which it so well deserves.

'Questions and Solutions in Magnetism and Electricity,' by William J. White, A.M.I.E.E. (Messrs. S. Rentell & Co.; Whittaker & Co. Price 1*s.* 6*d.* net.)

In this little book Mr. White has furnished solutions to the questions set at the examination by the Board of Education and latterly by the C. and G. of London Institute in stage I, Magnetism and Electricity, over the period 1907–1913. Care has evidently been taken to ensure accuracy and straightforward answers, and the sketches illustrating them are well done. The book should be very useful to telegraphists in their efforts to secure the double increment, and also to the workmen now attending the first year's course drawn up by the Department and being taught at the various institutes. The value of the book is enhanced by the index given at the end, which summarises the portions of the subject dealt with in the questions.

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ENGINEERING DEPARTMENT CHESS CLUB.

A friendly match was played on December 1st, 1913, with Messrs. C. & E. Morton's Club, and won by eight games to two, but the Club has yet to record its first success in the Civil Service League.

The Club Competitions have provided some interesting contests and are now nearing completion.

It is hoped to hold the Annual Dinner during April.

DEATH OF MR. J. T. DEAN.

Members of the staff of the old Metropolitan District, as well as of the now also extinct Metropolitan (North) District, will hear with much regret of the death of Mr. James T. Dean, late Chief Clerk of the Districts named, which occurred with painful suddenness in the early hours of Sunday, November 30th, 1913.

Mr. Dean entered the service of the Department so long ago as June 20th, 1872, and was transferred from the Central Telegraph Office to the Engineer-in-Chief's Department in May, 1880. He successively passed through the grades of Junior and Senior Clerk, and ultimately received the appointment of Chief Clerk to the now extinct Metropolitan District on November 30th, 1899, on the retirement from that position of Mr. Edward Collard, who survives him. In August, 1907, Mr. Dean, much to the regret of his many friends, was compelled to retire in consequence of ill-health, and since that time he has resided at Portslade, Sussex, where he was well known and much respected.

Mr. Dean was an enthusiastic whist player, and it was while indulging in his favourite game that the fatal blow fell, which removed from the world one of the most kindly and sympathetic of men. This occurred about 10 o'clock on the evening of November 29th, and Mr. Dean was at once removed to his home, but never again regained consciousness. He expired at 12.30 on the following morning. Death was certified as having been caused by epilepsy and coma.

All who knew Mr. Dean will feel that they have lost a firm and true friend, and their regret at his loss will find expression in much sympathy for Mrs. Dean in her great bereavement.

W. H.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	From.	To.	Date.
Kingston, J. R.	Asst. Engr.	Exec Engr.	28 : 11 : 13
Gwyer, J. H.	Chief Inspector	Asst. Engr.	
Armstrong, E.	,,	,,	
Smith, F. M.	,,	,,	
Curling, R.	,,	,,	To be fixed
Speight, A.	Junior Engr.	,,	later.
Smith, N. S.	,,	,,	
Bastow, F.	,,	,,	
Hembrough, J. R.	,,	,,	
Ellery, A. Q.	3rd Cl. Clerk, London Dist.	2nd Cl. Clerk, London Dist.	18 : 10 : 13
Pestell, G.	3rd Cl. Clerk	2nd Cl. Clerk	19 : 12 : 13
Martin, L. C.	Junior Engr.		3 : 1 : 14
Peck, H. G. S.	Chief Inspector		3 : 1 : 14
Kingsbury, H.	Junior Engr.	Asst. Engr. on	22 : 1 : 14
Nancarrow, F. E.	—	probation.	1 : 1 : 14
Faulkner, H.	—		5 : 1 : 14
Gregory, H. J.	—		9 : 2 : 14

STAFF CHANGES.

TRANSFERS.

Name.	Rank.	Transferred from	To	Date.
Beeton, H. G. . .	Asst. Engr.	E. in C.O.	Met. Power	12 : 1 : 14
Williams, R. H. . .	,,	,,	London	21 : 1 : 14
Grieveson, A. F. .	Asst. Engr. on probation	,,	S. E.	18 : 1 : 14
Boryer, W. F. . .	Ditto	,,	London	18 : 1 : 14
Campbell, H. M. .	2nd Cl. Engr.	N. Mid.	E.	9 : 3 : 14
Strong, E. . . .	Junior Engr.	E. in C.O.	Testing Branch	8 : 2 : 14
Day, T. F. . . .	Chief Inspector	Testing Branch	E. in C.O.	1 : 3 : 14
Simpson, W. W. .	3rd Cl. Clerk	Sc. W.	S. Mid.	5 : 10 : 13
Pine, T. F. . .	,,	S. Lancs.	,,	9 : 11 : 13
Schofield, W. H. .	,,	Sc. W.	,,	2 : 11 : 13
Corney, P. A. . .	,,	N. E.	,,	28 : 9 : 13
George, T. B. . .	,,	S. Mid.	London	1 : 11 : 13

RETIREMENTS.

Name.	Former.		Particulars.	Date from which to take effect.
	Rank.	District.		
Fletcher, T. . . .	Asst. Engr.	E. in C.O.	Superannuated	25 : 1 : 14
Johnston, D. W. . .	3rd Cl. Clerk	,,	,,	13 : 2 : 14
Robertson, G. A. . .	,,	Scot. East	,,	18 : 3 : 14

DEATHS.

Name.	Rank.	District.	Date.
Cleary, W.	Asst. Engr.	South Lancs.	20 : 1 : 14
Rydings, J. M. . . .	3rd Cl. Clerk	,,	4 : 1 : 14

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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.

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THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

STATION LIST

OF

OFFICERS ELIGIBLE FOR MEMBERSHIP OF THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

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Supplement to THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, *Vol. VII, Part* 1, *April,* 1914.

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Williams, R. H.	London	West Internal.
Morris, A. C.	N. M.	Nottingham.
Woollard, F. W.	London	Centre Internal.
Angwin, A. S.	Sc. W.	Glasgow (Light Construction).
Murray, J. K.	,,	Glasgow (M'ntenance).
Stone, H. C.	London	City External
Roberts, P. A.	,,	West External.

Name.	District.	Station or Section.
Asst. Engrs.—con.		
Coates, G. A.	N. E.	Hull.
Beasley, B. J.	S. M.	Reading (S. E's. O.).
Davidson, J.	Ire.	Belfast.
Bellwood, G. F.	N.	Newcastle (S. E's. O.).
Hetherington, T.	Sc. W.	Glasgow (S. E's. O.).
Cowie, J.	S. E.	Brighton.
Jones, E. P.	E. in C.O.	Power.
Stewart, W.	Sc. W.	Glasgow (S. E's. O.).
Hilyer, W. J.	E. in C.O.	Telephone.
Collinson, T. R.	N.	Darlington.
King, R. T.	E. in C.O.	Equipment.
Phillips, A. C.	S. W.	Bournem'th.
Platt, W.	S. Wa.	Cardiff (S. E's. O.).
Lockhart, J.	E. in C.O.	Designs.
Jones, J.	N. Wa.	Shrewsbury.
Beer, G. F.	S. Lancs.	Birkenhead.
Bassett, S. W.	N. M.	Nottingham (S. E's. O.).
Fleming, G.	Sc. W.	Hamilton.
Doak, H.	Ire.	Dublin.
Browne, F. G.	N. M.	Coventry.
Taylor, J. L.	E. in C.O.	Telegraph.
Sharpley, A. J.	London	North External.
Hall, F. M.	,,	North-east Internal.
Gadsby, G. J.	E. in C.O.	Equipment.
Jolley, L. B. W.	,,	Power.
Taylor, C. A.	,,	Test (Mount Pleasant).
Sanger, P. M.	S. E.	Croydon (S. E's. O.).
Robertson, J.	Sc. E.	Edinburgh.
Finlayson, W. J.	N. W.	Preston (S. E's. O.).
Hedley, J.	E. in C.O.	Telephone.
Gray, W. J.	,,	Local Lines.
Shepherd, G. M. B.	,,	Research.
Maddock, G. M.	,,	Equipment.
Blick, F.	London	South-west External.
Brocklesby, C.	N. Wa.	Birmingham (Inner).
Walker, J. C.	N. E.	Bradford.
Warnock, J. W.	Sc. W.	Glasgow (Light Construction).
Anson, B. O.	E. in C.O.	Telephone.
Perrin, E. S.	,,	Wireless.
Timmis, A. C.	N. M.	Leicester.
Cave-Browne-Cave, N. F.	N. Wa.	Hanley.
Dunsheath, P.	E. in C.O.	Power.
Lawson, C. G.	Power (London)	Mount Pleasant.
Redhead, C. H.	Ire.	Dublin.
Asst. Engrs.—con.		
Reid, F.	E. in C.O.	Construction.
Witherby, J. C.	Sc. W.	Glasgow (S. E's. O.).
Greening, A. C.	London	Centre Internal.
Warner, A.	,,	City Internal.
Payton, G. A.	,,	South Internal.
Fraser, A.	E. in C.O.	Wireless.
Davey, F. W.	,,	,,
Glover, J. B.	N. W.	Blackburn.
Leigh, C.	E. in C.O.	Main Lines.
Tebbits, J. S.	N. Wa.	Shrewsbury (S. E's. O.)
Wenman, H. E. A.	London.	City External.
Crocker, J. R.	E.	Cambridge
Jack, J. A.	Sc. W.	Glasgow (North).
McMullen, J. F.	S. Wa.	Cardiff (S. E's. O.).
McCormack, W.	N. W.	Lancaster.
McCandless, J.	Ire.	Dublin (S. E's. O,).
Evans, A.	N. M.	Peterboro'.
Turner, J. W.	E. in C.O.	Equipment.
Firth, S. S.	N. M.	Nottingham.
Shorrock, L.	S. Lancs.	Manchester (S. E's. O.).
Escot, H.	S. Lancs.	Manchester (Internal).
Henrici, R. C.	E. in C.O.	Equipment.
Hay, C. E.	,,	Research.
Aspinall, H. O.	London.	South-East External.
Lane, W. H.	S. Wa.	Gloucester.
Harris, E. C.	S. M.	Guildford.
Lemont, G. A.	S. M.	St. Alban's.
Gibbon, A. O.	E. in C.O.	Local Lines.
Hammond, G. W.	N. E.	Leeds (External).
Fletcher, J. E.	,,	Leeds (S. E's. O.).
Arundel, D. S.	N. M.	Nottingham.
Balcombe, R. C.	S. Lancs.	Manchester (East).
Elston, J. S.	E. in C.O.	Construction.
Morgan, J. A.	,,	Main Lines.
Calveley, W. H.	E.	Colchester.
Rattue, A.	S. W.	Bristol (S. E's. O.)
Lock, F.	S. Wa.	Newport.
Hunter, G.	E. in C.O.	Equipment.
Dolton, W.	London.	Centre External.
Newton, E. I. T.	E. in C.O.	Equipment.
Cowling, G.	,,	Designs.
Burbridge, W. C.	N. Wa.	Shrewsbury (S. E's. O.).
Cruickshank, W.	E. in C.O.	Designs.
Cobbe, T.	E.	Cambridge (S. E's. O.).

Name.	District.	Station or Section.
Asst. Engrs.—con.		
Wildgoose, G. H. A.	S. Lancs.	Manchester (S. E's. O.).
Smith, D. McE.	E.	Norwich.
Gravill, W. E.	S. M.	Kingston-on-Thames.
Smith, J. I.	N.	Middlesbro'.
Buchanan, J.	N. W.	Preston (S. E's. O.).
Childs, P. J.	London.	South-West External.
Johnson, A. S. A.	,,	S. E's. O.
McClarence, F.	,,	North-West External.
Neate, E. P.	,,	Centre External.
Partington, R. N.	S. E.	Canterbury.
Vickery, W.	S. W.	Bristol (S. E's. O.).
Ryder, W. V.	N. E.	Lincoln.
Mitton, F. E.	London.	S. E's. O.
Tremain, W. E.	N. M.	North'mpton.
Bell, J. H.	London.	City Internal.
Pratt, A. J.	S. Lancs.	Birkenhead.
Anderson, J.	E. in C.O.	Power.
Fleetwood, H. O.	S. Wa.	Cardiff (S. E's. O.).
McDonald, C. G. A.	N. Wa.	Birmingham (E. L.).
Gilbert, D. P.	S. Lancs	Manchester (S. E's. O.).
Dunthorne, H. R. J.	N.	Newcastle (S. E's. O.).
Beeton, H. G.	Power (London).	Mount Pleasant.
Coxon, J.	E. in C.O.	Power.
Bartlett, A. W.	Power (London).	Centl. Power Station.
Nevin, J. A.	S. Lancs.	Liverpool (External).
Cooper, J. O.	,,	Liverpool (Internal).
Deane, W.	London.	S. E's. O.
MacDermott, C. N.	E. in C.O.	Power.
O'dell, G. F.	,,	Telephone.
Mallett, E.	Sc. W.	Paisley.
Eason, A. B.	E. in C.O.	Power.
Bradfield, R.	S. W.	Bournem'th.
Cresswell, H. G. B.	Sc. E.	Edinburgh (S. E's. O.).
Broomhead, H. H.	Ire.	Belfast.
Peacock, C. T.	E. in C.O.	Designs.
Harding, R. W.	,,	Local Lines.
Ireland, W.	,,	Equipment.
Lonnon, W. W.	,,	,,
Plymen, H. S.	,,	,,
James, J.	S. Wa.	Cardiff (Internal).
Preston, E. L.	S. W.	Bristol.
Turner, F. G.	E. in C.O.	Telephone.
Jackson, R. W.	N.	Newcastle (External).

Name.	District.	Station or Section.
Asst. Engrs.—con.		
Price, L.	N. W.	Preston (S. E's. O.).
Cowburn, W.	S. Lancs.	Manchester (S. E's. O.).
Scutt, W. D.	N. E.	Leeds (Internal).
Stewart, J. H.	London.	West Internal.
Murphy, F.	E. in C.O.	Telephone.
Hannam-Clark, H. C.	S. E.	Tunbridge Wells.
Hansford, R. V.	Sc. E.	Inverness.
Monaghan, T. J.	Ire.	Dublin (S. E's. O.).
O'Neill, J. W.	,,	Dublin (S. E's. O.).
Marris, G. C.	S. Lancs.	Liverpool (Internal).
Ward, W. G.	N.	Newcastle (Internal).
Wood, W. K.	N. E.	Bradford.
Aldridge, A. J.	E. in C.O.	Research.
Gray, H. C.	,,	Construction.
Jessup, H. W.	,,	Test (Mt. Pleasant).
Clack, C. W.	,,	Designs.
Hill, S. F.	,,	Equipment.
Crompton, W. W. B.	,,	Local Lines.
Watkins, J. H.	,,	Designs.
Latimer, F. D.	S. Lancs.	Manchester (East).
Milnes, J. R.	N. M.	Nottingham (S. E's. O.).
Street, C. F.	E. in C.O.	Main Lines.
Legg, J.	,,	Test.
Hanford, S.	,,	,,
Morice, A. B.	,,	Research.
Carter, H.	,,	Construction.
Cottle, P. J.	,,	Test.
Rathbone, E. J.	,,	Equipment.
Newman, H. O.	N. E.	Leeds (S. E's. O.).
Smith, H. A.	London	S. E's. O.
Ritter, E. S.	E. in C.O.	Research.
Werren, H. T.	,,	,,
Hill, H.	,,	Equipment.
Hinton, N. P.	,,	Wireless.
Morgan, J.	,,	Local Lines.
Hanna, W.	,,	Equipment.
Stone, A. E.	,,	Telegraph.
Hannaford, F. S.	,,	Construction.
Innes, J.	,,	Local Lines.
Grieveson, A. F.	S. E.	Croydon.
Boryer, W. F.	London.	City Internal.
Morris, A.	E. in C.O.	Research.
Gill, A. J.	E. in C.O.	Wireless.
Ellson, F. A.	,,	Research.
Gill, R.	N. E.	Leeds (S. E's. O).
Pittman, W. C.	N. M.	Sheffield.
Mears, T.	E. in C.O.	Main Lines.

Name.	District.	Station or Section.	Name.	District.	Station or Section.
Asst. Engrs.—con.			*Asst. Engrs.*—con.		
Gardner, A. W.	E.	Cambridge.	Kingsbury, H.	E. in C.O.	Research.
Fewtrell, J. W.	E. in C.O.	Telephone	Nancarrow, F. E.	,,	Equipment.
Golding, W.	S. Wa.	Cardiff (External).	Faulkner, H.	,,	Designs.
			Gregory, H. J.	,,	Research.
Everatt, W. C.	N. E.	York.	Gwyer, J. H.	S. M.	Southampt'n.
Dawson, A. E.	Ire.	Dublin (S. E's. O.).	Smith, F. M.	London	East External.
Waters, E. W.	London	South-east External.	Smith, N. S.	E. in C.O.	Equipment.
			Bastow, F.	,,	Telephone.
Bell, R. W. S.	S. Lancs.	Manchester (S. E's. O.).	Hembrough, J. R.	,,	,,
			Curling, R.	Sc. W.	Glasgow.
Martin, L. C.	E. in C.O.	Construction.	Speight, A.	E. in C.O.	Telephone.
Peck, H. G. S.	London	Centre Internal.	Armstrong, E.	S. E.	Croydon (S. E's. O.).

CABLE SHIP "MONARCH."

Name.		District.	Station.
Submarine Superintendent	Pollard, F.	Submarine	Woolwich.
Assistant Submarine Superintendent	Lever, G.	,,	,,
Executive Cable Engineer	Ramsay, F. G.	,,	,,
Assistant Cable Engineer	Gorton, S. G.	,,	,,
Chief Navigating Officer	Broadbridge, A. J. W.	,,	,,
Second Navigating Officer	Firmin, E. W.	,,	,,
Third Navigating Officer	—	—	—
Fourth Navigating Officer	—		—
First Engineer	Saville, D. B. S.	,,	,,
Second Engineer	Allan, R.	,,	,,
Third Engineer	Borthwick, G.	,,	,,
Fourth Engineer	Newton, C.	,,	,,

CABLE SHIP "ALERT."

Name.		District.	Station.
Submarine Superintendent	Bourdeaux, J.	Submarine	Dover.
Assistant Submarine Superintendent	Bourdeaux, H. F.	,,	,,
Assistant Cable Engineer	Hutchons, E. R.	,,	,,
Chief Navigating Officer	Flavel, G. H.	,,	,,
Second Navigating Officer	Skilliter, C.	,,	,,
Chief Engineer	Duncan, R.	,,	,,
Second Engineer	Fitzpatrick, G. A.	,,	,,

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