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A SIMPLE METHOD OF PRODUCING LOW FREQUENCY CURRENTS OF SINUSOIDAL SHAPE AND THEIR MEASUREMENT.

J. G. Bedford, A.M.I.E.E., and H. Josephs.

To measure the electrical parameters of lines and apparatus at telegraph frequencies, that is, between 5 and 100 cycles per second, it became necessary to develop a portable generator which would produce an e.m.f. of sinusoidal shape and also be capable of an output up to at least 60 volts.

A simple method of doing this is to use some form of apparatus which gives square-topped reversals, and then eliminate the higher frequency components, thus converting the square-topped waves into sinusoidal ones. The requirements of this type of low-frequency generator may be divided into three parts as follows:—

(1) The provision of a suitable generator giving a square-topped wave with a negligible transit time and constant speed, and capable of speed regulation over the required range.

(2) The provision of a suitable filter to convert the square-topped waves into sinusoidal waves.

(3) The provision of a suitable frequency measuring device which will enable measurements of frequency to be accurately and rapidly made.

With regard to (1): a motor-driven type of Baudot distributor fulfilled this requirement fairly satisfactorily. The governor was removed in order to obtain a sufficient range of speed and an oscillographic test showed that the transit time was negligibly small. The Baudot distributor was driven by a series-wound D.C. motor, requiring up to 220 volt supply and 0.3 amp. The speed of the motor was regulated by means of a 1200 ohm slide wire resistance joined in the supply circuit. For frequencies from 4 to 40 cycles per second the 110 volt supply is suitable, and from 40 to 100 cycles per second the 220 volt supply is suitable.

The front plate of the distributor was removed and the motor drives the brushes over the face of the back plate by a belt and through the epicyclic gear. Ring 2 is connected to the output terminal and + and − battery are joined to the 22 segments of Ring 5. Alternate segments of Ring 5 are connected together, and to the + and − poles of the battery. A spark quench arrangement is connected across the battery and contact brushes.

A schematic diagram of the arrangement is shown in Fig. **1**, and a photograph of the Baudot distributor is shown in Fig. **2**. For a detailed description of this piece of apparatus see Herbert's "Telegraphy," pages 467-470, 3rd Edition, 1916.

With regard to (2): a low-pass filter fulfilled this requirement satisfactorily. In the case of the lowest frequencies, from 8 cycles per second downwards, a two-section filter is necessary if

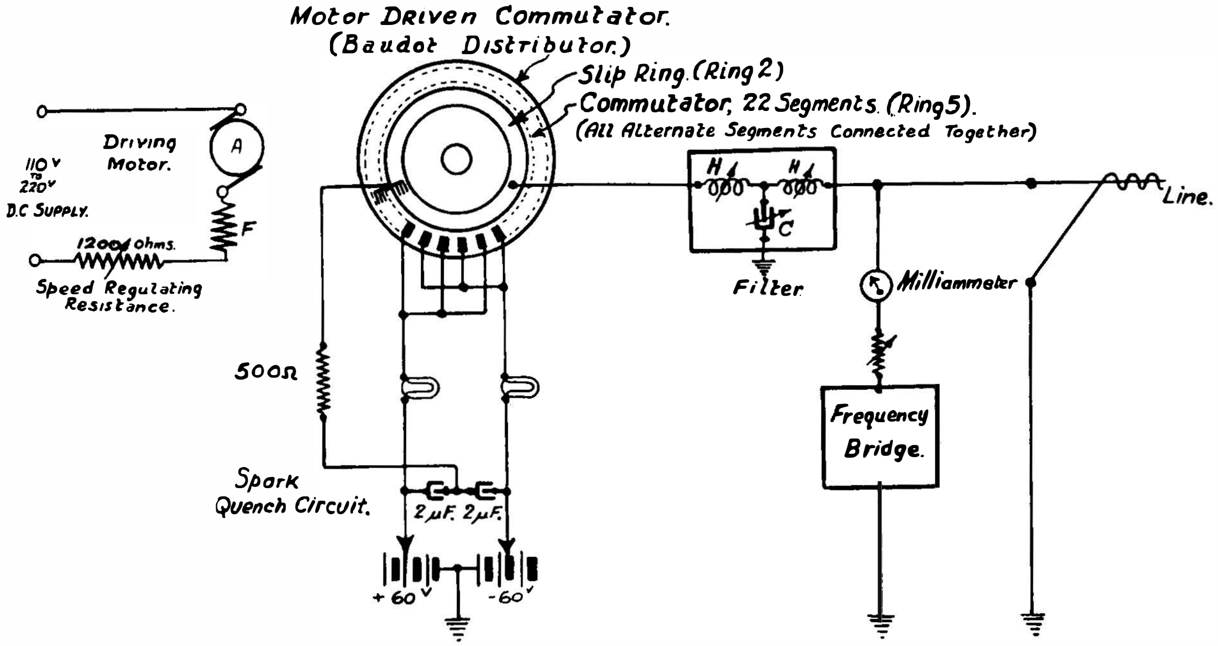


FIG. 1.—CIRCUIT DIAGRAM.

pure sinusoidal shape be required. Above 8 cycles per second a one-section filter only is required. Also above 15 cycles, one value of inductance will suffice for all frequencies up to 100 cycles, but a different capacity value should be used for each frequency band of 10 cycles.

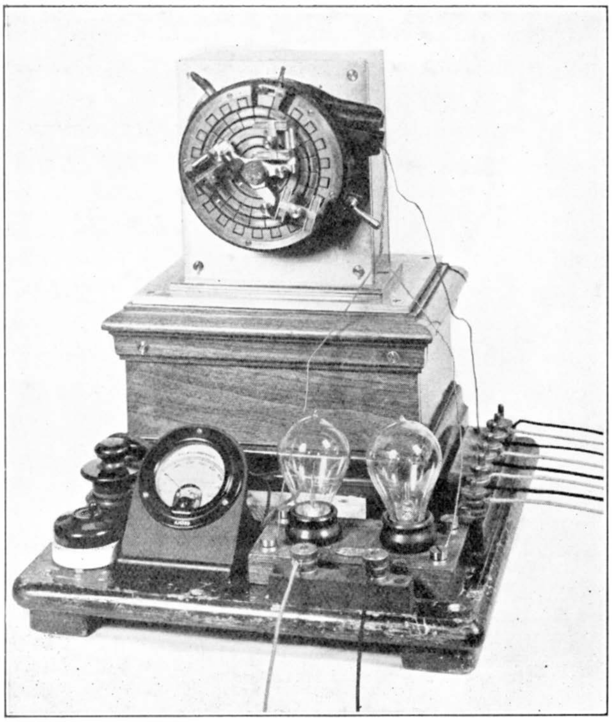


FIG. 2.—BAUDOT DISTRIBUTOR ADAPTED.

Four inductances, each having a value of 6 henries are required to cover the frequency range from 9 to 100 cycles, and four additional coils—two having an inductance of 6 henries each and two of 18 henries each are needed if it be necessary to go below 9 cycles per second. The inductance elements used consisted of coils wound on laminated iron stampings with an air gap in the centre leg and an $\frac{R}{L}$ value of 10.

One condenser only is required for each single section filter from 9 to 100 cycles. Below 9 cycles per second, a condenser of 40 μF capacity is required for each of the two sections of the filter. A type of condenser with tin foil and waxed paper insulation was used.

A three-position telephone key is used for switching in the inductance required for a particular frequency range. Fig. **3** gives the arrangement of plugs and key for the various frequency bands, and also gives the values of the filter elements. From Fig. **3**, it may be seen that the appropriate filter for a particular frequency is connected into the output circuit by

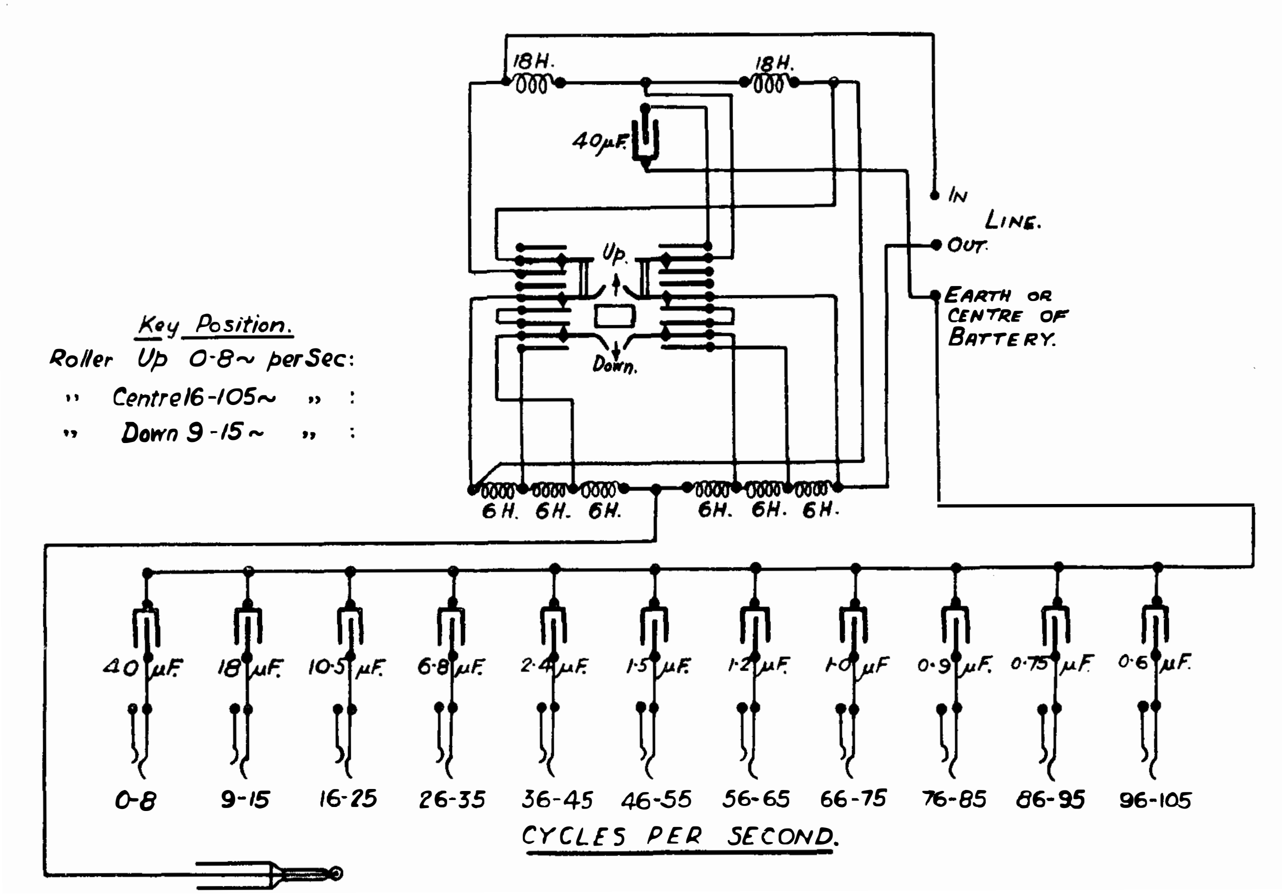


FIG. 3.—SHOWING INDUCTANCES AND CAPACITIES FOR VARIOUS FREQUENCIES.

means of the telephone key and the insertion of a plug into the appropriate condenser jack.

With regard to (3): an adaptation of Maxwell's Commutator Bridge method is convenient for the measurement of low-frequencies of the order of from 4 to 100 cycles per second.

The network is shown diagrammatically in Fig. 4, and is similar to the well-known Wheatstone bridge arrangement, except in respect to the arm BD. The points B and D are connected to the local contacts (indicated by "*x*" and "*y*" in Fig. 4) of a standard "B" relay. Condenser C is a good mica condenser, one terminal of which is connected to the tongue of the relay and the other to contact "*x*" and point D. G is a ballistic galvanometer, and in this case was a Tinsley portable instrument of 512 ohms resistance with a figure of merit of 17 mm. per micro-amp, and a periodic time of two seconds. In practice it was found convenient when measuring the lower frequencies

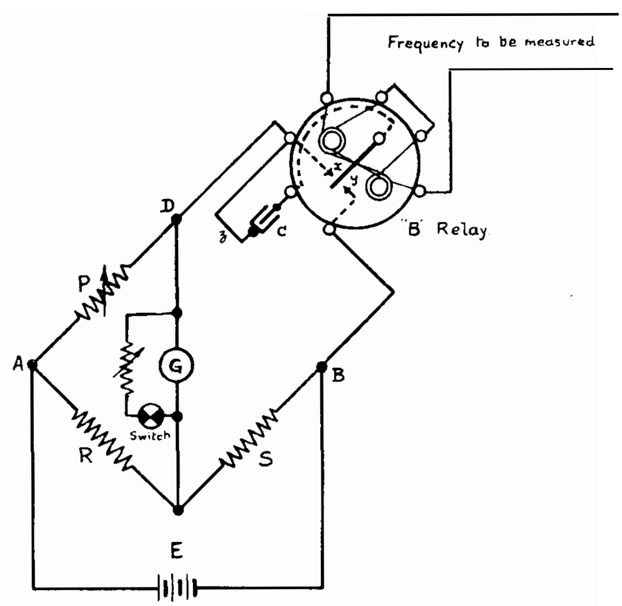


FIG. 4.—BRIDGE CONNECTIONS.

to shunt the galvanometer by a slide wire resistance in order to produce a steady deflection. P is an adjustable resistance (an F rheostat is convenient) and R and S are fixed resistances, and for low-frequency ranges resistance coils in metal cases are suitable. A battery is connected between the points A and B. The frequency supply under test is joined to the line terminals of the " B " relay, as shown in Fig. 4, and the current through the coils is adjusted to a suitable value.

The function of the relay tongue is to allow the condenser C to be charged and discharged at the periodicity of the supply under test. When the tongue is on the contact " *y*," the condenser is charged from the battery. When the tongue is on the contact " *x*," the condenser discharges itself *via* the connection ωx, the contact and tongue, to the other plate of the condenser. During the charging period a transient charging current will flow through the various arms of the bridge, part of which flows through P and part through R and G in series.

During the discharging period no appreciable amount of the transient current will flow through the galvanometer G, because the resistance of the connection ωx is negligibly small compared with the component parts of the bridge.

Due to the vibration of the tongue between the contacts " *x* " and " *y* " there will be a succession of momentary currents through the galvanometer G. In addition to these momentary currents there is a steady current through G during the whole time. If the summation of both the transient and steady currents through the galvanometer G over the whole time be zero the deflection of the galvanometer will be zero, provided the galvanometer is sufficiently ballistic. This condition is dependent upon the value of the condenser C, the periodicity *f*, and the values of the resistances P, R, and S. The relationship between these quantities is given in Maxwell's " Treatise on Electricity and Magnetism," 2nd Edition, Vol. II., pp. 776 and 777. The relationship there given is only an approximation and is not in a convenient form to be used by the engineer. Maxwell based his analysis on his dynamic theory in which currents play the rôle of velocities, and expressions are set up for the kinetic energy, potential energy, and dissipation, etc. The balancing relationship is then deduced from general dynamic equations. A mathematical investigation on modern lines has been made and is given in the Appendix.

It is there shown that,

$$f = \frac{R}{SPC}$$

where

f = frequency of the supply in cycles per second.
C = capacity of the condenser in Farads.
P = resistance of the adjustable arm in ohms.
S and R = fixed resistances in ohms.

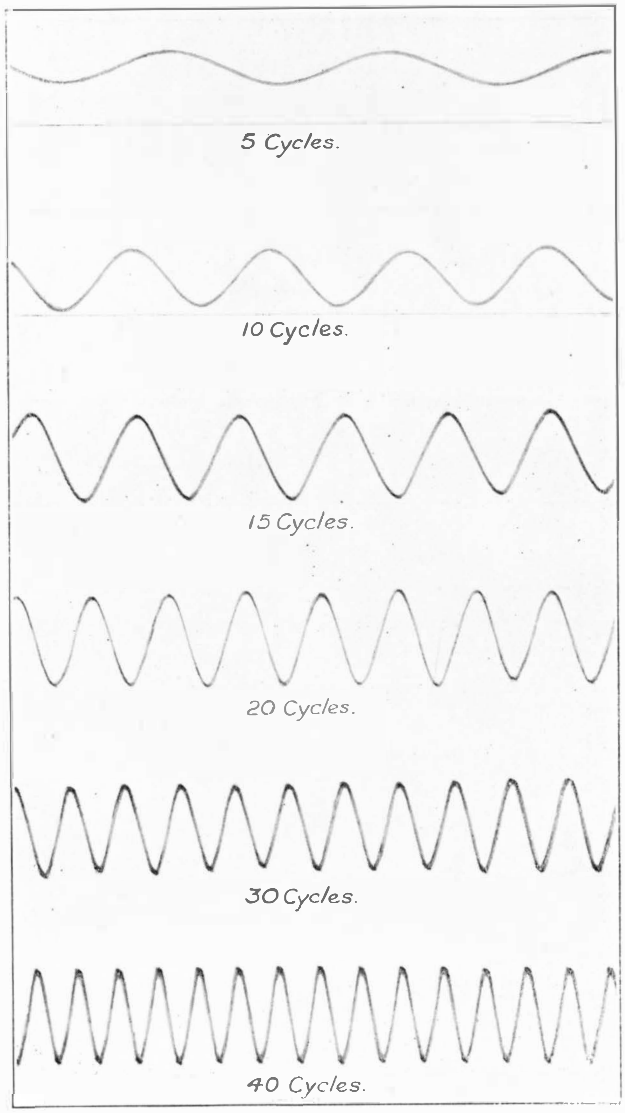


FIG. 5.—OSCILLOGRAMS SHOWING WAVE SHAPES AT DIFFERENT FREQUENCIES.

The ratio $\frac{R}{S}$ should be small, *i.e.*, of the order of $\frac{10}{1,000}$ or $\frac{10}{10,000}$.

R and S were 10 and 1,000 ohms respectively and P a Rheostat F, C was a 1 μF fixed mica condenser and E an accumulator battery of 20 volts. These values gave a convenient range of P from 2,500 ohms to 100 ohms for a frequency range of from 4 to 100 cycles per second. A calibration card for values of P was fixed near the bridge for ready reference.

The arrangement described is simple to manipulate and the adjustments necessary in changing from one frequency to another are rapidly made. A good sinusoidal wave shape is obtained and a Fourier analysis of oscillographic records of wave shapes down to 5 cycles per second, (see Fig. **5**), showed that throughout the range waves were completely free from harmonics of any description. Measurements made on oscillograms showed that a precise frequency regularity was obtained. In conclusion, it should be noted that a very wide range of output voltage and consistency of frequency is available by the arrangement described in this article; advantages which cannot be readily obtained by thermionic valve methods.

APPENDIX.

In order to deduce an expression giving the balancing relationship for the frequency bridge described in this article, first consider the equivalent circuit for the charging period, shown in Fig. **6**.

Let u, v and w denote the cyclic currents in the meshes and I_5 the current through the ballistic galvanometer G.

Also put $Z_1 = P$

$$Z_2 = \frac{1}{pc} \quad \text{where } p = \frac{d}{dt}$$

$$Z_3 = S$$

$$Z_4 = R$$

$Z_5 = G$ the galvanometer resistance

$Z_6 = B$ the battery resistance.

From Kirchhoff's law we have,

$$\left.\begin{array}{lllr} u(Z_3+Z_4+Z_6) & -vZ_3 & -wZ_4 & =E \\ -uZ_3 & +v(Z_2+Z_3+Z_5) & -wZ_5 & =O \\ -uZ_4 & -vZ_5 & +w(Z_1+Z_4+Z_5) & =O \end{array}\right\} \qquad \text{.....................(1)}$$

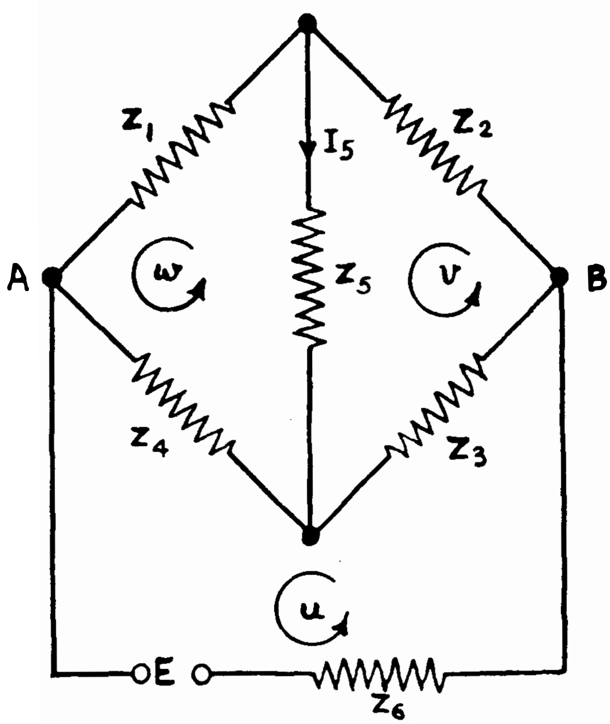


FIG. 6.—BRIDGE NETWORK, CYCLIC CURRENTS AND RESISTANCES.

Substituting $v = w + I_5$ and rearranging we get the determinant

$$I_5 = \frac{\begin{vmatrix} E & -(Z_3+Z_4) & (Z_3+Z_4+Z_6) \\ O & (Z_2+Z_3) & -Z_3 \\ O & (Z_1+Z_4) & -Z_4 \end{vmatrix}}{\begin{vmatrix} -Z_3 & -(Z_3+Z_4) & (Z_3+Z_4+Z_6) \\ (Z_2+Z_3+Z_5) & (Z_2+Z_3) & -Z_3 \\ -Z_5 & (Z_1+Z_4) & -Z_4 \end{vmatrix}}$$

Evaluating the above determinant we get

$$I_5 = \frac{E\left(PS - \frac{R}{pC}\right)}{\frac{1}{pC} \cdot K_1 + K_2 + K_3} \qquad \text{.................(2)}$$

where

$$K_1 = SR + PS + PR + PB + RB + SG + RG + GB$$

$$K_2 = S(PR + PB + RB + PG + GB)$$

$$K_3 = G(PR + PB + RB)$$

Equation (2) may be solved by the Heaviside operational method.

Putting E = 1, we may write.

$$\frac{PS - \frac{R}{pC}}{\frac{1}{pC}\;K_1 + K_2 + K_3}(1) \equiv \frac{1}{Z(p)}_{p=0} + \sum_{K=1}^{K=n} \frac{e^{p_K t}}{p_K \frac{\partial Z(p)}{\partial p}_{p=p_K}} \dots (3)$$

where

(1) = Unit discontinuous function.
$Z(p)$ = Generating impedance function.

Now

$$Z(p) = \frac{K_1 + pCK_2 + pCK_3}{pCPS - R}$$

$$\therefore\; p_1 = -\frac{K_1}{C(K_2 + K_3)}$$

and

$$p_1 \frac{\partial Z(p_1)}{\partial p} = \frac{1}{\left(\frac{PS}{K_2 + K_3} + \frac{R}{K_1}\right)}$$

Hence, for I_5, the current through the galvanometer, we obtain,

$$I_5 = E\left\{\frac{PS}{K_2 + K_3} + \frac{R}{K_1}\right\} exp\left(-\frac{K_1 t}{C(K_2 + K_3)}\right) - \frac{ER}{K_1} \dots\dots\dots\dots (4)$$

where

t = time in seconds, measured from the instant that the relay tongue first touches the contact y.

E = e.m.f. of battery of resistance B.

The equation for I_5 consists of two parts, one of which is the steady current component, and the other the transient current that flows through the galvanometer whilst the condenser is being charged. Now the condenser is charged and discharged f times per second and it may be seen that the condition for a balance is such that,

$$\lim_{t \to \infty} I_5 = O$$

From this condition we obtain,

$$\frac{EfC(K_2 + K_3)}{K_1}\left\{\frac{PS}{K_2 + K_3} + \frac{R}{K_1}\right\} = \frac{ER}{K_1}$$

$$\therefore\; f = \frac{R}{SPC - \frac{CR(K_2 + K_3)}{K_1}} \dots\dots\dots\dots (5)$$

Neglecting the very small battery resistance B, equation (5) may be written,

$$f = \frac{R}{SPC - \frac{CPR\left\{S\left(1 + \frac{G}{R}\right) + G\right\}}{P\left(1 + \frac{S}{R}\right) + S\left(1 + \frac{G}{R}\right) + G}}$$

Using the values given in the article it is found that the quantity

$$\frac{CPR\left\{S\left(1 + \frac{G}{R}\right) + G\right\}}{P\left(1 + \frac{S}{R}\right) + S\left(1 + \frac{G}{R}\right) + G}$$

is negligibly small compared with SPC.

Hence we obtain the balancing relationship

$$f = \frac{R}{SPC} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

where

f = frequency of the supply in cycles per second.

C = capacity of the condenser in Farads.

P = resistance of the adjustable arm in ohms.

S and R = fixed resistances in ohms.

THE EFFECT OF NOISE ON THE ARTICULATION OF A TELEPHONE CIRCUIT.

JOHN COLLARD, Ph.D., B.Sc. (Eng.).

INTRODUCTION.—At the present time the C.C.I.* and the C.M.I.† are considering the question of fixing permissible limits for the noise in telephone circuits. Considerable attention is, therefore, being directed towards the subject of noise measurement. In the past, it has been the custom to rely almost exclusively on subjective methods of measuring noise in which the personal judgment of the operator played a very important part. In this type of measurement different operators may obtain widely differing results for the same line noise, and even the same operator may obtain different results on different occasions. These variations are reduced to small values when trained operators are used, and the whole of the present international telephone network has been built up with the aid of such methods of noise measurement. In many instances, however, trained operators are not available and some objective method of measurement is therefore to be desired. This is particularly the case where noise is due to induction from a neighbouring power system, since a power engineer, on being accused of causing noise in the telephone circuit, not unnaturally desires to ascertain for himself the extent of the trouble. Usually the power engineer has had little experience in the measurement of noise so that the values he obtains may differ considerably from the values claimed by the telephone engineer. These differences may make it difficult for the two engineers to arrive at an amicable agreement, especially if it is a question of deciding whether or not the noise exceeds a permissible limit.

Since the ultimate effect of noise in a telephone circuit is to reduce the articulation obtainable over the circuit, it is generally accepted that the logical criterion of the interfering effect of noise is the reduction in articulation produced in some standard circuit. The choice of a method for the measurement of noise must therefore be based on a detailed knowledge of speech and the effect of noise on articulation.

A general study of articulation and noise is at present being undertaken by the International Telephone and Telegraph Laboratories, Inc., and it may be of interest to give here an outline of some of the results of this study already obtained.

One result of this work has been the development of a technique for the calculation of the articulation for any telephone circuit from a knowledge of the constants of that circuit. This has been used in the present paper to calculate

* *Comité Consultatif International des Communications Téléphoniques à Grande Distance.*

† *Commission Mixte Internationale Pour les Expériences Relatives à la Protection des Lignes de Telecommunication et des Canalisations souterraines.*

certain values of articulation and, since the technique is comparatively new, two examples have been given here to show that good agreement is obtained between actual measured values of articulation and results calculated by means of the technique. Fig. 1 shows measured and

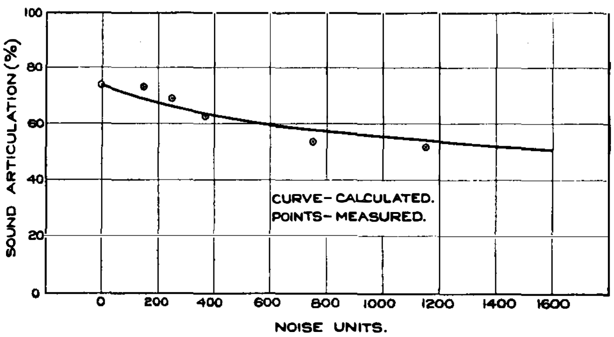


Fig. 1.

calculated values of sound articulation for an ordinary circuit between two subscribers with a 20 db. trunk and with different amounts of line noise entering the apparatus of the listening subscriber. The noise in this case was complex in form, having components spaced at intervals of 120 cycles per second. Fig. 2 shows the percentage reduction in sound articulation obtained in a similar circuit to Fig. 1, except that a 26 db. trunk was used and a pure tone of 1200 cycles per second was used as the noise. In both cases it will be seen that the measured points fall reasonably close to the calculated curves, the differences that occur are, to a large extent, due to the errors inherent in any articulation test.

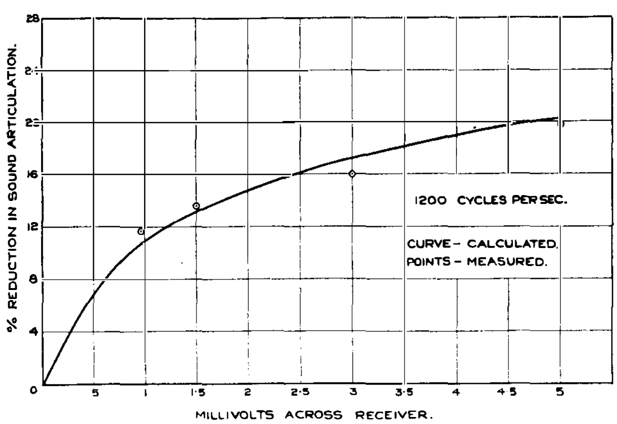


Fig. 2.

In these two examples, sound articulation has been used because the tests happened to have been made in terms of this quantity. The results that follow in this paper, however, have been expressed in terms of the syllable articulation obtained with the Esperanto Logatome lists proposed by the 4th Commission of the C.C.I.

Speech and Noise.—If the frequency spectrum of an elementary speech sound is studied, it will be found that the prominent components occur grouped together in one or more frequency regions or bands. These are called the characteristic bands of speech and it appears that a listener when receiving speech sounds, first subconsciously determines at what frequencies the characteristic bands occur and thence recognises what sounds have been transmitted to him. His ability to understand speech thus depends essentially on the success with which he recognises the individual characteristic bands. When one subscriber is talking to another over a telephone circuit, the characteristic bands produced by the talker are transformed into electrical energy and transmitted to the other end of the circuit where they are transformed again into acoustical energy and reach the listener's ear. In their passage from the talker to the listener the characteristic bands suffer a certain amount of distortion, due to the constants of the circuit. Each characteristic band reaching the listener's ear causes his basilar membrane to vibrate, the position of maximum vibration depending on the frequency of the band. When noise is present in the circuit it is transformed into acoustical energy by the receiver and sets into vibration those portions of the basilar membrane corresponding to the frequencies present in the noise. If that part of the basilar membrane corresponding to a given characteristic band is already being caused to vibrate at considerable amplitude by noise, then, when the characteristic band reaches the listener's ear, the additional vibration due to it may not be perceived. In other words, this particular characteristic band will play no part in assisting the listener to distinguish one sound from another, since it has been masked by the noise. Since the articulation obtainable over a given telephone circuit is directly dependent on the number of characteristic bands that the listener is able to recognise successfully, it follows that the masking of certain characteristic bands by noise will result in a reduction of articulation.

Figs. **3**, **4** and **5** have been prepared to illustrate this point more fully. Fig. **3** shows the distribution, both as regards frequency and magnitude, of the characteristic bands reaching a listener after transmission over an ordinary telephone circuit. Each dot does not represent a characteristic band, but the number of dots in any given area is proportional to the frequency of occurrence of the characteristic bands in that region. The magnitude of the bands has been expressed in sensation units, *i.e.*, the number of decibels that the band is above threshold. The dots are most closely clustered together in the region from 400 to 800 cycles per second, so that

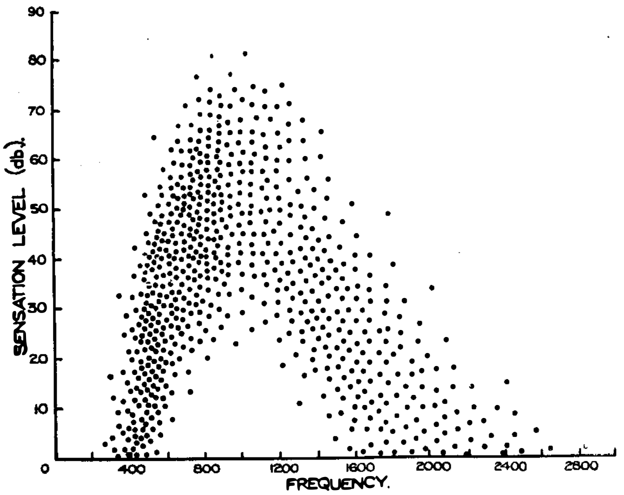


FIG. **3**.

this frequency range is very important from the articulation point of view. At the higher and lower frequencies, not only are the dots less closely spaced, but there are very few above threshold. These frequency ranges therefore play a relatively small part in assisting articulation over the normal telephone circuit. In the range 600 to 1400 cycles per second all the dots are well above threshold owing to the fact that at these frequencies the combined efficiency of the transmitter, circuit, receiver and ear is at a maximum.

Fig. **4** shows the effect of an 800-cycle tone when introduced into the circuit. The sensation level of the tone has been taken as 60 db. The shaded area indicates the area over which the

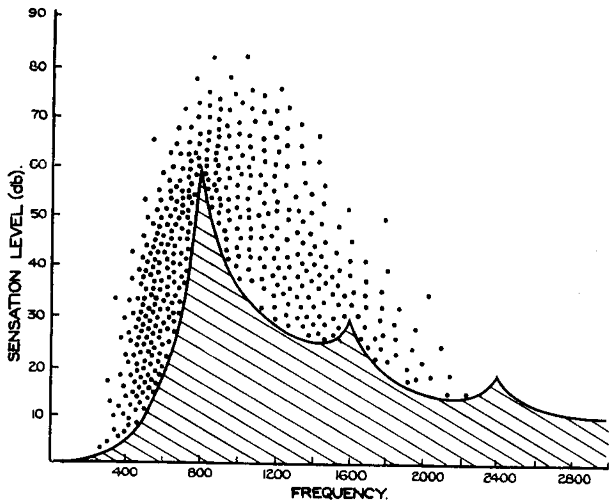


FIG. **4**.

masking occurs, *i.e.*, any characteristic band having a frequency and level such that it falls within the shaded area will be inaudible owing to the presence of the noise in the circuit. The peaks in the masking curve at 1600 and 2400 cycles per second are due, of course, to harmonics introduced in the listener's ear by asymmetric distortion. An approximate idea of the percentage reduction in the number of characteristic bands reaching the listener due to the presence of the noise can be obtained by subtracting the number of dots shown in Fig. **4** from the number shown in Fig. **3** and then dividing this by the number of dots in Fig. **3** and multiplying by 100. In the case shown here the reduction is about 33% and, since this corresponds to a reduction in logatome articulation of about 30%, this amount of noise in an actual case would obviously be quite prohibitive.

Fig. **5** has been prepared to show what occurs when a number of single frequency tones are present together in the circuit. Three tones, 400, 1000 and 2000 cycles per second, are shown. In this case each tone produces its own masking curve and, if the magnitude of the tones are small as they would be in an actual case, there is practically no overlapping of the individual curves. The total number of characteristic bands masked out by the three tones together is therefore equal to the sum of the numbers masked out by the individual tones when present separately in the circuit. We can say, therefore, that the effect on articulation of a number

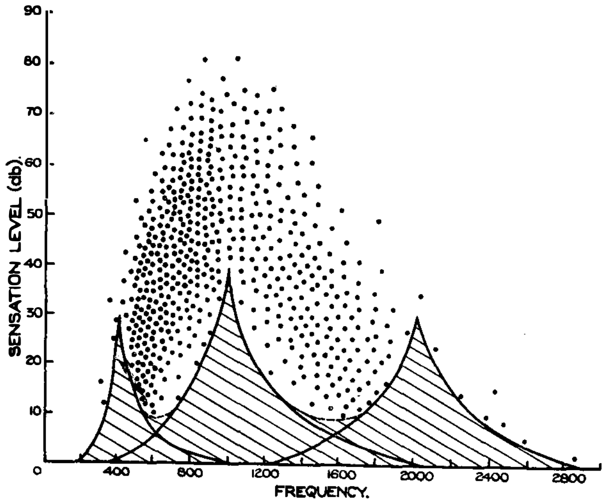


FIG. 5.

of tones when present together in a telephone circuit is equal to the direct sum of the effects produced by each tone when alone in the circuit.

The Addition of Noise.—This question of the addition of the different components in a complex noise from the point of view of articulation reduction is important, and it is therefore proposed to consider it in this section in rather more detail.

Consider, first of all, the effect of introducing a single frequency tone, say 800 cycles per second, into a telephone circuit, and suppose that this tone is gradually increased in amplitude from a very small value. At first, when the tone is small, the masking curve produced by it will not reach high enough up to mask any of the characteristic bands. As it is increased, however, the masking curve will just begin to mask some of the lower bands, but, since the bands in this region do not occur very frequently, the reduction in articulation will be small. As the tone is still further increased, the masking curve will begin to reach up into the area where the characteristic bands occur more frequently and the articulation reduction will therefore increase more rapidly than at first. Finally, for very large amplitudes, the masking curve will cover characteristic bands over a very large frequency range, resulting in a very rapid deterioration of the articulation. In order to show this point with greater clearness, two curves have been calculated to show the effect of introducing single frequency tones into an ordinary telephone circuit. These curves are given in Fig. **6**, one of them being for 400 cycles per second and the other for 1200 cycles per second. The circuit for which this calculation was made was one consisting of two sets of ordinary subscribers' apparatus with a connecting trunk of 30 db. These curves have been calculated over a range of articulation reduction extending up to 5%. Since this value is about the maximum that can be tolerated, we are not very much interested in values above it. It will be seen from these curves that the relation between articulation reduction and the voltage of the disturbing tone is not linear, although the curves do not depart very much from a straight line. The curve of Fig. **2** shows that over a wider range of articulation reduction the departure from a straight line is much greater.

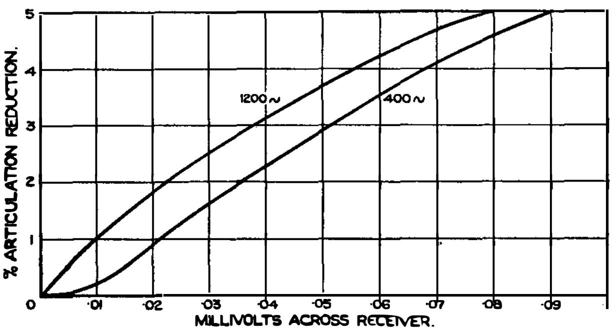


FIG. **6**.

In order to study the additive effect of single frequency tones a number of examples have been worked out in which the articulation reduction has been calculated for the circuit mentioned above, first with different single frequency tones present in the circuit alone and then with a number of these present together. The results of these calculations are given below in the following tables. Values of articulation reduction are given, first of all for each of the components when present alone in the circuit, and then for all the components present together in the circuit. For comparison with this last value, two other values are given. The first of these is obtained by adding together directly the articulation reductions due to the individual component when present alone in the circuit. The second value is obtained by taking the square root of the sum of the squares of these individual values.

TABLE I.

Frequency.	Sensation Level.	Percentage Articulation Reduction. Actual value for individual components when present separately.	Actual value for all components when present together.	Direct sum of values for individual components.	Square root of sum of squares of values for individual components.
400 800	20 40	5.6 5.2	10.0	10.8	7.5
800 1000	40 40	5.2 3.3	8.2	8.5	6.1
800 1000 1200	30 30 30	1.0 1.0 1.9	4.0	3.9	2.3
800 900 1000 1100 1200	30 30 30 30 30	1.0 0.9 1.0 1.4 1.9	6.6	6.2	2.9

The above examples have been chosen so that they cover a range of total articulation reduction from 4 to 10%. It will be seen from these examples that, even when the different frequencies are spaced only 100 cycles apart, the resultant articulation reduction is practically equal to the direct sum of the individual articulation reductions. The square root of the sum of the squares is in every case too small, the error varying from about 25 to 55%. As a final check on this point, an analysis of typical line noise which actually occurred in practice has been taken and the articulation reductions for this have been worked out. The values are given in the following table and confirm the previous statements :—

TABLE II.

Frequency.	Relative Amplitude.	Percentage Articulation Reduction. Actual value for individual components when present separately.	Actual value for all components when present together.	Direct sum of values for individual components.	Square root of sum of squares of values for individual components.
320 440 720 920 1030	11 110 26 13 9	0.2 2.6 6.8 1.6 2.0	13.0	13.2	7.8

Conclusions.—The most interesting result of the work described here is the fact that when noise consists of a number of components at different frequencies, the total interfering effect of the noise is proportional to the direct sum of the effects produced by each component separately. This fact does not appear to have been generally realised before and it has generally been assumed in the past that the square root of the sum of the squares should be taken. In the Telephone Interference Factor Meter of H.S. Osborn, for example, a thermocouple is used as the integrating device.

This direct additive effect applies to most types of line noise such as are usually encountered in telephone circuits subject to induction from neighbouring power lines. There are, however, a few particular cases where this direct addition is not altogether correct. If the frequencies of the different components are sufficiently close together and their amplitudes are sufficiently great, then it is possible for the masking curves of the components to overlap to some extent and where this occurs the direct addition does not hold.

If the masking curves overlap to a large extent, the resultant interfering effect is probably more nearly the root square value than the direct sum. If the overlapping is only partial, the true resultant is somewhere in between the root square value and the direct sum.

An example where the different components are close together is the case of babble which is produced in a telephone circuit by the combined effect of cross-talk from a large number of other circuits. The cross-talk from any one circuit will probably consist of components which are sufficiently widely spaced to give the direct additive effect. The components from different circuits, however, are very likely to occur close together. A further case where the direct addition may not hold exactly is room noise due to traffic in large towns or due to a number of typewriters being operated simultaneously. In such cases the best result would probably be obtained by dividing the whole frequency range into a number of narrow bands, taking for each band the root square value and then adding directly the values for the different bands.

This suggests that a suitable instrument for the measurement of noise might consist of a series of band-pass filters to which a thermocouple or valve voltmeter could be switched in turn. Readings would then be taken for each filter and added together directly. If the components of any complex noise were close enough together to fall within the range of a given filter they would be added by the measuring device as the root square value, whereas if components were widely enough spaced so that each came in the range of a different filter they would be added directly. If some components were close together and some widely spaced, then the proper form of addition for each would be obtained by the use of such an instrument. The practical realisation of such a device would appear to be extremely difficult, however, and possibly a simple form of instrument embodying a weighting filter and a square law measuring device could be used, the filter being so arranged as to weight each frequency by a factor rather greater than its actual interfering effect. Such a device, however, would give values of noise which were too high in the case of single frequencies and rather too low if there were a large number of components. The factors could possibly be arranged, however, so that they gave about the right value for most ordinary cases.

The relation between the amplitude of a single frequency tone and the articulation reduction it produces is such that a curve giving the relative interfering effect of different single frequency tones will be different for different amplitudes of the tones. Any network used in an instrument for the objective measurement of noise for weighting the different frequency components according to their interfering effect can obviously only operate according to one fixed curve. Hence the instrument will give indications which are incorrect for all amplitudes of tone except one. Fortunately, as shown here, the curves of articulation reduction against amplitude do not depart very much from a straight line for small values of tone such as are encountered in practice. Errors of this nature will therefore be small.

In this connection it is interesting to notice that there are two ways of defining the relative interfering effect of noise. The first is to take the articulation reduction produced by a fixed voltage. The second is to take the voltage required to produce a fixed articulation reduction. These two definitions do not give exactly the same curves of relative interference for the reasons given in the previous paragraph. In the past it has been the custom to take the first definition, although actually it would appear better to adopt the second one. We are interested chiefly in noise which falls somewhere near the permissible limit; in the case of noise very much less or very much more than this limit we do not require to know its value so accurately. The best definition to take would seem to be the voltage required to produce the maximum permissible reduction in articulation, in whatever circuit is chosen as standard.

The diagram of Fig. **3** was constructed for a particular type of circuit and applies only to that type. For any other type of circuit a different distribution of the dots would be obtained. Since the interfering effect of any frequency is proportional to the number of dots covered by its masking curve, it follows that the same frequency will produce different interfering effects in different circuits. A curve of relative interfering effect obtained for an ordinary telephone circuit would not, therefore, apply to a high quality broadcasting circuit; nor could the curve for the high quality circuit be used for the ordinary telephone circuit. It may be necessary in practice to produce two curves of relative interfering effect, one for an ordinary circuit and another for a high quality circuit.

The explanation given here of the way in which noise in a telephone circuit produces a reduction in articulation leads to rather an interesting conclusion. It is usually assumed that the effect of line noise is to annoy the listener in some way and hence to render him less able to concentrate on what is being said to him. In fact, the expression, the annoying effect of noise, is often used. Actually, however, as will be clear from the description given in this paper, the effect of noise is merely to prevent some of the characteristic bands from being perceived by the listener. He is, therefore, left with fewer clues from which to distinguish one speech sound from another, and consequently obtains a smaller value of articulation. Any annoyance that the listener may experience is thus the result of the articulation reduction rather than the cause of it. That this is so is shown by the close agreement between the calculated and measured values of articulation reduction due to noise, since the calculated values are based only on the ordinary masking curves and include no annoyance factor.

A NOVEL DEVELOPMENT OF CONFERENCE FACILITIES.

W. R. Beach, Wh. Sch., A.C.G.I., D.I.C.

APART from making long distance telephony a comparatively simple matter, the introduction of telephone repeaters has widened the scope of omnibus circuit facilities and more particularly, conference facilities.

In this connection, Messrs. Paul E. Derrick, Advertising Agents on behalf of Messrs. John Walker & Sons, Ltd., applied for suitable telephone facilities to enable them to give in several towns simultaneously with the actual playing of the Test Matches, what, in effect, is a visual running commentary. The progress of the Match was intended to be indicated on a " Score Recording Board " which would show not only the state of the play, but also the names of the bowler, batsmen, fielder and a ball in motion, following as nearly as possible the movements of the actual game.

In order that the scheme should be successful it was considered essential to provide high grade transmission circuits in balanced cables and as all the towns where Score Recording Boards were proposed to be placed could be reached by means of the main cable network, the application was accepted and the facilities provided in the following manner :—

At the outset, the main trunk circuits and local ends to the Score Recording Boards and the cricket grounds, indicated in Fig. 1 (with the exception of the circuits to Portsmouth and Margate, which were provided later) were set up and omnibus repeaters were made available at the Derby, Manchester and London Repeater Stations. In the case of a particular Test Match, it was then only necessary to select those circuits required and to make any special apparatus changes to meet the requirements for the individual Match.

The first Test Match was played at Nottingham, and Score Recording Boards were displayed at Nottingham, Manchester and Blackpool. Originally, it was intended to include Leeds and not Blackpool, but, with only a few days' notice, Blackpool was substituted, and on all subsequent occasions modified requirements

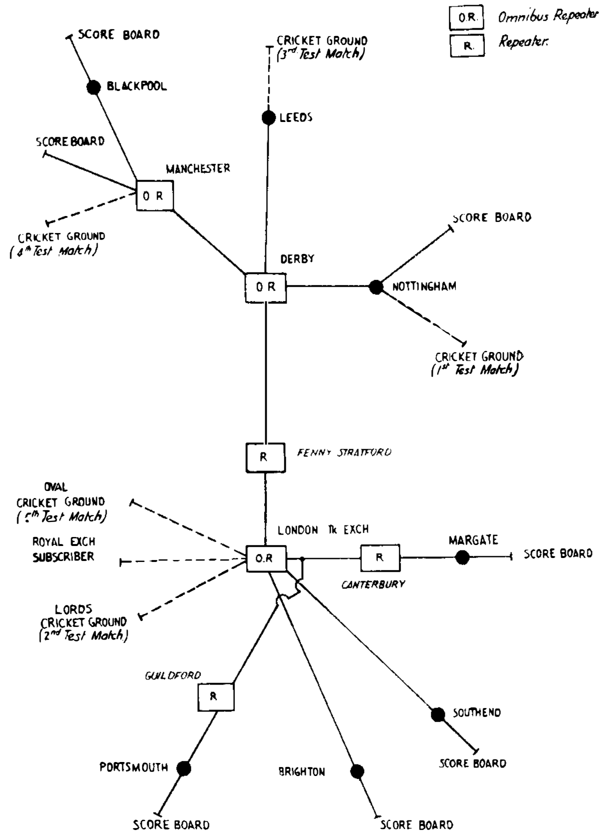


Fig. 1.—General Circuit Arrangements.

at short notice had to be met, owing to the difficulties of the applicants in regard to sites and permissions. The first trial was so successful that a crowd of over 15,000 spectators congregated at the Manchester board on the last day of the Match, in consequence of which, objection was taken locally and it was not possible to arrange an alternative site in time for the second Match.

The second Test Match was played at Lord's Cricket Ground, and Score Recording Boards were displayed at Southend and Brighton. This necessitated the use of the omnibus repeater at the London Repeater Station.

The third Test Match was played at Leeds Cricket Ground and Score Recording Boards were displayed at Manchester, Blackpool, Nottingham and Brighton. Manchester was once again included, but on this occasion the Board was displayed in the City Hall, Deansgate. Arrangements in this case were similar to those made in connection with the first Test Match, with the exception that a fourth Score Recording Board was available and was displayed at Brighton. On this occasion a fixed timed telephone call was given to Messrs. John Walker & Sons, Ltd. A normal call was passed from an extension of their Private Branch Exchange, connected to Royal Exchange, thence to the London Trunk Exchange, where the local junction was intercepted and connected to the main repeater network by way of the omnibus repeater. In this way, instructions were issued to their operators at the several Score Recording Boards, direct from Messrs. John Walker's offices at London. This was the first occasion on which the Department had operated two omnibus repeaters in series with one system of circuits.

The fourth Test Match was played at Manchester, and Score Recording Boards were displayed at Manchester, Blackpool, Nottingham and Brighton. Although the Score Recording Boards were displayed in the same towns as for the third Match, the Leeds circuit was no longer required and an additional local end to the Cricket Ground at Manchester necessitated the use of the omnibus repeater at Manchester Repeater Station. The circuit arrangements therefore again called for a system employing two omnibus repeaters.

The fifth Test Match was played at the Oval, and boards were displayed at Brighton, Southend, Margate and Southsea. The omnibus repeater at London was used in this case and the Margate and Southsea circuits were teed together at the London Repeater Station.

The following details indicate briefly the construction of the Board, and the method of operating and recording the progress of the game. Fig. **2** is a photograph of the Score Recording Board at Brighton. Fig. **3** is a schematic diagram showing the mechanical arrangement of the Board. The Board is mechanically operated from information received telephonically, the operators having been previously specially trained in the work.

The batsmen are represented by two square coloured metal plates, one red and the other

FIG. 2.—SCORE BOARD AT BRIGHTON.

yellow. Projections from the backs of the plates pass through narrow parallel grooves in the "pitch," the projection on one plate being connected to the driving side and on the other plate to the following side of an endless bicycle chain, running on two chain wheels and rotated by hand. The respective batsmen are identified by corresponding coloured discs and pointers at the

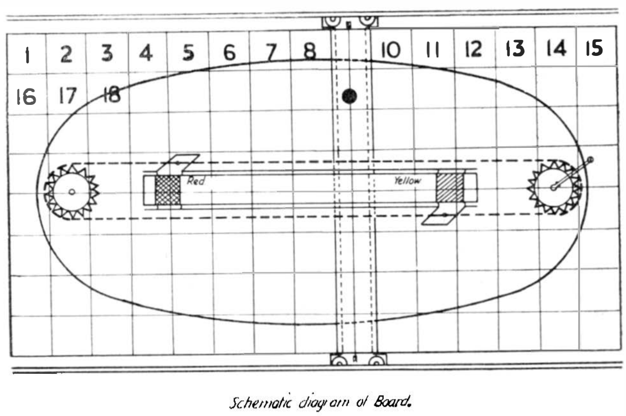


FIG. 3.

bottom of the Board against their names and individual scores.

The ball is suspended on an endless wire passing through top and bottom guides which are fixed to a vertical lath located out of sight at the back of the panel representing the field of play. The endless wire is connected to a sliding handle on the lath. As the operator slides the handle up the lath, or down, the ball moves correspondingly, so that it is always at the same position on the front of the field of play as the handle is at the back. The lath is mounted on horizontal runner bars so that the whole ball control mechanism can move horizontally across the field of play. All working parts move freely on ball bearings so that the combination of vertical and horizontal ball movements will give diagonal or curved movements. The back of the field of play is divided into numbered squares. A telephonist at the Cricket Ground states the square to which the ball should be moved and all the operator has to do is to draw his handle in a direct line from the wicket to that square and the ball in front moves correspondingly. When a wicket fell, a flap with the word " out " in red letters dropped down and obscured the individual score of the batsman. At the same time, the way in which the wicket fell was indicated by replacing the blank panel against the particular cricketer's name by a panel marked " bowled," " caught," etc., the ball being left either at the fallen wicket or in the field at the position at which the catch was made. The bowler and the fielder were indicated by red pointers which were made to slide up and down on pulleys by the side of the players' names. The names of the batsmen who had completed their innings were shown in red with the scores opposite their names. The names of the players who had yet to bat were shown in black. A blank panel at the top right hand side of the board was used to indicate such information as " luncheon," " tea " and " rain stops play."

The operators were very proficient in working the mechanical devices and the play on the board was seldom more than one over behind the play on the cricket field.

The spectators applauded at the appropriate times and appeared to be as interested as they would be at the actual game. At a particularly brilliant piece of play or the batsman completing his 50 or 100 runs, " Johnnie Walker " on the top of the board raised his hat ! A special score recording card was used for each over to ensure correct operation of the Board. A copy of a typical card is shown in Fig. 4.

DATE............ Nº. 197.. ...

BALL	BOWLER END A....	BATSMAN END......	BYE WIDE NO BALL	REMARKS (WICKETS)	RUNS BAT	FIELDER	SQU	RET'D TO	TOTAL BAT	TOTAL EX	SIDE TOTAL
1	WALL	HOBBS			1	BRADMAN	13		13		59
2		SUTCLIFFE		BOUNDARY	4		20		45		63
3		•			–	KIPPAX	47		–		–
4		•		BOUNDARY	4		6		49		67
5		•			–	FAIRFAX	43		–		–
6		•			1	BRADMAN	14		50		68

SIDE TOTAL	WICKETS DOWN	RED BAT END	YELLOW BAT. END	TOTAL EXTRAS
68	–	50	13	5

Typical Recording Card.

FIG. 4.

Acknowledgements are due to Messrs. Paul E. Derrick, for permission to reproduce the photograph of the Score Recording Board and the Recording Card, and to The Sign Construction Co., Ltd., manufacturers of the Score Recording Board and the Sectional Engineer, Brighton South, who kindly supplied the information relative to the mechanical operations of the Board.

FIG. 5.—CROWD AT BRIGHTON WATCHING SCORE BOARD.

THE CENTRALISED TROUBLE SERVICE OF THE MUNICIPAL TELEPHONE SERVICE AT AMSTERDAM.

Dr. Ch. E. A. Maitland.

I.

THERE are several methods for the organization of the trouble service in a large telephone system with many exchanges.

(*a*) *Complete decentralisation.* Each exchange has its own trouble service. The subscribers have to lodge their complaints at the exchange to which their number is connected. Testing, administration and statistics are also concentrated at the Wire Chief's desk. The Troubleman is despatched from and reports to this desk. Each exchange has its own staff of Troublemen and works entirely independently of the others.

(*b*) *Partial centralisation.* The filing of the complaints, the administration and the statistics are centralised, and also the despatching of Troublemen. Testing and controlling are done at the Wire Chief's desk.

(*c*) *Complete centralisation.* All functions are centralised. The investigation and testing of reported faults is done on special test boards concentrated at one point for the whole system.

Until 1927 method (*b*) was followed at Amsterdam. Towards the end of that year system (*c*) was introduced and this system will be described below.

II.

First a couple of definitions. What is a trouble? What is the object of a trouble service? A trouble may be defined as a fault in the plant which is reported by a subscriber. There is also a group of faults found by the staff which may not have been reported by a subscriber. Some of them may have been observed by a subscriber, but when the latter does not report them these faults cannot be distinguished from the others and statistically cannot be recorded as troubles.

A distinction has to be drawn between the trouble service and the repair service. The purpose of the former is to clear the trouble as soon as possible. The object of the latter is to prevent complaints by detecting faults before they cause difficulties in the service. Both services are complementary to each other, not only technically but also economically.

When rapidity in clearing troubles is regarded as of prime importance economical use of the trouble staff is not possible. The number of complaints fluctuates widely and the staff being determined by the peak load would be idle during slack periods. Therefore, in order that no working time may be lost it is essential that the time for clearing troubles must be made a function of the number of complaints, or a buffer service must be organised to utilise the surplus of working time by decreasing trouble frequency. The maintenance and repair service can be organised to balance the fluctuations of the trouble service; it prevents faults and therefore complaints; it improves service and raises the reputation of the telephone system, and this is one of its most valuable assets.

In the exchanges where a fault may have considerable consequences and would be able to cause a series of complaints, it is obvious that maintenance takes first place. Prevention of faults is of the first importance and 80% to 90% of the faults will be found by routine testing.

The same methods cannot be applied in the outside plant, but although trouble service is of the first importance, prevention need not altogether be neglected.

In a modern telephone system equipped with well maintained automatic exchanges, the number of exchange troubles is negligible as compared with the normal amount of trouble in the external plant. Therefore, further improvement of the service must be sought in the reliable and speedy trouble service supported by a suitable maintenance and repair service. For this reason the new centralised trouble service was designed.

The functions of a complete trouble service may be described as follows:—

(1) Reception of complaints.

(2) Investigation of the fault, diagnosis of the case.

(3) Orders to trouble staff.

(4) Control of the work of the Troublemen and ensuring that the reported trouble is properly cleared.

(5) Statistics.

  (*a*) Per line.

  (*b*) Total, differentiated with respect to the description of fault.

  (*c*) Per man to judge of the efficiency of his work.

  (*d*) Statistics referring to the quality of the trouble service as a whole.

(6) Administration based on the results, orders for repair, maintenance or traffic investigation.

(7) General work to investigate the quality of service and regular preventive overhaul of the plant.

The organisation under the management of the Chief of the Trouble Service consists of the following parts:—

  (*a*) Complaint receiving desk.

  (*b*) Control Board.

  (*c*) Statistical report desk.

  (*d*) Administration.

These parts of the organization will be described below, showing how all the various functions are fulfilled.

All equipment has been manufactured and installed by Messrs. Siemens & Halske, Berlin.

III.—*The Complaints Receiving Desk.*

There is one desk for each unit of 10,000 lines. Fig. 1 shows this Board. It has two positions

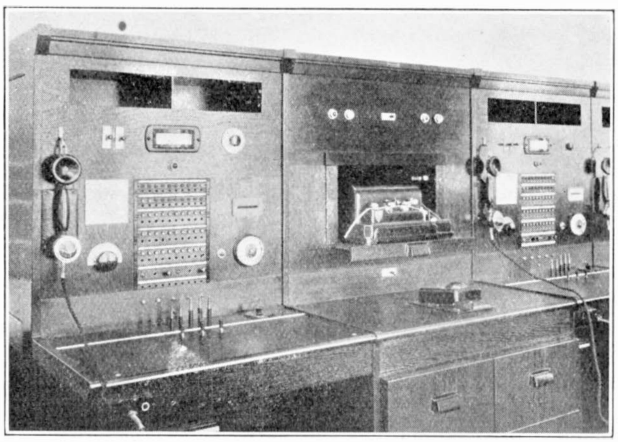


FIG. 1.—COMPLAINTS RECEIVING DESK.

and three panels, the middle one containing a time-recording apparatus and an impulse register serving both sides. The side panels each take 20 lamps and jacks for incoming complaint calls. They are multipled to all boards and also on the control board.

The lamps associated with the 10,000 line unit to which the board belongs are white, all others are red. Normally only the white lamps are in operation, the red ones being connected to enable team work to be carried out during the peak hours.

Subscribers are requested to lodge complaints to the desk which attends to the number concerned in the complaint, but when they do not the call is extended on an order wire to its proper position where it is picked up in the multiple.

The installation is designed to permit of such concentration as may be necessary and the trouble control office may be attended to by as many officers as required. During night time the whole system is operated by one man sitting at the control board. Generally, however, complaints are dealt with on the desk to which the number belongs. At this desk each number has a card showing the name and address of the subscribers, the cable pair, the type of apparatus, extra contacts, switches, extension bells, etc. On this card is entered the date, time, character of complaint, time of clearing and nature of the fault. All those items are designated by a simple code so that they are filed according to a universal system. The cards may never be removed from their places unless they are wanted by the administration for alteration. In this event a dummy takes the place of the card removed, stating where the card has been taken to. The Trouble Officer has therefore all the cards at his disposal always. As soon as a complaint comes in he takes the card to verify the communications of the subscriber and at a glance has a brief summary of the history of the line, this being of great assistance in enabling him to judge of the character of the complaint. Investigation and testing are put in hand at once and this is one of the greatest advantages of the system.

The officer plugs up a test jack, of which there are two in each unit of 10,000. These test jacks are also multipled on all the boards for concentration. The test lines lead to test selectors, the contacts of which are connected with a special line switch in each 100's group. This final selector is also used in regular service, but is provided with a special device for testing (one extra relay). It is always connected to the 10th contact of the 3rd group selector, those being seldom busy.

The officer dials the subscriber's number and then he tests the outside and inside lines by means of a 16-point rotating switch, each position of which corresponds with a special testing device as shown in Table I.

TABLE I.

CONNECTIONS OF THE 16 POINT ROTATING SWITCH.

0	Zero.
1	Dialling the number.
2	Measuring Insulation Resistance A wire to earth.
3	,, ,, ,, B ,, ,, ,,
4	,, ,, ,, A to B wire.
5	Negative pole to the A wire.
6	,, ,, ,, ,, B ,,
7	Postive ,, ,, ,, A ,,
8	,, ,, ,, ,, B ,,
9	Testing of Subscriber's Condensers, charging.
10	,, ,, ,, ,, , discharging.
11	Speaking, calling, howler and dial test.
12	Same as 11 but A and B wire reversed.
13	Speaking through artificial cable, 2.5 neper.
14	Measuring resistance of the loop.
15	Testing Exchange side.
16	Same as 15 but A and B wire reversed.

After the investigation, the report is made on a slip of paper with all necessary particulars as to type of line, apparatus, cable pair, etc. This ticket is stamped with a time-recording apparatus and put on a carrier inside a row of boards on which it is transported to the Control Board. The card goes home, but is drawn out a little to the left so that one can see at once which cards belong to a number from which a complaint is current.

After the clearing of the fault the ticket comes back, the report is booked and the card restored to its place. This work is done by the same officers in slack periods.

On the cards all sorts of indices can be placed to mark special conditions, *e.g.*, line blocked, subscriber not in, construction work in progress on the line, line being overhauled by repair service or controlled by the Traffic office. On each Board there is also a test line to the M.D.F. which is multipled on all Boards.

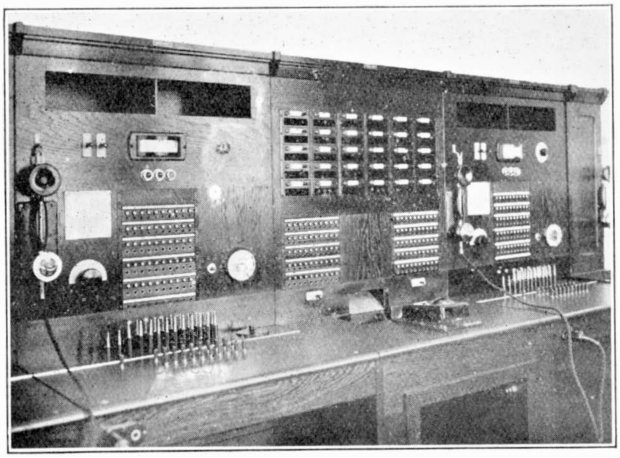


FIG. 2.—THE CONTROL BOARD.

IV.—*The Control Board.* (Fig. 2).

The officer on this board is responsible for sending out, directing and controlling the Troublemen. There are two boards, each with two positions. In the side panels there are 30 test jacks with busy lamps giving access to the test selectors. This is the multiple of the test lines on the receiving boards. Above, there are 20 lines for calls from the Troublemen. Below, there are 10 order wires for internal communications. On the key shelf there are two plugs and keys for answering and calling and 20 plugs and keys for direct test lines to the M.D.F. There are also a dial, a testing switch in accordance with Table I., an ohmmeter and keys for a howler and control lamps.

In the centre panel are situated the same calling lamps and jacks as appear on the receiving board, for use during concentration periods. There are also 20 test lines to the M.D.F., each equipped with an answering jack, a test jack and two calling lamps, one for incoming and the other for outgoing calls during testing. On the centre panel there is also mounted the output of the carrier, where tickets arrive, and in the lower part the impulse register stands on a slide. On the top of the centre panel there are a number of pigeon holes, each with a busy lamp and push button. The tickets for each of the Troublemen are stored in this compartment.

The working scheme is as follows:—

As each ticket arrives it is deposited in the pigeon hole of the Troublemen nearest to the place where the faulty number is located, regard being paid to efficient distribution of work. As soon as each particular case comes to its turn, the address is given to the Troublemen who reports the clearing of the previous case and a test plug is inserted into a jack of a control test line to the M.D.F. where the number is jumpered. Here the test line is plugged to the required subscriber's line. This operation does not affect the subscriber's line, so that a subscriber is not disturbed if his line is in use. When the line is no longer busy, a cut-off key is pressed which disconnects the cable from the exchange line. The cable and exchange sides of the line are transferred to a calling lamp on the control board.

Calls from outside are answered on the control board and the calling party is informed that the line he asks for is faulty but is about to be repaired. On the cable side the Troubleman on duty reports as soon as he is on the spot, using a simple test box when the subscriber's apparatus is unfit for use. If the faulty line is still fit for use, the Troubleman rings up the Trouble office in the ordinary way, but on a number located on the control desk and only then is the cut-off key pushed, which disconnects the line.

The man at the control board first of all verifies the diagnosis of the receiving desk. He directs the Troubleman in his work, which is of great importance when the dial proves to be faulty or when poor transmission is reported. In the former case the impulse register is used and in the latter case an artificial standard cable with an attenuation of 2.5 neper. The most important task of the officer at the control board is to verify that the reported fault has really been cleared. The Troubleman is not discharged until this has been verified. The result is entered on the ticket which, after having been stamped by the clock, is sent to the Statistics Department, this being a desk placed at right angles to the control board. The effect of this method of controlling the Troubleman was evident from the decrease of repeat faults and from the decrease of the percentage of unfounded complaints from 50% to 30%.

The controlling officer has also a convenient opportunity to verify the condition of the whole of the subscriber's installation. Faults located in the exchange or in the cable plant are dealt with somewhat differently. It has been found that both those categories of faults only amount to about 20% of the total. Both kinds of troubles are reported to the exchange and to the cable repair service respectively. For them also, tickets are made out which are expedited to the Statistics Department where they are set aside until the clearing of the fault is reported by telephone. Faults detected in P.B.X. installations, which have to be dealt with by the P.B.X. Department, are handled in the same way. Most of these complaints, however, reach the P.B.X. Department at once.

The control of the Troublemen is carried out as follows:—

As soon as the man arrives on the spot and starts to work, the button near his pigeon hole is pushed. This lights the lamp so that it is

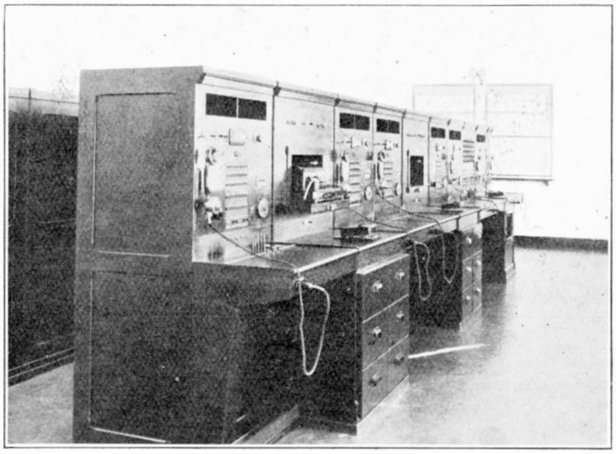


Fig. 3.—Row of Boards in Central Trouble Office.

immediately apparent which Troublemen are on the job; secondly, a counter is worked which gives the number of cases handled; and thirdly, a time meter is put in action which afterwards shows the time taken to clear the fault. For each man, therefore, it is possible to know how many cases he has handled, his working time and also, by simple subtraction, the time occupied by travelling from one place to another. His total time on duty is registered at the control board. As soon as a man is superfluous he is shifted over to the repair service for overhaul work. Fig. **3** shows the row of boards consisting of two receiving desks and a control board. There are two of such rows at the Trouble Central Office at Amsterdam.

V.—*The Statistical Department.*

At this table, shown in Fig. 4, all tickets issued arrive; not only those referring to troubles cleared either by the Trouble service or by another department, but also those referring to complaints on which no fault could be found. When the service is closed down at night, this desk must have issued all the tickets. This is always verified to ensure that no tickets are missing.

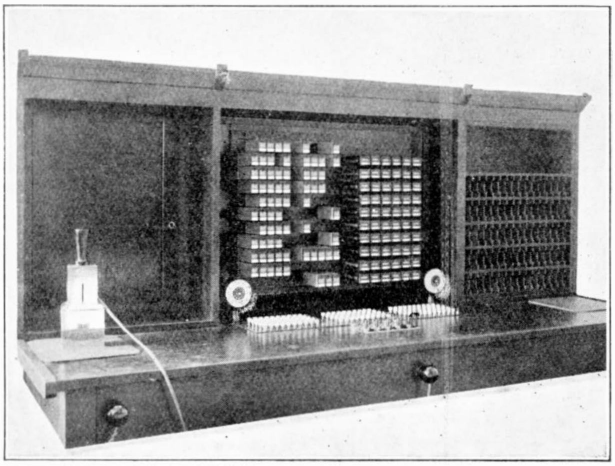


Fig. 4.—The Statistograph.

On the statistical report desk are concentrated all the meters. These include the counters referred to above for controlling the working time and two groups of counters worked by a key board in the shelf. One of them registers the effect of the service and the other produces the statistical records regarding the character of faults. The effect of the service is measured by the time which elapses between the filing of the complaint and the clearing of the fault. This is done in two ways, once by taking the difference between the two time stamps, and again by deducting the time during which service has been suspended. The first item gives the time the subscriber has waited for the removal of the fault, the second gives the time taken by the service to clear the trouble. In Table II. the result of these statistics is reproduced for the year 1929.

Table II.

STATISTICS ON THE DURATION OF FAULTS.

	Subscriber's time.	Service time.
	%	%
Less than ½ hour	20.80	26.80
½ — 1 hour	26.90	27.50
1 — 2 ,,	21.70	24.20
2 — 3 ,,	12.50	14.20
3 — 6 ,,	2.95	5.50
6 — 12 ,,	2.96	6.50
12 — 24 ,,	10.30	0.95
More than 24 hours	1.98	0.35
	100.00	100.00

The statistics showing the character of the faults are derived from the code indications on the tickets, each of them having a number represented on the key board. Complaints and faults are divided into groups which are subdivided into smaller groups and finally reassembled into larger groups. All this work is done automatically by routing the meter current from the keys in a special way. For this purpose meters and key contacts are connected in series and parallel, which can be done on an intermediate distributing frame so that the grouping may be altered as circumstances require. At any moment the statistics can be detailed as much as necessary and as long as useful without difficulty and without incurring more work. This counting apparatus, Statistograph, does automatically all the statistical work, divides into groups, combines again, totalises, gives daily and monthly records and controls itself. Statistics cost no more time than is wanted to read the tickets and to push a button; the Chief has all his data and records daily by reading the counters and another set of counters gives the monthly records.

VI.—*The Administration.*

All tickets finished at the Statistical report desk go back to the Receiving desk *via* the Administration. Here a record is kept of all complaints on which no fault could be detected. When the same number appears three times within a period of a month, an order is given to the Repair service for a thorough overhaul. When the number appears again, it is reported to the Traffic office for permanent observation.

The Administration further assembles the statistics, keeps the card system up to date, places indices on the cards for all purposes and controls the complete circuit of the tickets. When the ticket returns to the Receiving desk the card is put in its place after the report has been noted.

Finally, a few remarks about the systematic overhaul. Every Troubleman not wanted for clearing faults is transferred to the Repair service and used for overhaul of plant. Besides the overhaul of numbers with an abnormal trouble frequency, as mentioned above, there is also a systematic revision of the whole plant in order to prevent complaints and to inspect the installation at the subscriber's premises. In slack periods the Receiving desk arranges for numbers to be tested systematically and reports all defects to the repair service.

The advantages of the methods described above can be summarised as follows:—

With a smaller staff than previously, it has been found possible to organise a highly efficient and rapid Trouble service, open practically all day, *i.e.*, from 8 a.m. to 11 p.m. on week days and from 9 a.m. to 5 p.m. on Sundays. The time taken to clear the fault is short, being on the average 2.061 hours in service time and 3.587 hours in subscriber's time; 47% of the faults are cleared within one hour. Investigation of the fault commences as soon as the complaint is made and this makes a good impression on the public, which sees that attention is being given at once.

It is also important that in many cases it is possible to investigate the complaint at the moment it arises, particularly with intermittent troubles. As a trouble card is at hand for each number, diagnosis is facilitated and exaggerated complaints by the subscriber can be exposed at once.

Another feature of great importance is the control of the Troubleman, who is not released before he has really cleared the fault. As the time the Troubleman takes for his work and to travel from one place to the other is recorded no time can be wasted. The statistical report gives the Chief a daily survey of the results obtained.

The systematic preventive inspection or overhaul of the plant prevents faults, keeps up a highly efficient service, fully employs the spare time of the staff and affords a rapidly working Trouble service even at peak load without any waste of time in slack periods. With the inspection and overhaul, the administrative data of the installation at the subscriber's premises are kept under review at the same time and this is very useful.

In order that all numbers shall be overhauled within a reasonable time a small permanent staff is wanted for the overhaul service.

To realise the scheme described above, it is necessary to have a staff of two officers at the Receiving Desk, one at the Control, six to seven Troublemen and two men for permanent revision service per 10,000 lines. For the Administration one man is required per 20,000 lines. With this staff 15,000 troubles and 3,000 revisions can be handled per annum. As stated above, the P.B.X. service is not included.

DEVELOPMENT IN P.A.B.X. DESIGN.

B. F. Moss,

General Electric Co., Ltd.

THE primary purpose of this article is to give a description of a recent development in the design of Private Automatic Branch Exchange systems.

In order, however, that the merits of the new system may be clearly appreciated, some attention will be paid to the operation of existing systems with a view to reaching conclusions as to their respective advantages and disadvantages. From these considerations it should be possible to obtain an impression of the requirements of an ideal system. The system to be described is the result of attempts to meet these requirements.

In order, also, that the system may be readily understood, the line of thought which influenced the design of each section of it will be closely followed. The reasons underlying the design of these sections will be discussed before the system, as a complete unit, is described.

A P.A.B.X. may be described as a private automatic exchange which has connection to the local main exchange. As the exchange is private, the numbers of the extensions on it will not be generally known to main exchange subscribers and hence it is necessary that incoming calls to the P.A.B.X. are intercepted by an operator, who is in a position to extend the calls to the correct extension.

It is not the purpose of this paper to discuss the automatic switching plant in P.A.B.X's. This plant is generally based on well proved main exchange practice which has, for the present, reached a certain degree of finality. The intention is to consider that portion of a P.A.B.X. which is concerned with providing communication with the main exchange, for it is in this direction that the recent development in design has been applied.

In so far as the method by which they provide connection with the main exchange is concerned, the existing types of P.A.B.X. systems may be divided into two classes. In both these types of P.A.B.X's calls incoming from the main exchange are extended in the same manner. For the reasons already stated these calls are intercepted by the local operator, who extends them to the required extension lines. It is in the method of switching outgoing calls in which these classes of systems differ.

In one class of system all outgoing calls are controlled by the local operator. On the receipt of a call from an extension, the operator completes the connection, with her cord circuit, to the junctions to the main exchange. If the main exchange is automatic, and it will be assumed that this is the case wherever main exchanges are discussed, the operator has to dial the number of the wanted subscriber.

In the other class of system each extension obtains connection with the main exchange automatically after the dialling of a pre-determined prefix digit, and without any intervention by the local operator.

Each of these systems has certain inherent advantages and disadvantages. The first mentioned type, that in which all calls are controlled by the operator, has the disadvantage that the services of the operator are required for the complete setting up and releasing of each outgoing call. That is to say, the operator has to manipulate cords and plugs, effect the necessary dialling, and then generally supervise the call in order to release the connection on receipt of the clear signal. It is proposed to criticise these points individually.

Firstly, the manipulation of cords and plugs gives rise to a chance of incorrect operation, particularly when it is remembered that a P.A.B.X. operator is not, as a rule, as efficient as a public exchange operator. Secondly, the dialling by the operator naturally occupies an appreciable amount of time, particularly as the main exchange may be in a Director or other type of multi-exchange area, when up to seven trains of impulses have to be dialled. In addition, as very often the actual number required will be repeated by word of mouth by the extension to the local operator, misunderstandings may often arise and wrong numbers be connected.

Finally, the fact that the operator has control of the release of the connection has a bearing on the amount of traffic which can be carried by the junction lines. On these outgoing calls the junction is held busy as long as the operator leaves a cord circuit connected to a junction. Therefore to utilise the junction as efficiently as possible each connection should be taken down as soon as the clear signal is given. Although a well trained operator might not lose much time in responding to clearing signals, she naturally, and quite correctly, gives attention to calling signals in preference to clearing signals. Therefore, it is quite probable that on every outgoing call a certain amount of time may be lost before the connection is released after the clearing signal is given. Although this amount may be small, where exchange lines are concerned every second lost unnecessarily has its effect on the traffic efficiency and therefore the economic value of these lines.

There is one definite advantage that is obtained from this particular type of system. As the operator has control over all outgoing calls, she can use her discretion in deciding whether the originating call is one that should be extended to the main exchange. In many cases the calling extension may not know the number of the wanted subscriber. If this should be the case the extension communicates the name of the subscriber to the operator who, from a public directory, is able to ascertain the required number. If, however, the extension is provided with facility for reaching the main exchange direct he would be tempted very often to request this, or any other, information from the main exchange operators, who might therefore be troubled very often and quite unnecessarily from these enquiry calls. It is quite probable that a 50 line P.A.B.X. having, say, five exchange lines and in which all extensions can dial out direct, may easily create enquiry calls to the main operators far out of proportion to the number of exchange lines in use.

It should be mentioned that on systems of this type facilities are always provided whereby extensions can call their local operator and, if necessary, be connected by her to the main exchange. This fact, however, does not influence the argument that has been propounded.

The type of system which provides extensions with direct dialling facility to the main exchange has the advantage that the local operator is relieved of all work in connection with outgoing calls and she can therefore concentrate on the control of incoming calls. Each operator is able to attend to a larger number of these calls and therefore fewer operators would be required for a P.A.B.X. of given size with a given junction traffic. This type of system has, however, the disadvantage, already discussed, that it allows possibility of the main exchange operator being unnecessarily troubled.

From this discussion on the merits of the existing systems it should now be possible to define the requirements that would be demanded from an " ideal " system.

Obviously an ideal P.A.B.X. system would be one that incorporates the advantages of each of the systems already discussed, with the disadvantages of neither. As the chief advantage of one system is that the operator controls the outgoing calls and of the other that the operator does not have to concern herself with these calls, the ideal system would be one in which the operator controls all these calls without spending any time on them. This is obviously impossible; the nearest that can be reached to this ideal is a system in which the operator controls all outgoing calls but spends as little time as possible on each.

In order to build up the system which is to be as near as possible to the ideal, it will be necessary then to take as a basis the system in which the operator has full control of outgoing calls, and attempt to reduce the time she spends on each call.

Now it has been stated that it is a disadvantage if the operator dials out, but no disadvantage if the extensions dial out. Therefore in the new system it should be arranged that the operator connects a calling extension through to the junctions and it should then be possible for the extension to dial through the cord circuit. This requirement is easily met by arranging the cord circuit to include an impulse repeater operating on standard principles, whereby the impulse dialled out by the calling extension and received by this repeater would be repeated over the junctions to the main exchange. It will not prove difficult to arrange, in the same cord circuit, that the operator is able to dial out should the calling extension be unaware of the number required.

The arrangement decided upon then is that the operator controls all outward calls, but does not necessarily have to effect the dialling for each call. This will economise on the amount of time the operator spends on each call. To reduce this time still further, however, it is necessary to pay attention to the other points that have been mentioned as disadvantages of this system. It was mentioned that the operator has to resort to the use of plugs and cords with consequent risk of wrong connections and that she has to supervise the call and take down the cords as quickly as possible at its termination. These points bear a relationship to each other and may be considered together.

It is an advantage, it has been argued, if the operator controls the setting up of outward calls. Her services afterwards, now that it is arranged for the extension to dial out, will only be required for taking down the cords when the call is finished. In fact, if there were no cords to be taken down, the operator's services would not be required beyond the connecting through of the call to a free junction line. In order to determine whether, on these outgoing calls, the cords may be eliminated, it is necessary to consider the functions the operator normally performs with them and ascertain if, and to what extent, these functions may be performed by automatic apparatus.

The answering cord is used by the operator for connecting a calling extension line to a cord circuit. This action may be defined as consisting in the operator connecting an idle cord circuit to a particular calling line. This sequence of operations, however, is analogous to that which occurs on most of the small automatic exchanges operating on the line-finder principle. On exchanges of this type each first selector has directly connected to it a line-finder switch of rotary type. By the use of assignment switches the selectors are assigned to function in rotation.

It may be said that the action of the operator in choosing a free cord circuit is the same as that of an assignment switch. When the operator plugs into the particular calling jack she does no more than a line-finder switch when it makes connection with the calling line. The action in both cases provides the same result. Thus these actions of the operator have a direct simile in a line-finder system. Hence it should be feasible to effect, by automatic means, this operation of answering a calling extension.

Each cord circuit then, on its answering side should have its answering plug and cord replaced by a rotary line-switch, which may be termed the extension finder, operating as a line-finder. In order that the free cord circuits may be correctly assigned a pre-assignment switch, which may be common to a number of cord circuits, will be required. So that they may be distinguished more easily it is proposed that the cord circuits of the new system be termed "Auto-Cord Circuits."

The sequence of operations now arrived at will consist in the extension dialling "●" and the extension finder switch associated with an idle auto-cord circuit, will then hunt for and make connection with, the calling line. In order to give a calling signal a lamp should glow on the manual board. This lamp should be in close proximity to other apparatus, individual to each auto-cord circuit, which it may be found necessary to mount on the manual board. A Speaking Key will enable the operator to speak to the calling extension.

The case to be considered now is that of the operator extending a call to the main exchange junction lines. This normally is effected by the operator plugging into a free junction jack with the calling plug of the particular cord circuit in use. This operation can be said to consist in the operator causing a certain cord circuit to make connection with any free junction line. This sequence of connections is also analogous to those in use in automatic switching practice and it can be performed automatically on either the line-finder or preselector principle. In order to concentrate as much apparatus as possible in the auto-cord circuit it proves preferable if the preselector principle is employed. That is, a rotary line switch is connected to each auto-link circuit and, under certain conditions, will hunt for and make connection with, a free junction line. It is necessary that this switch action is controlled by the operator, as not every call will require extending to the main exchange. Hence a key is required to set the switch, which may be termed the Junction Finder, into operation. This Junction Connect key should be restored when a junction is seized and dial tone is heard.

As a repeating element is to be included in the auto-cord circuit, the extension may now dial the required number and the operator need have no further interest in this call, provided her services are not required for any releasing purposes. It is quite feasible, however, to provide automatic release because, as the circuit has been set up automatically, it should be possible to release it in the same manner. The action then of the calling extension replacing his receiver should disconnect the junction and restore the auto-cord circuit to normal.

The results achieved by the auto-cord circuit effectively overcome the disadvantages that have been said to exist if the operator extends outgoing calls. The operator's total work on the majority of these calls will consist in throwing one key to speak to the caller and then throwing another key momentarily to connect to a junction, thereafter her services are not required. The risk of the operator making wrong connections is eliminated, as plugs and cords have been deleted, and the risk of the operator misunderstanding the number wanted is eliminated by allowing the extension to dial for himself. Finally, as the junction and cord circuit are released automatically immediately the extension hangs up, the fullest possible efficiency is made of them for traffic carrying purposes.

Having increased the efficiency in operating outgoing calls by the introduction of automatic switching principles, it may be possible to improve the operating of incoming calls in the same manner. Consideration therefore should now be given to the operation of incoming calls.

In normal practice each junction terminates in a jack and lamp equipment on the manual board. The operator answers a junction call by plugging into the jack associated with the calling lamp and extends the call by plugging into the jack associated with the line of the wanted extension. When the operator answers the call she causes a particular junction to be connected to a free cord circuit. This is analogous to the case, already discussed, of connecting a particular extension to a free cord circuit and can be completed automatically. A Junction Finder switch is already required for each auto-cord for use on outgoing calls. By suitable circuit arrangement it should be possible to utilize this same switch and cause it to act as a line-finder on incoming junction calls.

The advantage gained by making this operation of answering incoming calls automatic are two-fold. Firstly, the answering plug has been entirely dispensed with, as all answering actions can now be performed by automatic means. Secondly, the manual board apparatus associated with the junction lines, such as lamp and jacks, can be deleted as all connections between junctions and auto-cord circuits are completed automatically.

The final function of the operator to be discussed is that of extending an incoming junction call to the wanted extension. This is generally effected by the operator obtaining direct connection by cord and plug. This connection could be completed by the operator dialling the number of the wanted extension, but this method is not efficient as the operator would have to spend time in dialling and also each call would then occupy a train of switches in the P.A.B.X. Hence the arrangement would be slow and expensive. Therefore it does not appear that the existing method can be improved upon, particularly as it is quick in operation and has, in fact, no outstanding disadvantages.

On incoming calls then, the calling junction will be automatically connected to a free auto-cord circuit and the operator will then plug into the jack associated with the required extension line. Each auto-cord circuit will thus have connected to it a plug and cord for this type of call. In order to simplify operating arrangements it should not be difficult to ensure that when, on receipt of the clearing signal, the operator withdraws the plug, the auto-cord circuit is restored to normal.

Sufficient data has now been obtained for the auto-cord circuit to make it possible to draw up a schematic trunking diagram of a P.A.B.X. embodying this circuit and, from it, to give a brief description of the operations occurring on outward and inward calls. Fig. 1 illustrates the main elements of the P.A.B.X.

When an extension lifts his receiver and dials "O," relays in the auto-cord circuit, which has already been assigned by the assignment switch, are operated and cause the Extension Finder switch to hunt for the calling line. As soon as the auto-cord circuit is seized, the assignment

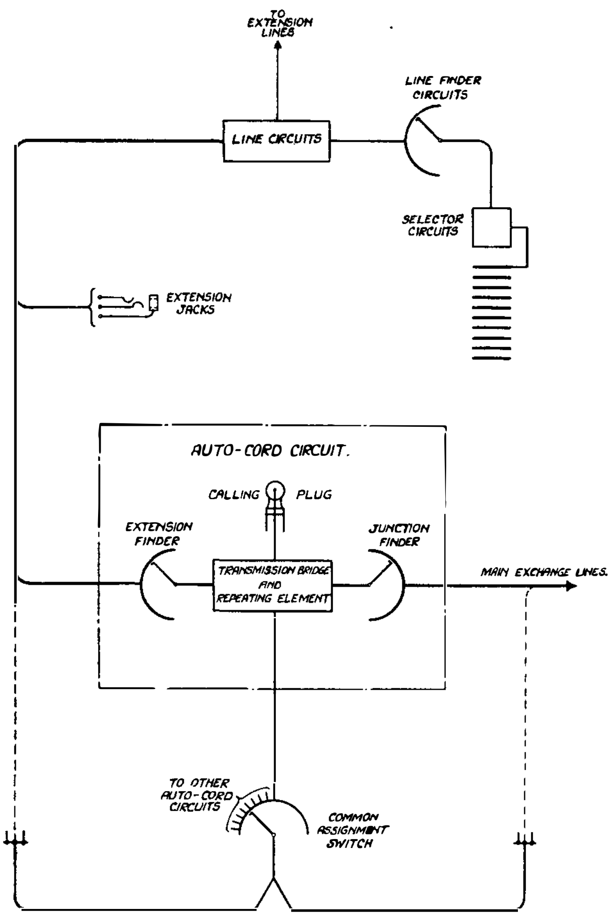


Fig. 1.—Trunking Scheme of Auto-Cord Type P.A.B.X.

switch operates automatically to assign the next free circuit. A calling lamp glows to give the necessary signal. The automatic switches, comprising line-finder and selector, taken into use by the extension in dialling "O," are released as soon as the auto-cord circuit is connected through its extension finder to the calling line.

The operator throws the respective speaking key and speaks to the calling line. If the latter requires connection to the main exchange and wishes to dial himself, the operator throws the Connect Key. This causes the Junction Finder to hunt for a free junction line. The operator holds the Connect Key thrown until she hears dial tone, indicating that a first selector has been taken into use at the main exchange. The operator informs the caller when to dial and then restores both keys. The extension's dialling impulses are received in the auto-cord circuit and repeated out over the junction.

The action of the caller hanging up releases all relays in the auto-cord circuit and therefore disconnects the holding loop to the main exchange, the auto switches at the main thereupon release to normal. The auto-cord circuit is now available for use on other calls.

On incoming junction calls a cord circuit is seized in just the same manner as on outgoing extension calls. The same assignment switch can be employed for both types of calls. Hence on receipt of an incoming call, relays are operated in the particular auto-cord circuit which is seized and cause the Junction Finder switch associated with it to hunt for the calling junction. A Junction Calling Lamp indicates to the operator the type of caller. On noticing this lamp the operator throws the Speaking Key connected to the auto-cord circuit, and speaks to the caller.

The operator now plugs into the jack of the wanted line with the plug associated with the auto-cord circuit. She then rings out in normal manner by throwing a Ringing Key. Supervision from the called extension is given on a third, supervisory, lamp.

On receipt of the clearing signal, given by the supervisory lamp, the operator withdraws the plug. This action automatically releases the auto-cord relays and renders the circuit free to be seized by other calls.

It has been mentioned that three lamps are required on each auto-cord circuit, two lamps being employed as respective calling signals from extensions and junctions. The third lamp is used to give the clearing signal on incoming calls. In order that the operator may be able to note the quantity of circuits in use at any one moment a fourth lamp, the Engaged Lamp, is employed. This lamp is not normally in use, but should the operator wish to originate a call herself she presses a certain common key. This causes the engaged lamps to glow on all busy circuits. The operator can therefore at any time ascertain which circuits are free and take one into use if she wishes.

It might appear that considerable complication of the extension line circuits is necessary to enable the extension finders to search for calling extensions. Actually this arrangement is made possible by the addition of a non-inductive resistance to each line circuit and no additional contacts or other apparatus are necessary. This point is of considerable importance, as the cost of each line circuit has naturally an important effect on the total cost of an exchange.

In order to illustrate easily the various apparatus fitted on a manual board equipped with auto-cord circuits, a diagrammic view is given in Fig. 2 of a board serving an 80 line P.A.B.X.

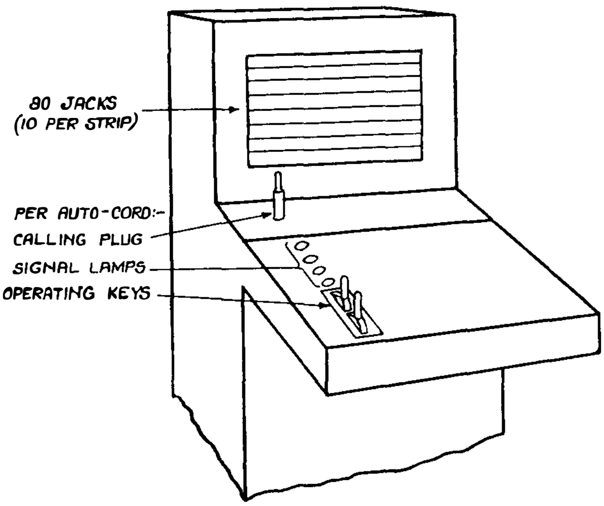


FIG. 2.—80-LINE AUTO-CORD TYPE SWITCHBOARD.

Each auto-cord circuit is shown to have a plug, four lamps and two keys. One lamp, the Engaged Lamp, is very rarely employed and for ordinary operation the operator has only to concern herself with the three lamps. Apart from the auto-cord circuit apparatus the only other apparatus fitted on the board are the 80 extension jacks.

It should now be possible to discuss the auto-cord system on the question of economics and compare it, on this basis, with existing systems. As the existing system which the auto-cord system more closely resembles is that with direct dialling-out facility, it is with this that comparison will be made.

Fig. 3 illustrates, diagrammatically, the equipment required on a manual board, serving an 80 line P.A.B.X. of the direct dialling-out type. In comparing Fig. 2 with Fig. 3 it may be noted that the equipment mounted on the vertical panel of the manual board actually occupies 175% more space in Fig. 3 than in Fig. 2. This fact alone facilitates the use of a manual board of especially simple construction wherever the auto-cord system is employed. In addition, much of the apparatus in the auto-cord circuits is concentrated, as far as wiring connections are concerned. Thus it can all be mounted on a frame work separated from the manual board and comparatively few wiring connections between rack and switchboard will then be required. Hence, there is no apparatus, such as relays, that need be mounted on the switchboard, thus further simplifying this portion of the exchange.

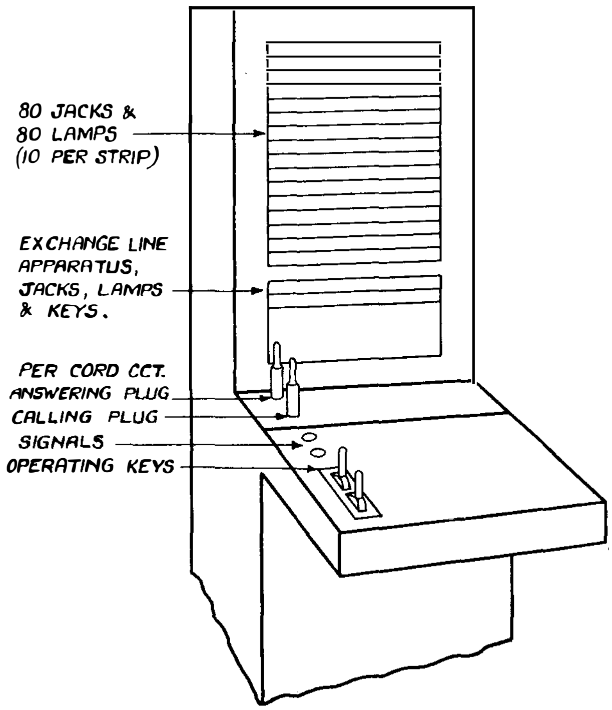


FIG. 3.—80-LINE STANDARD TYPE SWITCHBOARD.

In practice, the boards shown in Figs. 2 and 3 are equipped with certain miscellaneous apparatus which, as they are not the concern of this article, have been deleted. For the sake of comparison both boards are shown to have one panel only. This would not necessarily be the case in practice.

In Fig. 4 a detailed comparison of apparatus quantities is given between two 80-line P.A.B.X. systems, one operating on the direct dialling-out basis, the other on the auto-cord scheme. It is assumed that both exchanges have the same traffic rate.

FIG. 4.

COMPARISON OF APPARATUS FOR 80-LINE P.A.B.X.

	Standard P.A.B.X. System.	Auto-Cord System.
AUTO-SWITCH PLANT.		
Line Circuits	80	80
Selector Circuits	12	9
MANUAL BOARD APPARATUS.		
Extension Jacks	80	80
,, Calling Lamps	80	Nil
Junction Lines	7	6
Exchange Lines Jacks, Lamps and Keys	7	Nil
Exchange Repeater Circuits	7	Nil
Cord Circuits	8	7
Cords and Plugs per Cord Circuit ...	2	1
Keys ,, ,, ,, ...	2	2
Signals ,, ,, ,, ...	2	4

It will be noted that a reduction of three circuits is made in the selector circuits. This is made possible by the fact that the selectors do not carry any main exchange traffic and are only held in use momentarily on calls to the P.A.B.X. operator. On the standard system, however, the selectors carry all outgoing traffic and therefore sufficient switches must be provided to carry this, and the internal, traffic.

It will also be noted that six junction lines are quoted for the auto-cord system against seven for the standard system, although it was stated that the traffic rate of each exchange is the same. This difference is explained by two facts. Firstly, in the auto-cord system each junction call is completed and released, at the termination of the call, with the minimum of time lost. Each junction therefore is operated at a higher rate of efficiency and thus can carry a higher traffic rate than the junctions on the standard P.A.B.X. Secondly, all junction calls on the auto-cord system are intercepted by the P.A.B.X. operator, and, for reasons already discussed, fewer enquiry calls will therefore be carried by the junction lines.

Another point to note in Fig. 4 is that seven cord circuits are quoted for the auto-cord system against eight for the standard system. These figures require a little explanation.

Taking, firstly, the case of seven auto-cord circuits, it has been stated that the number of junction lines required for the auto-cord system is six. Hence the maximum number of conversations that can take place over these junctions is also six. To establish these connections a similar number of cord circuits is required. Therefore to carry the junction traffic six cord circuits are required; to enable the operator to deal with enquiry calls when the junction traffic is at peak load, a seventh circuit should be provided.

As, on the standard system, outgoing calls are dialled direct, it might be argued that eight cord circuits are unnecessary for seven exchange lines, for it may appear that these cord circuits have only to carry incoming traffic. On this type of exchange, however, extensions always can, if they wish, be connected to the main exchange by the P.A.B.X. operator. Therefore, sufficient cord circuits must always be provided to carry, besides the peak incoming traffic, certain of these outgoing calls and still have at least one circuit for enquiry calls.

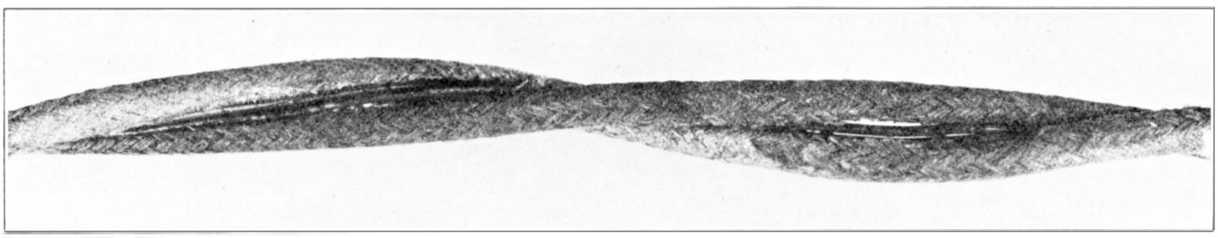
A point then that can be raised against the direct dialling-out system is that although, as has already been mentioned, sufficient selectors must be provided to carry the peak outgoing traffic, the number of cord circuits must be sufficient to carry some outgoing calls. It is clear then that at any given moment a certain number of either the selectors or the cord circuits must always be idle.

The figures given in Fig. 4 refer to exchanges having a certain traffic rate, of an average value. If, as may be quite possible, a particular 80-line exchange has a higher traffic rate than in the examples given, the difference in quantity of apparatus required for the two types of systems will naturally be more marked.

From a consideration of known types of P.A.B.X. systems one is lead to believe that the manual board equipment has merited more development than it has received. By applying automatic switching principles to this manual board equipment and rendering automatic many operations which have hitherto been considered of a purely manual nature, it is suggested that a more efficient system has been developed.

PECULIAR LIGHTNING EFFECTS.

READERS of the Journal will be interested in the following account of the peculiar effects of a lightning stroke which have been communicated to Sir Thomas Purves by Mr. H. P. Brown, Secretary of the Postmaster-General's Department, Commonwealth of Australia. The telephone line concerned was a subscriber's circuit, metallic throughout, and consisted of 50 yards of 10 lb. conductor P.C. cable, and 3.6 miles of 40 lb. cadmium-copper wire. About half a mile from the subscriber's premises, the circuit left the main line at a cross-armed pole. The cross connections were made with insulated wire, and this wire was found in six pieces. The insulation was not damaged, but it was possible to draw the end pieces of the wire freely from the insulation. The circuit was led in to the subscriber's premises by means of a twisted pair V.I.R. insulated cable 90 feet in length. The second pole from the subscriber's premises was struck, and a chip 9″ long, ½″ wide and ¼″ deep was taken off the sap wood at the tip of the pole. The copper cadmium wires were burnt through in two spans between the terminal and the junction poles. This is, of course, quite a normal occurrence in such cases, but the peculiar effect which it is desired to bring to notice concerns the twin insulated leading-in wire between the terminal pole and an insulator which secured the wire to the building. This wire was not burnt or charred in any way, but the black insulated conductor was completely removed from its insulation as though the latter had been slit spirally along the lay with a knife, and forced into intimate contact with the red insulation of the other conductor. The red insulation was not cut through so completely as the black, but close inspection revealed the fact that the fibres were damaged, since it was easy to tear the insulation longitudinally. In some parts, both wires were actually found inside the red insulation.



Photograph showing Conductors between braidings.

The fuses in the subscriber's premises are said to have operated and there were marks of a heavy discharge on the lightning protectors. The heat coils did not operate. At the exchange, the fuses operated, but it cannot be stated definitely that there were any signs of the protectors having discharged.

It is reported that there was a lighted kerosene lamp on a table about four feet from the telephone, and that although this was extinguished, it was not damaged in any way.

It is not very easy to provide a satisfactory explanation for this phenomenon. The damaged cable has been examined microscopically and the opening along the rubber appears to be a perfectly clean mechanical cut. The indiarubber does not appear to have been affected by any appreciable rise in the temperature of the conductor, and there are no signs of burning on the braiding. It would, therefore, appear that the explanation is that the occurrence was due to an intense mechanical attraction between the two conductors when each was momentarily carrying a heavy current in the same direction. A rough test on the force required to cause one of the conductors to cut through the rubber and the braiding in this way has enabled a calculation to be made which shows that, to produce the effect, each wire must have carried an instantaneous current of the order of 15,000 amperes!

An article has appeared recently in a contemporary journal which describes this occurrence, and advances the theory that "the passage of a momentary strong discharge intensely heated the surface of the wire so that the air or any other gases evolved were expanded with sudden violence, and consequently with explosive effect." It is difficult to understand how this effect could result in placing both conductors in the one braiding, it would seem that such an action would rather tend to separate the conductors.

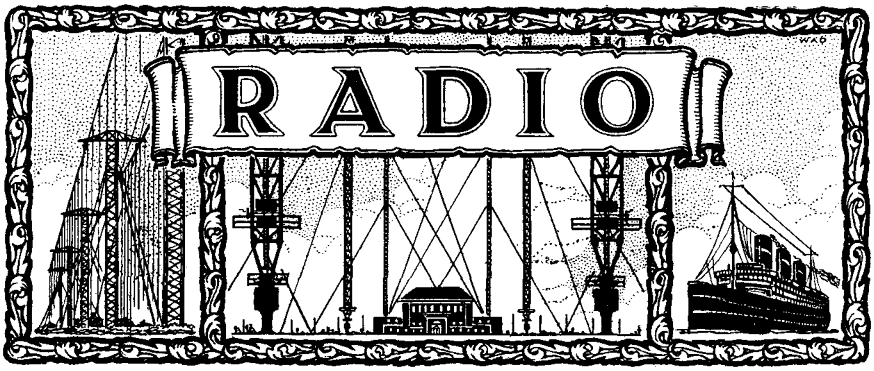
It is somewhat difficult to obtain a photograph of the damaged cable which will show the two conductors in the one braiding. The accompanying illustration, however, shows a representative length. At one end, both wires are clearly shown free of their insulation, whilst at the other end, one conductor is still covered.

H.C.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONES AND WIRE MILEAGES, THE PROPERTY OF AND MAINTAINED BY THE POST OFFICE IN EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1930.

No. of Telephones owned and maintained by the Post Office.	Overhead Wire Mileage.				Engineering District.	Underground Wire Mileage.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.
684,086	529	3,964	53,684	130	London.	25,123	89,040	2,595,358	85,800
90,838	2,182	21,502	70,886	2,165	S. Eastern.	4,043	63,778	258,864	34,661
94,108	4,482	32,023	66,184	3,951	S. Western.	21,954	17,861	200,627	63,762
75,996	6,332	39,335	69,924	6,456	Eastern.	24,699	47,965	160,401	62,513
107,996	9,661	45,252	65,990	4,761	N. Mid.	33,130	63,469	281,487	103,393
94,036	4,828	31,329	80,833	4,168	S. Mid.	13,881	31,466	226,050	78,771
63,191	4,576	30,140	58,743	3,503	S. Wales.	6,645	30,920	140,675	68,399
118,098	7,966	27,045	55,828	4,130	N. Wales.	13,831	43,462	318,966	52,951
173,464	1,469	16,049	45,459	3,092	S. Lancs.	14,561	89,996	546,484	61,698
101,723	6,083	30,770	50,428	3,251	N. Eastern.	14,062	51,042	281,137	72,498
69,690	3,907	24,122	41,114	2,717	N. Western.	7,753	37,277	180,587	43,310
52,579	2,494	15,903	27,497	3,253	Northern.	7,597	22,155	146,862	37,919
24,126	4,427	8,944	14,721	632	Ireland N.	135	3,160	51,923	2,407
72,893	4,815	27,381	42,279	1,319	Scotland E.	6,474	17,929	168,770	40,098
95,433	7,247	24,722	46,160	1,283	Scotland W.	11,475	29,793	240,094	32,950
1,918,248	70,998	378,481	789,730	44,811	Total	205,363	639,313	5,798,285	841,130
1,892,658	70,576	377,284	775,678	44,508	Figures as at 31 Mar., 1930.	203,138	622,970	5,678,546	839,746



RADIO DIRECTION FINDING AT POST OFFICE COAST STATIONS.

G. H. Farnes and F. Hollinghurst.

During conditions such as obtain in fog or stormy weather with low visibility, when it is not practicable to obtain astronomical bearings or visual bearings on landmarks when approaching a coast, navigators of ships feel the need of some means of checking the ship's position as determined by the very approximate method of " dead reckoning."

In order to fix accurately the position of a ship three bearings on different fixed points are necessary; these bearings when laid out on the chart give the well-known " Cocked Hat." Two bearings on fixed points will, however, enable a ship's position to be determined with fair accuracy, and even one accurate bearing from a position suitably situated with regard to a harbour or estuary will be of considerable use to a ship during poor visibility conditions.

There are several methods whereby radio systems can be utilized to fill this need, and after careful examination of the problem it was decided in 1921 to investigate the possibility of utilizing the existing coast stations of the British Post Office and the corresponding ships' installations for this service. Under this method no special apparatus would be required on ships, the bearing of a ship being taken at a coast station by special receivers at that station utilizing the signal from the ordinary ship's transmitting set.

Although the situations of the Coast Stations then in existence were not ideal for the purpose, the cost of apparatus necessary for direction-finding at an existing station is very small compared with the cost of equipping and running a complete station solely for direction-finding purposes. The ideal system would, of course, be a chain of stations erected simply for direction-finding purposes, but the cost of such a scheme would be prohibitive.

Niton Wireless Station in the Isle of Wight was accordingly equipped with directional receiving apparatus. The system tested was that known as the Marconi Bellini Tosi system. This apparatus was employed for some time to obtain trial bearings from ships and fixed stations. In certain directions there appeared to be appreciable errors, but on the whole navigators comparing radio bearings with their estimated positions reported very favourably on the accuracy of the bearings. Finally a detailed calibration was made with the aid of a vessel specially loaned by the Admiralty. This vessel's positions were accurately determined by visual means from the shore and a correction table was prepared from the radio bearings corresponding to visual bearings, as more fully described later.

Following upon the success of the installation at Niton Radio Station the following stations were equipped and calibrated:—Cullercoats, Wick, Portpatrick, Humber, Malin Head.

The directional receiving apparatus is also employed for normal reception of ships' traffic by the stations and materially assists in overcoming interference due to jamming. The stations at Fishguard, North Foreland, Seaforth, Lands End and Valencia are also equipped with directional receiving apparatus, but on account of unfavourable situations, or pressure of ordinary traffic, are not calibrated for the purpose of giving bearings to ships, the directional apparatus being installed simply on account of its anti-jamming properties. The apparatus employed is identical with that at the other calibrated stations, with the exception of Seaforth, where a rotating loop direction-finder supplied by Messrs. Siemens has been installed.

The aerial system of the direction-finding apparatus consists of two aperiodic, triangular, single-turn loops of large dimensions, the base

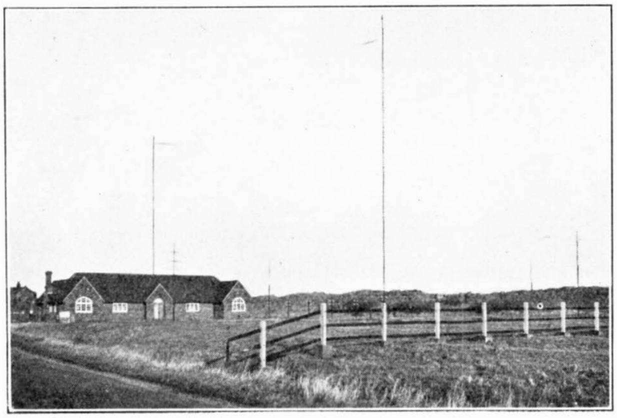


FIG. 1.

of each triangle being of the order of 120 ft. in length and the apex 70 to 100 ft. above the ground. The loops are generally supported in the centre by the main transmitting mast and are at right angles to each other. Fig. 1 illustrates a typical Bellini Tosi directional aerial system. The two pairs of wires from the ends of the loops are led into the building to the receiving apparatus by means of a transposed transmission line as shown in Fig. 2.

The aerials must be electrically symmetrical and balanced, a condition which it is sometimes difficult to fulfil owing to the influence of the transmitting aerial, stays, and other local obstructions. The lead-in is as short as possible and is transposed, and sometimes screened, in order to secure this symmetry and balance which is necessary to give well defined bearings.

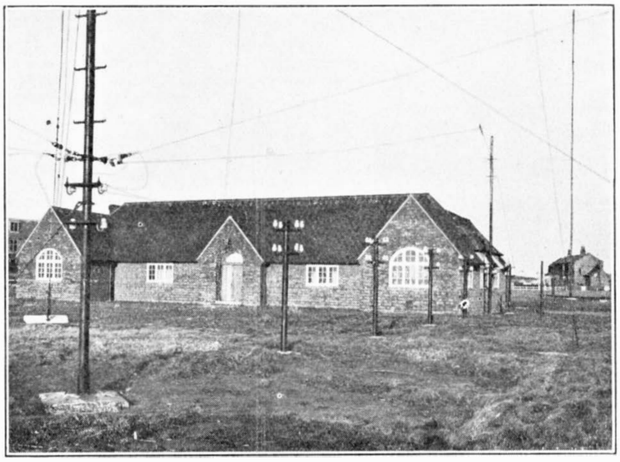


FIG. 2.

A photograph of the receiving apparatus is shown in Fig. 3. The aerials are led into the lower left-hand panel which contains the radiogoniometer. This consists of two coils arranged on a cylindrical former exactly at right angles to each other. One coil is connected to each loop; a search coil capable of rotation in the plane of the two fixed coils provides the coupling between the fixed coils and the receiver. The rotation of the search coil of the goniometer produces the same effect as regards the reception of signals as does the rotation of the frame aerial of a frame aerial receiver. The circular scale on this panel is divided into 360 degrees, the pointer being adjusted to give true North at zero, other bearings being read off in degrees east of true north.

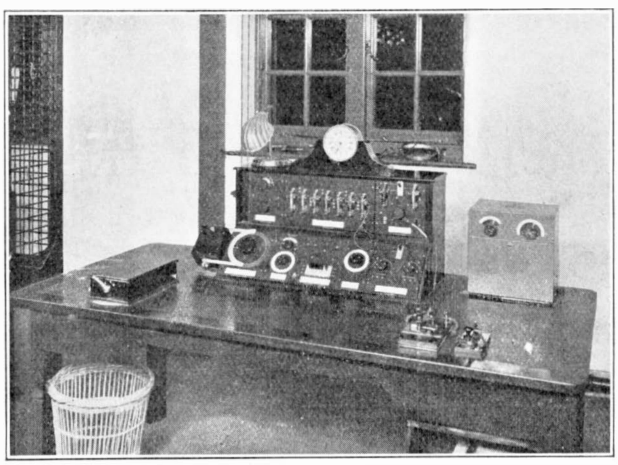


FIG. 3.

A simplified schematic diagram of connections of a Marconi direction-finding receiver is shown in Fig. **4**. The search coil is coupled through a tuned intermediate circuit to a six-stage, aperiodic, high-frequency amplifier and thence to a two-stage low-frequency amplifier. High frequency or low frequency stages may be cut out at will.

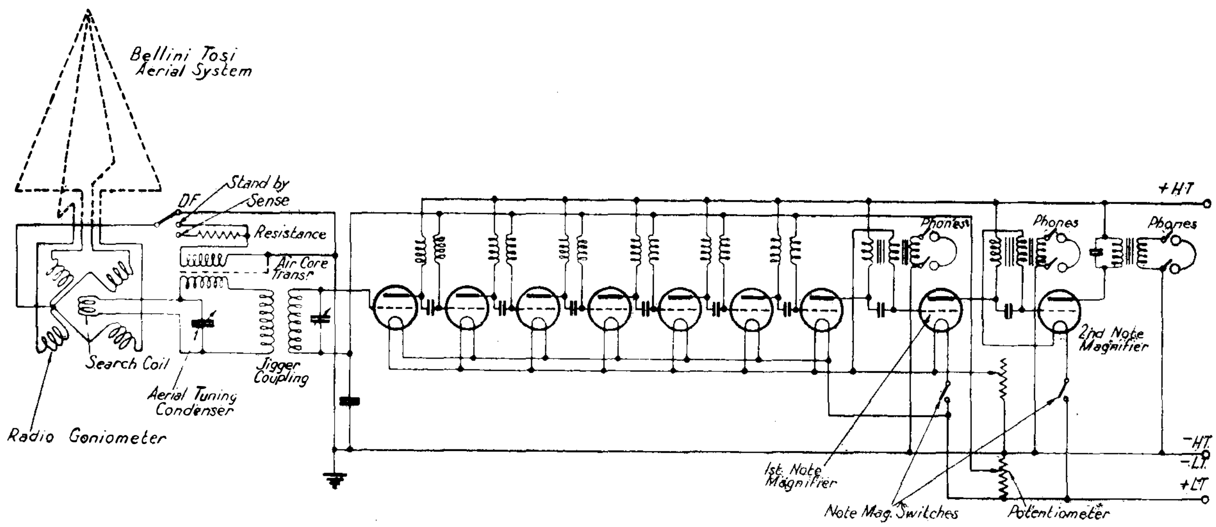


FIG. **4**.—SIMPLIFIED SCHEMATIC DIAGRAM OF RECEIVER.

By means of a switch on the high-frequency transformer panel the receiver may be used in either the "stand-by," or direction finder, positions or for "sense" determination. With this switch in the "stand-by" position, the loops are grouped and coupled on to the receiver, so as to form a simple vertical aerial with a circular polar diagram of reception. In the "D.F." position the loops are coupled on to the receiver by means of the rotating search coil in the goniometer and a "figure of eight" polar diagram of reception having two positions of minimum signal strength 180° apart, similar to that produced by a frame aerial, is obtained. The "sense" position gives a combination of the "D.F." and "stand-by" positions producing a "heart-shaped" or "cardioid" polar diagram. This enables the "sense" of the incoming signal to be determined. These polar diagrams of reception are shown in Fig. **5**.

The procedure in giving a bearing is described in detail in the Admiralty List of Wireless Signals and is substantially as follows:—The ship requiring the bearing calls the Direction-Finding Station and on receiving acknowledgement of its call and instructions to "Go ahead," transmits the code for the request "What is my bearing from you." The Direction-Finding Station then signals the code instruction to send the ship's call sign for 60 seconds. While these signals are being transmitted the shore operator sets the direction finder to "Sense" by pressing a key, and by observing the approximate position of a single minimum signal obtained by rotating the search coil, determines the approxi-

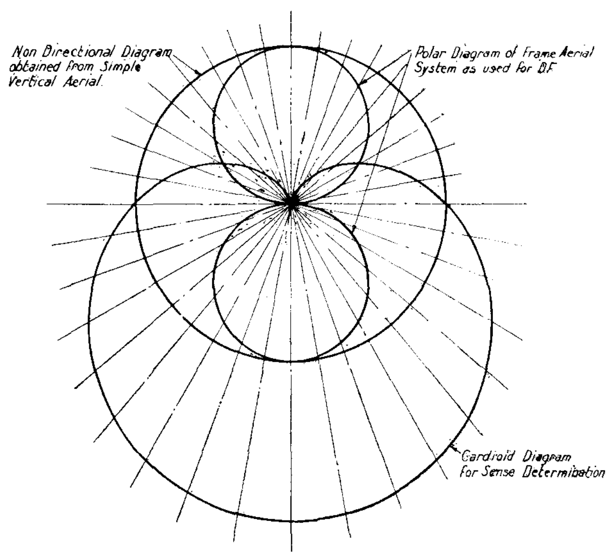


FIG. **5**.—POLAR DIAGRAMS OF RECEPTION.

mate direction of the ship and notes it as " North," " South," " East " or " West." He then sets the key to " D.F.", and after accurately retuning the receiver to the ship's wave-length and adjusting the strength of the received signal to a suitable volume again rotates the search coil. Two positions of minimum signal approximately 180 degrees apart are obtained and these must be determined to within one degree. This is done by swinging the pointer over an arc of a few degrees about the minimum position and noting two positions where signals of equal strength are obtained. The mean of these positions is the required minimum. Four such pairs of readings are taken and used to obtain four means, two for the position corresponding to the approximate direction determined with the key to " Sense " and two for the reciprocal position. The reciprocal readings are then converted to their direction equivalents by the subtraction or addition of 180° and the average of the four means is calculated. From a calibration table the true bearing corresponding to this result is read off and is signalled to the ship. The whole operation occupies about 1½ minutes.

Installation and Calibration of a Direction Finder.

Given ideal site conditions free from obstructions in the form of irregularities of coast line, or ground, groups of trees, buildings, masts, aerial equipment, etc., and with a well-screened receiver housed at the centre of the loops there should be no necessity to apply corrections to obtain a true bearing. In certain cases where errors are of a particular " quadrantal " type the apparatus can be adjusted to give sufficiently accurate readings directly without reference to a calibration table. Such conditions, however, are not obtained at combined coast and direction-finding stations where the site has not been chosen with regard to its suitability for direction finding, where obstructions in the form of masts, aerials and buildings are present, and where the receiver is generally housed in a building about 100 to 150 ft. from the centre of the loops. In these circumstances the aerials are carefully balanced and adjustments to the transmission line and apparatus are made to minimise errors and, finally, the direction-finder is calibrated by comparing the radio bearings of a ship's transmitter at a number of positions with the corresponding positions of the ship obtained by means of accurate visual bearings from the shore.

If the direction-finding Station is on the coast, a theodolite is set up at a convenient point in close proximity to the loops, but giving a wide angle of view over the sea. A telephone circuit connects the theodolite position with the operating position near the direction-finding receiver in the building. A tug or other suitable vessel equipped with wireless apparatus is hired for the purposes of the calibration, and the movements of the tug are controlled by instructions from the theodolite position telephoned to the radio operator in the building and transmitted by radio to the tug.

The distance of the tug from the radio station depends largely upon the weather conditions and visibility. It is usual, however, for the tug to cover the calibrated arc once at a radius of about five miles and to return over the same sector at a radius of about 10 miles. The vessel is stopped about every five degrees for a bearing to be obtained. The vessel remains as stationary as possible for the period of about one minute, during which the bearing is being obtained, but may drift as much as one degree in this time under unfavourable weather conditions. To minimise error from this source, the true bearing is taken by means of the theodolite at the beginning and at the end of the one minute transmission time. The mean of these readings then corresponds with the mean of the four swings taken on the radio-goniometer in the same time. In order to obtain the true bearing from the loops, which are marked on the navigation charts, small correction is applied to the theodolite reading. When the visual and radio bearings have been satisfactorily obtained at one position, the vessel is requested to move to the next position. With favourable weather conditions about forty bearings per day may be obtained and a station completely calibrated in two or three days. The results are plotted in the form of a graph as shown in Fig. **6** which was obtained during a recent calibration at Cullercoats Radio Station. The abscissae give readings obtained on the radio direction-finder and the ordinates give the necessary corrections to be applied in order to obtain true bearings. Fig. **7** shows a similar curve taken for Niton Station.

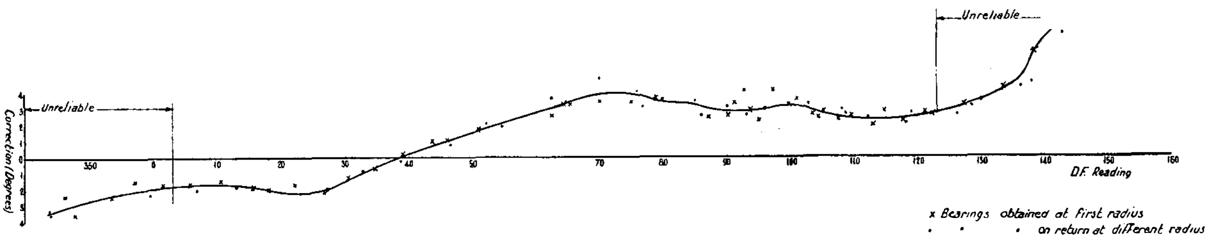


FIG. 6.—CULLERCOATS D.F. CALIBRATION. NOVEMBER, 1929.

The sectors which show any sudden changes or fluctuations in the slope of the correction curve are carefully explored by taking more bearings.

For operating purposes these corrections are tabulated for quick reference.

One of the most serious causes of error is that due to coastal refraction. Radio waves arriving at the coast having a small angle of incidence are refracted in a similar manner to that in which light is refracted upon entering a medium of different density. This error is negligible if the angle of incidence of the wave be large, and in practice all bearings making an angle of more than 20° with the coast line are found to be immune from its effects. All bearings where the angle is less than this are tabulated as "unreliable" and the ship is informed to this effect when a bearing is given in such a sector. The maximum range at which reliable bearings are given is 100 miles.

The procedure of calibrating a direction-finding station which is not in very close proximity to the coast is considerably more complicated. In order to fix the true bearing of the ship from the radio station it is necessary to have two theodolite positions several miles apart on the coast. Simultaneous visual bearings must be taken at each theodolite at the same time as the radio bearing is being taken at the coast station. Communication between the theodolite positions and the radio station is maintained by means of portable radio equipment.

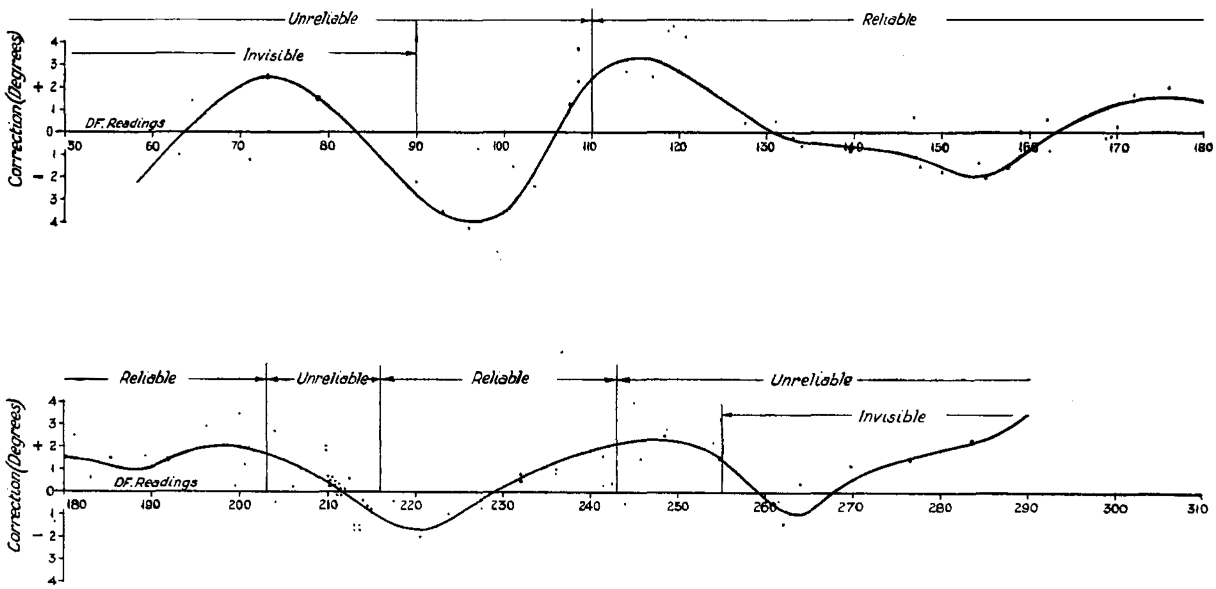


FIG. 7.—NITON RADIO STATION—D.F. CORRECTION CHART—15TH APRIL, 1930.

The stations are recalibrated periodically, or on any occasions when it is necessary to modify the plant of the stations in such a manner as may possibly alter the readings on the direction finder.

In conclusion, it may be stated that the service, for which a small charge is made to the ship, is widely used and provides a valuable aid to navigation under difficult conditions.

DEVELOPMENTS IN BROADCAST RADIO RECEIVING APPARATUS.

A. J. Gill, M.I.E.E., M.I.R.E., and A. G. McDonald, A.C.G.I., B.Sc., A.M.I.C.E.

IN this article it is proposed briefly to discuss some of the more recent developments in broadcast receivers and their components.

The requirements for broadcast receivers are in many respects different from those for receivers used for commercial radio telephony services. For a broadcast receiver, compactness, low first cost, simplicity of operation and high power output are the main essentials. A commercial type of receiver on the other hand can, within reason, be unrestricted in dimensions, it demands the highest degree of selectivity and sensitivity, ability when necessary to operate and furnish a constant level of output under conditions of severe fading and suitability for connection to sharply directional types of antennæ. In addition, adequate measuring equipment must be provided to enable the performance of the receiver as a whole or of any constituent stage to be readily determined. There must also be provision of equipment enabling faults in the apparatus to be immediately notified and located.

Recent progress in broadcast receiver design may be classified under the following headings:

(1) *Increasing use of public supply mains as power supply for receivers.*—This trend has led to the development of methods of rectification for power supply and of special valves using low voltage alternating current for filament heating. In general, the indirectly-heated type of valve, in which the cathode surrounds and is separate from the heating element, has superseded the directly-heated type employing a short thick filament designed to retain its heat and hence its emission during the normal periodic A.C. fluctuations.

An interesting departure from the more usual designs is the use in the Columbia All-electric Receiver No. 304 of ordinary battery type valves, the filaments of which are heated by the D.C. output from a metal-oxide rectifier. This system is quite successful and a similar method using a gas-filled rectifier with the output smoothed by an electrolytic condenser is also satisfactory.

The main reason for the development of all-mains receivers was the fact that suitable high tension supplies could readily be obtained in this way and it was an obvious step to obtain the filament supply in the same manner, thus eliminating all necessity for charging or replacement of batteries. This situation was accentuated by the higher power demands of loud speakers of the moving coil and cone types, which need a considerably greater driving force than that required for the satisfactory operation of the horn type loud-speakers previously in use.

(2) *Improved selectivity combined with high quality.*—The greater power output from the Brookman's Park transmitters has necessitated research into methods of obtaining extreme selectivity without sacrificing quality by cutting the side bands. Filter circuits before the first high frequency valve and cascade connection of two or more screened grid amplifying stages, each with tuned circuits, have been the main lines on which development has taken place. The super-heterodyne receiver with its great possibilities of selectivity does not appear to have received the attention it deserves. This is probably because the early types of super-heterodyne receivers for broadcast reception suffered from two serious defects which made them unpopular. Firstly, the screening of the intermediate frequency stages was insufficient to prevent direct pick-up of stations working in the intermediate frequency band, and, secondly, the selectivity before the first detector was not capable of eliminating strong stations on the opposite side of the beating oscillator. A super-heterodyne receiver, having adequate high frequency selectivity and in which a flatly tuned high gain intermediate frequency amplifier is combined with a correctly designed band-pass filter of the Campbell type to give the necessary selectivity, is probably the ultimate goal in receiver design.

(3) *Extensive use of screening, both of components and of amplifier stages.*—In this case, the design of broadcast receivers has lagged behind the practice in commercial receivers. The question of keeping the cost low may have been

the cause of this delay, but now marked improvements in valve performance and increasing gain per stage has forced the introduction of screening to ensure stability.

(4) *Ganging of controls.*—The use of multi-stage amplifiers has led to ganging of controls in order to enable non-technical users to tune such sets easily. Side-by-side condenser drums were used initially, but the present tendency seems to be to have all condensers ganged on one control with either small parallel condensers for trimming or with some form of clutch to line up the circuits at the ends of the range. For high quality, absolute resonance of all the circuits is not desirable; a double or triple humped response curve is a closer approximation to the ideal flat top curve, so that in this case slight errors in tuning are not necessarily harmful.

(5) *Methods of detection.*—Development in methods of detection has been practically stationary for some considerable time, makers being content with grid leak detection or, exceptionally, using anode bend rectification. It is of interest to note that recently two new systems have been receiving attention, namely, power grid detection and push-pull detection.

(6) *Decoupling schemes and automatic grid bias systems.* — These developments have naturally followed the use of mains power. Decoupling is now employed in all receivers, but methods of obtaining grid bias have not yet become standardised. Free grid bias by tapping across resistances in the negative high tension return is the system usually adopted, although the use of a separate supply from a small metal-oxide rectifier is almost as popular.

(7) *Radio-gramophones.*—Nearly all the better class radio receivers are associated with equipment for the reproduction of gramophone records. The need for higher output from the power stage of the L.F. amplifier has probably been found necessary because of the comparison with the output from an ordinary gramophone. The louder passages need a fairly wide margin of power to give clear reproduction without overloading obscuring the effect.

Since power is obtained from the mains, anode voltages of the order of 350 to 500 are now more or less common. Low voltage power valves giving a large output for low anode voltages are available, but they depend for their high emission on special activation processes. These often are of very fleeting duration and valve lives, for full emission, are undesirably short.

It may perhaps be of interest to note that modern valves are surprisingly variable as regards measured characteristics, and that of ordinary receiving valves tested as high a proportion as 30% are considerably below the makers' published specification. The pumped, as distinct from the gettered valve, is still the best if a long life be desired.

To obtain high tension voltages from A.C. mains a transformer and some form of rectifier is necessary. For low voltages the dry metal oxide rectifier of the Westinghouse Metal, or Igranic Elkon, type is deservedly popular on account of its convenience and long life. For higher voltages the cost of this type of rectifier becomes excessive and a new type of thermionic rectifier, the mercury vapour hot cathode rectifier, is more suitable for these voltages. The new rectifier possesses the high voltage capabilities of a hard vacuum diode with the low and constant volt drop of a mercury arc rectifier. Samples of Messrs. Philips rectifiers tested show a potential drop of 40 volts in 4000, while the General Electric Co.'s G.U.1 shows a drop of 15 volts in 2000. These values are constant for all loads and represent extraordinarily high efficiencies. It will be appreciated that for high power amplifiers and for high tension supplies for transmitters the mercury vapour rectifier has a promising future. Since the potential drop across the valve is small, the heat developed at the anode is also small and consequently the size of the glass envelope can be reduced to a minimum. For example, the G.E. Co.'s G.U.1 type of rectifier, which has a maximum output of 250 milliamperes and a peak reverse voltage of 3000 (half wave), has the same size glass envelope as an ordinary D.E.L. 210 receiving valve.

The reason for the inclusion of mercury vapour is to neutralise the space charge effect which, in a normal thermionic diode, is responsible for the large potential drop, in many cases between 20% and 30% of the total voltage applied to the anode. The space charge effect is due to a proportion of the electrons emitted from a heated filament congregating as a cloud around the filament instead of flowing on to the anode. This cloud constitutes a negative charge and tends to prevent newly emitted electrons reaching the anode, thus giving rise to a potential drop between filament and plate.

If any gas be present in a valve, it will be ionised when the high tension is switched on, and such ionisation in a soft valve is usually followed by an unduly high anode current and, accompanying this phenomena, is rapid disintegration of the filament by positive ion bombardment from the ionised gas. If, however, the potential drop across the valve can be kept below a certain critical figure, *i.e.*, 22 volts for mercury vapour, the disintegration is prevented. Mercury vapour has an ionisation voltage of 10.4 volts, so that it is a possible gas filling.

Argon and neon have the property of preventing the disintegration of a heated cathode, but such gas fillings are limited to low voltage working. The Tungar, Ediswan and Philips rectifiers all employ inert gas fillings. In general this type of rectifier is most suited to low voltages of, say, 2 up to 500 volts, although 1000 volt rectifiers have been made.

In the new type of rectifier, a hard vacuum is employed and the mercury vapour for providing the ionised electron path is obtained by evaporation from globules of mercury splashed around the sides of the glass envelope. The mercury vapour does not protect the filament from bombardment in the same way as an argon or neon filling does, and it is necessary to limit the current rectified by the valve to the normal electronic emission from the filament.

From this it follows that the high tension voltage must only be switched on when the filament is up to normal heat. If the high tension be switched on without the filament being heated, the resulting ionisation and bombardment breaks up the filament. In tests on one type of mercury vapour rectifier this effect was tested for, and during quite a short interval between switching on and off large pieces of the oxide-coated filament were observed to fly off. This limitation is probably more serious when the rectifier is used for all-mains receivers than when it is used on a transmitter where a delay relay circuit can readily be arranged for. A simple type of bimetallic strip delay relay would be quite suitable for a broadcast receiver to ensure that the anode circuits were not energised until the rectifier filaments were at normal working temperature.

A further interesting characteristic of this rectifier is that its behaviour is entirely different from that of a hard thermionic rectifier in its property of current limiting. An ordinary diode has a limiting output current which is fixed by the electron emission from the filament. The new mercury vapour rectifier does not limit in any way, but if the current passed exceeds the thermionic emission of the filament deterioration of the valve ensues. In operation during the positive cycle the valve is coloured with the blue-green glow of ionised mercury.

A list of valves of this type now available is given below:—

G.E.C.

Type.	GU 1	E 255	E 244
Filament volts.	4	4	4
Filament current	3	11	40 amps.
Peak anode current ...	1.5	6.0	15 amps.
Mean rectified current ...	.25	1.0	2.5 amps.
Peak reverse voltage ...	3,000	10,000	20,000 volts.

EDISWAN.

Type.	ESU 75.
Filament volts.	2
Filament current	8 amps.
Max. Peak current	.9 amps.
Mean rectified current	.35 amps.
Max. reverse voltage	5,000 volts.

(All the above valves are half-wave).

PHILIPS.

Type No. ...	1061	1071	1062	1077	1072
Filament volts.	2.1	2.1	2.1	2.1	2.1
Filament current	2.8	2.8	4.5	4.5	4.5 amps.
Rectified D.C. Output ...	.05	.1	.15	.3	1.0 amps.
Max. anode voltage ...	1000	500	4000	3000	500 volts.

(All the above series are full wave).

The GU1, ESU 75 and 1071 are very suitable for use in amplifiers requiring, say, 80 to 100 milliamps at 400-500 volts, and in the case of the first two mentioned are decidedly the cheapest method of obtaining such a supply. All of these valves use low temperature oxide-coated filaments, so that if they are worked under correct conditions long lives may be expected.

It may be of interest to note that many commercial radio gramophones including the HMV series employ mercury vapour hot cathode rectifiers, while the ESU 75 is extensively used in talking film and public address equipment.

Although the broadcast listener does not require anything like such a high power, the valves are still suitable for lower powers because of their cheap first cost and high efficiency. The full wave and half wave circuit diagrams for these valves are absolutely identical with those normally used for ordinary thermionic rectifiers. Half-wave rectifiers are used very widely because any unsmoothed ripple is less likely to be unpleasant at 50 cycles per second than it is at 100 cycles per second—the output frequency from a bi-phase rectifier. This is due largely to the diminished output of most moving coil loudspeakers at 50 cycles and their pronounced resonance at 100 cycles.

(8) *Gas-filled Rectifiers.*—Rectifying valves having a gas filling of argon, neon or other gases of the inert series have been made for some considerable time. Complete equipments for battery charging and high tension supply are fairly extensively used, but the use of this type of valve seems to be almost entirely neglected by those who build their own equipment.

In this type of valve the argon or neon filling serves to protect the filament from positive ion bombardment and also from wastage by evaporation. The presence of the argon is also necessary to provide the necessary positive ions to neutralise the space charge. The actual gas pressure used is chosen so that minimum cathode disintegration and maximum anode current are obtained. The gas pressure must be kept fairly low if the valve is required to withstand voltages of the order of 500. This rectifier works on an arc discharge, the conducting gas path being formed by the gas ionised by collisions between the electrons emitted from the filament and the gas molecules.

Valves of this class are very suitable for both battery charging and high tension supply. The ionisation potential is approximately 16 volts. A short list of gas-filled rectifiers is:—

EDISWAN.

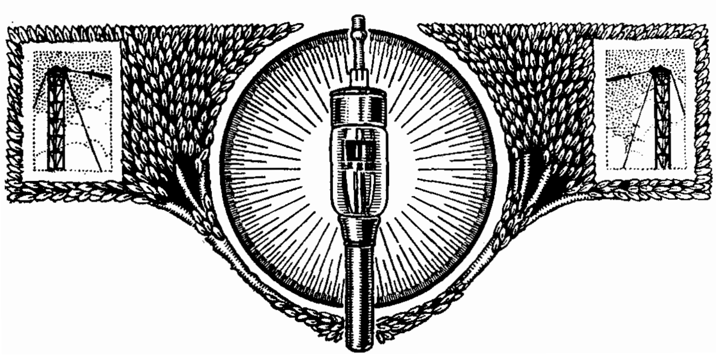
Type.	U 235	U 222	HU 235
Filament volts.	2	2	2
Filament current	3.5	2.5	3.5 amps.
Max. reverse volts per anode	30	150	400 volts. r.m.s.
Max. Output current ...	1.5	.1	.3 amps.

(All the above are full wave).

Messrs. Philips have a very comprehensive series with voltage outputs ranging from 16 to 500 and current outputs from .1 to 40 amperes.

With these valves it is necessary to include in the return lead from the centre tap of the transformer secondary a ballast resistance to take up the difference between the voltage necessary for ionisation 16, and the working voltage, say, 6 to 7 for battery charging. This resistance is usually iron wire in hydrogen and such barreters are designed for each type of valve.

[*Notes on developments under the other headings, outlined above, with special reference to the apparatus at the 1930 Radio Show, Olympia, will be included in the second part of this article. —Eds. P.O.E.E.J.*]



NOTES & COMMENTS

BY the courtesy of Mr. S. W. Bassett, who found the documents in an old guard-book in the Lineman's Stores at Oxford many years ago, and Mr. John Darke, we are enabled to publish the following official instructions of earlier times, which were issued before any member of the Engineering Department now serving had entered the service, indeed, before many of them had been born.

The first is dated 9th January, 1871: its sense is as applicable to-day as it was in '71. Those who run may read, or, as the vulgar say, "A nod's as good as a wink to a blind horse."

POST OFFICE TELEGRAPHS.

Engineer's Department,
North Western Division,
Birmingham.
Jany. 9th, 1871.

To Supts.

Herewith I send you a copy of the Act of 1863—the restrictive clauses of which apply to the Dept.

Supts. and others should always remember the LAW *of the case, but in practice, of course we wish to evade the troublesome part of the restrictions when we can—prudence however will show the point beyond which we must not endeavour to go.*

J. Bolton,
for Div. Eng.

The second is incomplete. The caligraphy is extremely neat and the subject matter deals with the cleaning of insulators which had suffered from a plague of spiders during the heat of the previous summer "both in agricultural and smoky districts."

Birmingham.
19th Sept., 1876.

To Superintendents.

Independent of the special steps in various districts, for which Works order applications have been made, intended to improve our Insulation during the coming winter, there are certain ordinary measures that, if steadily carried out during all the available time of our Linemen, especially those stationed on high roads, must produce most beneficial effects.

Every report I have seen during the present year concurs in stating that the growth of spider webs is most abundant in almost all forms of insulator in ordinary use, and that this is the case both in Agricultural and smoky districts.

No doubt the exceptional heat of the past summer has had something to do with it. It is therefore necessary to take special steps to remove the spider webs and the accumulation of dirt between the cups of the insulators, irrespective of the further steps in the way of washing or changing that may be effected.

If you would issue something like the following to your Inspectors it may be well:—

"Spider webs having accumulated very rapidly in the Insulators on the Road lines during the late Summer, it is necessary

that Linemen proceed at once to take the most energetic steps for their removal.

" Washing and replacing insulators is a special step, arrangements for which will very shortly be made; but the removal of cobwebs is an ordinary duty that a single Lineman can undertake. It is only necessary to pass a piece of cane with the head split open so as to form a rough brush, or a piece of waste secured to the head of a stick, round the inside cup of the insulator to effectively remove cobwebs, and such rubbish attached to them.

" This process can be carried out comparatively rapidly; it requires the carrying of no tools except a ladder, or climbers, and a single . . . . .

Then, as now, depressions approached us from the Atlantic, but it is surprising to find the Department preparing itself a few days ahead for anticipated damage. The hope expressed in the advice of the 30th October, 1877, that no refreshments would be required was not borne out; a marginal note on the side of the paper states " Claims sent in on the 2nd November ! "

26th Oct., 1877.

To Supts.

I received following from Engineer this morning and immediately wired you—

" A telegram from New York announces the coming of a strong S.E. gale which will probably strike the British Coast about Saturday next.

" It is so far verified that the wind has been S.E. to-day.

" Of course the date and in fact the occurrence of a storm at all is by no means to be relied on, but seeing the uncertain season we are in it is well to be ready and have all men warned."

Please take necessary steps to have all men in readiness in case of damage.

It will perhaps be as well if your Inspectors came on duty either on Sunday morning or afternoon, if the gale does not appear before, so that in the event of anything happening they may have their men all out in good time in case there are any faults.

F. E. Evans.

To Supts.

The Engineer-in-Chief would be glad to know at once whether you have any, and if so, what Claims to submit in respect of refreshments supplied to men engaged in restoring the communication interrupted by the recent gales.

As the work of renewal was not carried out under any particular disadvantage as regards weather I rather expect you will not have any demands for special allowances.

F. E. Evans.

30th Oct., 77.

The next letter is of important historical significance, since it shows that the Engineer-in-Chief in 1877, instead of regarding the telephone as a scientific toy, is prepared to hire the instrument on a rental basis of £10 per annum for two stations. He is guarded of course in his advice and makes it clear that the Department, while willing to install sets on open lines, does not hold itself responsible for its operation or warrant its satisfactory working. Inductive disturbances are feared, but the use of " low power and slow instruments " on other circuits indicates that the authorities at headquarters were fully aware of the cause of such disturbances. It is still " out of the question to lay a special pipe for any two wires between stations."

Dec. 6, 1877.

To Superintendents.

I have received the following from the Engineer-in-Chief:—

" The Telephone.

" Arrangements have been concluded between the Department and Mr. Reynolds (the Agent for Professor Bell) under which we are now in a position to supply the telephone should it be required.

" I enclose a few circulars received from Mr. Reynolds, from which you will gather the terms he asks: we of course must charge at the same rate.

" Under the arrangements with the patentee the telephone will not be sold out and out, but will be supplied at an annual rental of £5, i.e., for one end—a speaking set to communicate between two places is £10 per annum,

" But, while you are at liberty to make known the fact that the Department does supply this instrument, it is I think right to be very guarded in any opinion you may give as to the circumstances under which the supply can be made.

" A metallic circuit is required for these instruments, i.e., a return wire instead of earth. If the two wires needed therefore can be erected in an isolated position it is clear there is no difficulty in working the telephone; at any rate for reasonable distances. If the two wires on open poles already occupied by other open circuits the working of the telephone will be to some extent interfered with by induction, but if the other circuits are worked with low power and slow instruments, perhaps it will be found that there are many cases in which this induction, though present, does not prevent the telephone speaking. In any cases however in which renters should decide to have wires erected for them for telephonic purposes they must understand that the success of such wires, except when isolated, is at their own risk.

" The chances are that a short wire will work while a long wire will be very materially hampered.

" If underground wires are wanted, for the present they cannot be supplied, as I presume it is out of the question to lay a special pipe for any two wires.

" However, experiments are being conducted in order to ascertain all the circumstances under which the telephone can really be used, and very shortly I shall be able to communicate with you on the point. As yet, go no further than I have said, and be particular to guard against making the Department responsible, or warranting the operations of the telephone in any way. We are obliged by public clamour to adopt it sooner than would otherwise be judicious. Its powers have to be tested; and the chances of improvement have to be developed."

F. E. Evans.

ERRATA IN JULY ISSUE.

The Editors,
I.P.O.E.E. Journal.

Dear Sirs,

With reference to my notes *re* the Manchester Automatic Telephone System, which you were good enough to insert in the July issue of the Journal, I notice the following errors to which attention might be drawn, in order to prevent confusion :—

(1) Page 107, left hand column. At the foot of the page the last sentence should have read : " For this purpose such a group will be divided into two portions. The left hand portion will be used as first choices, etc."

(2) Page 107, right hand column. The last paragraph at the foot of this column should have commenced as follows : " In addition, the first jack of each 5 circuits will have, etc."

(3) Figures 10 and 11 have been interchanged. The title of Figure 10 appears below Figure 11, and vice versa.

(4) In the title of Figure 11, the second line should read : " Code selector level method of multiple fee registration."

(5) In Figure 12, the " (3d.) " shown against level 4 (BLA), should be deleted.

I am,

Yours faithfully,

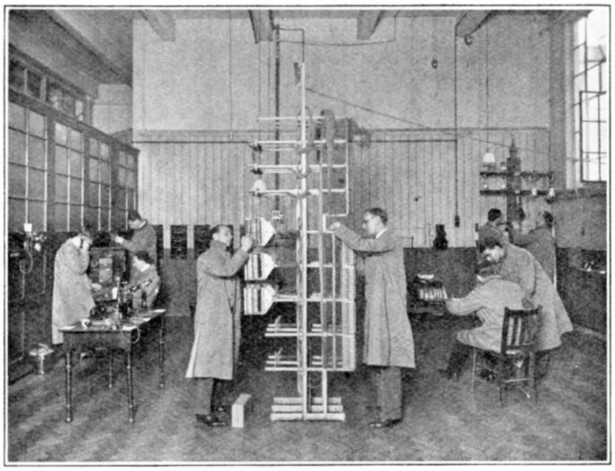
L. F. Morice.

18/7/30.

TRAINING.

PROBATIONARY ASSISTANT ENGINEERS AND PROBATIONARY INSPECTORS.

THE training scheme for probationers in the Engineer and Inspector grades has recently been modified. The probationary period of two years is unaltered, the most notable departure from the former arrangement being the introduction of a full time course of instruction extending over a period of 12 weeks at a Headquarters School, on the completion of which the trainees are posted to Engineering Districts for practical training.

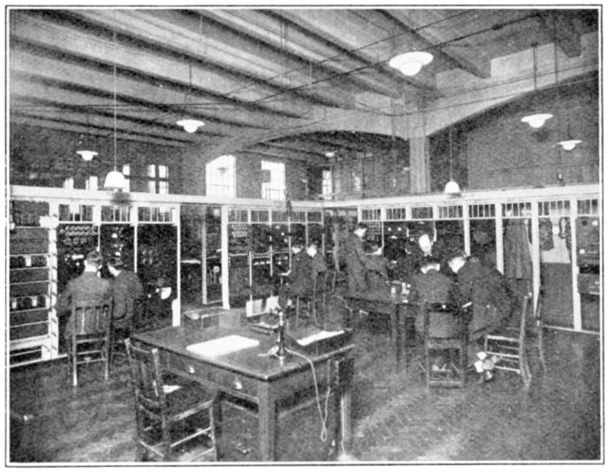


GROUP OF STUDENTS IN THE WORKSHOP.

The new scheme is applicable to Probationers entering the Engineering Department after the 1st January, 1930, and training commences with the full time course at the Training School, which is intended to deal not only with the scientific and technical aspects of the work of the Engineering Department but also with its general administration and organisation; thus, by giving a general survey of the work and activities of the Department, Probationers are better equipped for practical training in the Districts. The school instruction is in the form of lectures and practical work, such as wiring, soldering, jointing, relay adjustment, the examination of telephone apparatus, etc., and some 100 lectures are given by headquarters officers who possess expert knowledge of particular subjects; a lantern is available for illustrating lectures.

During the school period also, the trainees are conducted over the factories of contractors to the Engineering Department and visit internal and external works in progress in the London Engineering District under the guidance of District officers.

The introduction of the school course has been simplified by utilising the existing training organisation in automatic telephony and Repeater Station practice, additional accommodation having been secured and suitably equipped.



IN THE REPEATER SCHOOL.

Some of the time is spent at the Research Station, where lectures and practical demonstration in cable balancing and precision testing are given by experts in those subjects.

A liberal number of copies of all technical instructions and regulations is held in the School for reference purposes, and each probationer is supplied with a complete bibliography arranged under the following headings:—

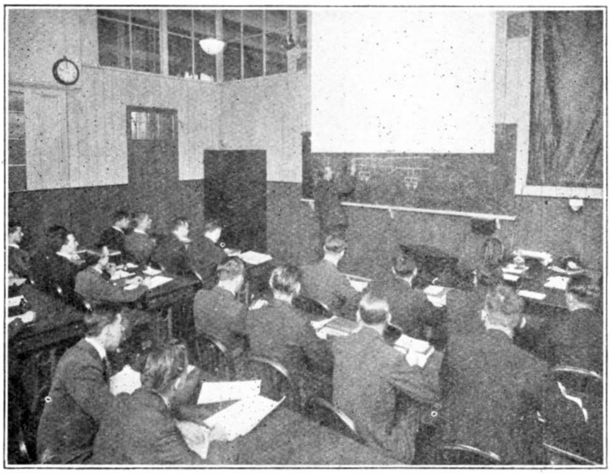
- General Telephony.
- Automatic Telephony.
- Telephone Transmission.
- Telegraphy.
- External Construction.
- Radio Communication.
- Carrier Current Telegraph and Telephone Systems.
- Organisation, Management and Finance.

The information is scheduled under:—

A. Text books, Treatises, Technical Instructions and Numbered Circulars.
B. Technical Pamphlets, professional papers.
C. Important articles from technical journals.

The bibliography also includes a list, with titles of Technical Instructions, Technical Pamphlets for Workmen and important circulars.

The demand from a recent batch of students for printed papers of the I.P.O.E.E. has been fairly heavy and the library of the Institution has been freely drawn upon.



In a Lecture Room.

The probationers are required while at the School to prepare daily reports bearing upon the lectures, practical work and visits; these are examined by the Officer-in-charge and are returned to the writer for filing as personal notes; suitable loose leaf covers for filing are provided by the Department. The reports are written on foolscap size squared paper, so that freehand sketches can be made quickly and neatly.

The practical work room is equipped with a short pole complete with various standard fittings; a number of sample joints, lengths of cable, samples of "made off" stays, and many special tools are also available. A combined main and intermediate distribution frame is provided; this is cabled and wired by the trainees. A floor pattern P.B.X. and a number of extension instruments are also provided. These are additional to the equipment available in the Automatic School and the Repeater School. The accompanying illustrations will give some idea of the arrangements.

The early part of the morning and afternoon is given up to lectures, the remainder of the time being devoted to practical work, demonstrations and organised reading of Technical Instructions.

An interesting feature of the course is a short reception lecture. This lecture welcomes the probationers, outlines the activities of the Engineering Department, points the way to success in the job, emphasises the need for careful management, both of material and men, indicates the pitfalls, and stresses the need for *service*. This lecture is very greatly appreciated and the newcomer is made to feel that he is joining a great organisation.

Readers of the Journal will appreciate from the following Syllabuses, the extent of the school course. It is recognised, of course, that a detailed knowledge cannot be obtained, but the general survey given by the lectures and the practical work performed, must be of immeasurable value to the Probationer and enable him to get the maximum profit from his District experience.

SYLLABUS A. (4 Lectures).

Reception. Lectures on Organisation.

The functions of the Engineering Department and its relation to other Departments.
Organisation. Engineer-in-Chief's Office, Districts, Sections, Areas.
Territorial and functional organisation in Districts.
Departmental staff tree.
Necessity for co-operation and for co-ordination of works.
Relation with Public Authorities.
Regulations referring :— A^1 to A^4 and D^1.

SYLLABUS B. (10 Lectures).

Telegraph and Telephony. Overhead Construction and Maintenance.

Preservative treatment of poles and timber.
Various types of pole fittings.
Insulators.
Erection of poles.
Distribution of terminal poles.
Properties and use of different types of wire; hard drawn copper, cadmium, copper, bronze, iron and steel.
Suitability and testing of materials employed.
Methods of erecting wires.
Insulated wires used in overhead construction.
Types and use of aerial cables.

Design and construction of aerial cable lines.
Stresses and poles.
Static and kinetic stresses on wires, law connecting dip or sag and stresses.
Factors of safety.
Erection of stays and struts.
Roof standards, brackets and methods of leading in.
Elimination of cross talk by the twist and transposition systems.
Tools and safety appliances; safety first precautions.
Protection from power circuits; power crossings.
Maintenance of overhead lines; Clearing of faults.
Technical Instructions referring :— 3, 8, 13, 15.

SYLLABUS C. (14 Lectures).

Telegraphy and Telephony. Underground Construction and Maintenance.

Iron and earthenware single and multiple way conduits, pipes, bends and couplings.
Troughing.
Manhole and joint box construction.
Types of cables used for trunk and local working.
Construction of leading-in chambers.
Design of dry core and submarine cables.
Jointing wires; twisted, soldered and sleeve joints.
Numbering wires and joints.
Drying joints, plumbing, pressure testing and desiccating.
Installing and joining up loading coils.
Precautions against damage to loading coils.
Precautions against and testing for electrolytic damage to cable sheaths; bonding.
Precautions against interference from power and electric lighting systems.
Divided and multiple way joints.
Termination of trunk and local cables on main frames, on testing tablets and on terminal poles.
Tools and appliances.
Methods of dealing with faults; repairs to cables.
Maintenance organisation.
Safety first precautions.
Development schemes for local telephone areas.
Block wiring.
Technical Instructions referring :— 3, 8, 14, 15, 20.

SYLLABUS D. (15 Lectures).

Telephony. Subscribers' Apparatus. Construction and Maintenance.

Testing and maintenance of Leclanché primary batteries.
The various transmitters and receivers in common use.
Automatic, Central Battery, Central Battery Signalling and Magneto subscribers' instruments.
Extension working (plan numbers).
Automatic and manual branch exchange switchboards.
Power and ringing supply to private branch exchanges.
Party lines.
Call offices.
Common faults experienced.
Maintenance of subscribers' apparatus.
Technical Instructions referring :— 8, 18, 23.

SYLLABUS E. (12 Lectures).

Telephony. Manual Exchanges—Construction and Maintenance.

Magneto, central battery signalling and central battery systems; multiple jacks, operators' telephone circuits, cord circuits, subscribers' and junction circuits.
Main and intermediate distribution frames.
Trunk working.
Layout of exchanges including frames, racks, sections, desks and power plant.
Fault procedure and maintenance organisation.
Exchange transfer procedure.
Technical Instructions referring :— 1, 2, 8, 12, 18, 22, 26, 27.
Circulars E 18, A.T. 103.

SYLLABUS F. (18 Lectures).

Telephony. Automatic Exchanges. Construction and Maintenance.

Reasons for adopting automatic system; advantage and disadvantages; step by step system.
The standard impulse; impulse distortion.
The need for and characteristics of the various tones.
Pre-selectors.
Group and final selectors.
P.B.X. final selectors.
Test and trunk offering arrangements.
Rural automatic exchange apparatus and circuits employed, cabling and wiring, junction arrangements, fault alarm transmissions, call office arrangements, power plant.
Relay design.
Requirements to be met in large (Multi-exchange) areas.
Satellite working; discriminating selectors.
Outline of the director system.
Intercommunication between automatic and manual exchanges.
Call indicator " B " position working.
Key Sender " B " position working.
Straight forward junction working.
Trunking and grading; the traffic unit; grade of service.
Cabling and layout of automatic exchanges.
Fault procedure and maintenance organisation.
Routine testers and routiners.
Fault alarm schemes.
Exchange transfer procedure.
Technical Instructions referring :— 25.
Circulars A.T. 101, 104, 105, 106, 109, 110, 111, 112, 113.

SYLLABUS G. (18 Lectures).

Telephone and Telegraph Transmission.
Section I. Telephony.

The voice and ear in telephony.
Limiting transmission factors, attenuation, distortion and noise.
Units for expression of attenuation and line constants.
Transmission standards. Transmission formulae and their application to design of aerial and underground, trunk, junction, and subscribers' circuits. Coil and continuous loading; loaded line constants and characteristics. Phantom telephone circuits.

The transmission effect of each apparatus component in a transmission circuit with special reference to transmitters, receivers, induction coils, transformers and bridging apparatus.

Equivalent networks, electrical filters.

Transmission testing, alternating current bridges.

Voice-ear comparative tests. Tests of transmission efficiency of subscribers' apparatus.

The nature, cause and measurement of cross-talk.

Telephone repeaters 2-wire, 4-wire and cord circuit types; circuits and signalling arrangements.

Transmission circuits employing repeaters; attenuation at different frequencies, amplification limits, reflection, echo and transient effects, echo suppression, time of transmission, singing test for balance comparison, gain measurements, transmission levels.

Line impedance measurement and calculation of repeater balances. Localisation of impedance irregularities in lines.

Brief outline of carrier frequency telephony.

Trans-Atlantic radio telephone circuits.

Section II. Telegraphy.

Fourier Integral. Its application to telegraph transmission theory.

Limiting transmission factors as regards speed of working on long aerial, underground and submarine telegraph lines. Comparative speeds of telegraph systems.

Simultaneous telegraphy and telephony, (superposed and composited working), filters and smoothing circuits.

Long submarine cables. Earth currents and methods of preventing disturbance therefrom.

Technical Instructions referring :— 19, 20, 21.

SYLLABUS H. (10 Lectures).

Telegraphy. Telegraph Apparatus and Circuits.

Wheatstone's A.B.C., single needle, sounder (ordinary and polarised), keys relays, line galvanometers, and condensers. Wheatstone transmitter, receiver and perforator (including keyboard types); Hughes, Baudot and teleprinter apparatus.

Single and double current duplex, central battery, quadruplex, multiplex, Wheatstone automatic, modern type-printing and concentration systems. Use of one battery for a large telegraph office.

Simplex, duplex and high speed repeaters.

Brief outline of voice-frequency telegraphy and phototelegraphy.

Methods of protecting lines, submarine cables and apparatus from (*a*) Lightning, (*b*) power circuit currents.

Internal wiring of large telegraph offices.

Care and adjustment of sounders, relays, keys, etc. Balancing of duplex circuits. Common faults experienced in telegraph apparatus.

Technical Instructions referring :— 5, 6, 7, 12, 28.

SYLLABUS J. (4 Lectures).

Telegraphy and Telephony. *Power Plant.*

General description and requirements of power plant.

Power distribution leads, cables, permissible potential drop.

Main, distribution and alarm fuses.

Noise elimination from Exchange power supply.

Ringing machines and tone interrupters, automatic ringing change-over arrangements.

Power board layout and instruments, alarm voltmeters.

Types of prime movers and rectifiers used for battery charging.

Maintenance and operation of power plant and secondary cells.

Emergency power arrangements.

Technical Instructions referring :— 24.

SYLLABUS K. (7 Lectures).

Telegraphy and Telephony. Testing methods and procedure.

Fault localisation. Testing methods in use by Post Office.

Routine maintenance testing (morning test) of long distance lines.

Test desk arrangements at telephone exchanges.

Routine testing at repeater stations.

Precision testing for the localisation of faults in underground cables.

Balancing of cables and acceptance tests.

Technical Instructions referring :— 2, 4, 8, 19, 27.

This instruction will be given at the Research Section, Dollis Hill.

SYLLABUS L. (8 Lectures).

Finance and Administration.

Finance. Vote and Telephone Capital Account. Annual Estimate for Budget purposes. The "Commercial Accounts" of the Post Office.

The preparation of works estimates; direct and indirect charges.

The financial authority of Superintending and Sectional Engineers.

Works orders, Annual Works Orders, departures from estimates.

Engineer's Orders and District Engineer's Orders.

Specification and tenders. Supervision of contract works. Reinstatement of pavings. Certification of accounts.

Local Orders.

The control of labour costs; Unit Maintenance and Construction Costs.

Advice Note procedure.

Repayment Works.

Engineering Department's specification and stores acceptance tests.

Stores; requisitions, delivery and transfer notes, maintenance exchange, loans.

Section stocks, normal stocks, pole stocks, plant lists and tool lists.

Correspondence procedure.

Procedure in case of damage to Departmental or other property.

Procedure in connection with accidental cases.

Powers and obligations of Postmaster General under Telegraph Acts; wayleaves.

Board of Trade Regulations, Home Office Regulations, Factory Acts, etc., affecting the Department.

Regulations referring :— B^1 to B^4, C^1, F^1, G^1 to G^6.

Reg. 88 Provincial Advice Note Procedure.

L.E.D. District Circular 11. do.

SYLLABUS M.

Practical Work.

Forming and lacing switchboard cables.
Soldering wires to tags.
Jointing bronze and copper wire.
Dismantling and re-assembling pieces of apparatus, such as dials and switches; adjusting relays and simple mechanism.

The first course under the modified scheme was completed in June and its success was very largely due to the headquarter's officers who were called upon to deliver the lectures; they may be interested to learn that 800 questions were asked by the students, an average of eight per lecture. This does not include the many questions asked at the informal chat which invariably took place, when a lecture was finished.

By a happy coincidence it was possible owing to the kindness of the Western Electric Co., to show the probationers a film, with sound accompaniment, of the laying of the Newfoundland-Azores submarine cable. This was much appreciated.

C.W.B.

OUTLINE NOTES ON TELEPHONE TRANSMISSION THEORY.

W. T. Palmer, B.Sc., Wh. Ex., A.M.I.E.E.

INTRODUCTION.—There are many excellent text-books written in English bearing on the subject of Telephone Transmission. No one can ever absorb all the information he will need, however, on any particular subject, and in the case of Transmission so much valuable literature exists that those students who merely desire to memorise enough in order to find their way about encounter exceeding difficulty in deciding what may be regarded as of primary practical importance and what may be regarded as of secondary importance. It is mainly for those students that the following brief notes have been written and their perusal is intended to bear the same relation to existing literature (see references at the end of each Section) as the reading of a map bears to a journey in a strange country. Even the reading of a map demands some existing knowledge of physical geography on the part of the student and the perusal of these notes requires some mathematical knowledge, since the solutions of transmission problems are, generally speaking, essentially mathematical in character. For this reason, Section I. reviews the principal theorems and formulæ used in the later notes and a knowledge of the elementary mathematics involved therein should form part of the mental equipment of the intending student of Telephone Transmission at the outset. Section I. also introduces the conventions and symbols which will be adopted in the subject matter of subsequent sections.

Section I.

(*a*) *The Binomial Theorem* states that:—

$$(a+x)^n = a^n + na^{n-1} \cdot x + \frac{n(n-1)}{\lfloor 2} \cdot a^{n-2} \cdot x^2 + \frac{n(n-1)(n-2)}{\lfloor 3} \cdot a^{n-3} \cdot x^3 + \ldots\ldots$$

This is true for all values of n. If n be positive, the right hand side contains $(n+1)$ terms. If n be negative, the number of terms is infinite. Writing $a = 1$ we get:—

$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)}{\lfloor 2} \cdot x^2 \pm \frac{n(n-1)(n-2)}{\lfloor 3} \cdot x^3 + \ldots\ldots$$

Further, if $x \rightarrow$ zero (if x approaches zero), we get the much used approximation:—

$$(1 \pm x)^n \fallingdotseq 1 \pm nx$$

(*b*) *The Exponential Theorem* states that:—

$$a^x = 1 + x \log_e a + \frac{x^2}{\lfloor 2} \cdot (\log_e a)^2 + \frac{x^3}{\lfloor 3} \cdot (\log_e a)^3 + \ldots\ldots$$

where $e = 1 + 1 + \frac{1}{\lfloor 2} + \frac{1}{\lfloor 3} + \ldots\ldots\ldots\ldots,$ the base of natural or Napierian logarithms.

This Theorem can be derived directly from the Binomial Theorem and the following are the chiefly used forms:—

$$e^{\pm x} = 1 \pm x + \frac{x^2}{\lfloor 2} \pm \frac{x^3}{\lfloor 3} + \frac{x^4}{\lfloor 4} \pm \ldots\ldots$$

and $\log_e (1 \pm x) = \pm x - \frac{x^2}{2} \pm \frac{x^3}{3} - \frac{x^4}{4} \pm \ldots\ldots$

which is true when $x < 1$.

(*c*) *De Moivre's Theorem* states that:—

$$(\cos x \pm j \sin x)^n = \cos nx \pm j \sin nx = e^{\pm jnx}$$

where j stands for the imaginary quantity $\sqrt{-1}$. This is true for all values of n. Hence when $n = 1$, we get:—

$$\left.\begin{aligned} e^{jx} &= \cos x + j \sin x \\ \text{and} \quad e^{-jx} &= \cos x - j \sin x \end{aligned}\right\}$$

which are two very important relationships used to a large extent in ordinary classic Transmission Theory. These two relationships can also be derived directly from a consideration of the Exponential Theorem and the expansions of $\sin x$ and $\cos x$ in powers of x.

(*d*) *The Hyperbolic Functions* are:—

The hyperbolic cosine of $x = \frac{e^x + e^{-x}}{2}$

and is written—

$$\cosh x = \frac{e^x + e^{-x}}{2}$$

The hyperbolic sine of $x = \frac{e^x - e^{-x}}{2}$

and is written—

$$\sinh x = \frac{e^x - e^{-x}}{2}$$

The hyperbolic tangent of $x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$

and is written—

$$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

From De Moivre's Theorem we have:—

$$\cos x = \frac{e^{jx} + e^{-jx}}{2} \text{ and } \sin x = \frac{e^{jx} - e^{-jx}}{2j}$$

Writing jx for x we get:—

$$\cos jx = \frac{e^x + e^{-x}}{2} \text{ and } \sin jx = \frac{-e^x + e^{-x}}{2j}$$
$$= \frac{j(e^x - e^{-x})}{2}$$

Hence by the foregoing definitions of the hyperbolic functions we have:—

$$\left.\begin{aligned} \cosh x &= \cos jx \\ j \sinh x &= \sin jx \\ j \tanh x &= \tan jx \end{aligned}\right\}$$

and also:—

$$\left.\begin{aligned} \cosh jx &= \cos x \\ \sinh jx &= j \sin x \\ \tanh jx &= j \tan x \end{aligned}\right\}$$

These form the principal relations between the trigonometrical and hyperbolic functions.

From these relationships it is possible to convert an expression containing hyperbolic functions into one of ordinary trigonometrical functions, or *vice versa,* and frequent use is made of such conversions. (See paragraph (*g*)).

Fig. **1** shows curves of the hyperbolic functions and one of the most important features shown by these curves is that *for values of* $\theta \geqslant 2$ *we have* $\tanh \theta \fallingdotseq 1$ *and* $\sinh \theta \fallingdotseq \cosh \theta$.

(*e*) *Vector Quantities.*

All quantities can be divided into two main classes viz., scalar and vector. The former have magnitude only, but the latter possess in addition to magnitude, three other important attributes—

(1) Point of application.
(2) Direction or line of action.
(3) Sense or way along that line.

The essential feature of vector quantities is *direction.* All other quantities are scalar as they can be drawn to scale but do not involve direction, *e.g.,* mass, length, volume, etc. Examples of vector quantities are force, velocity, momentum, electric current and potential, etc.

A vector quantity can be completely represented by a straight line such as OP, Fig. **2**(*a*), where ● is the point of application, the length OP to scale represents the magnitude in units of the quantity considered, the angle θ gives the direction with respect to a fixed line OX and the arrow gives the sense or way along the line OP.

If the length of OP contains A units we repre-

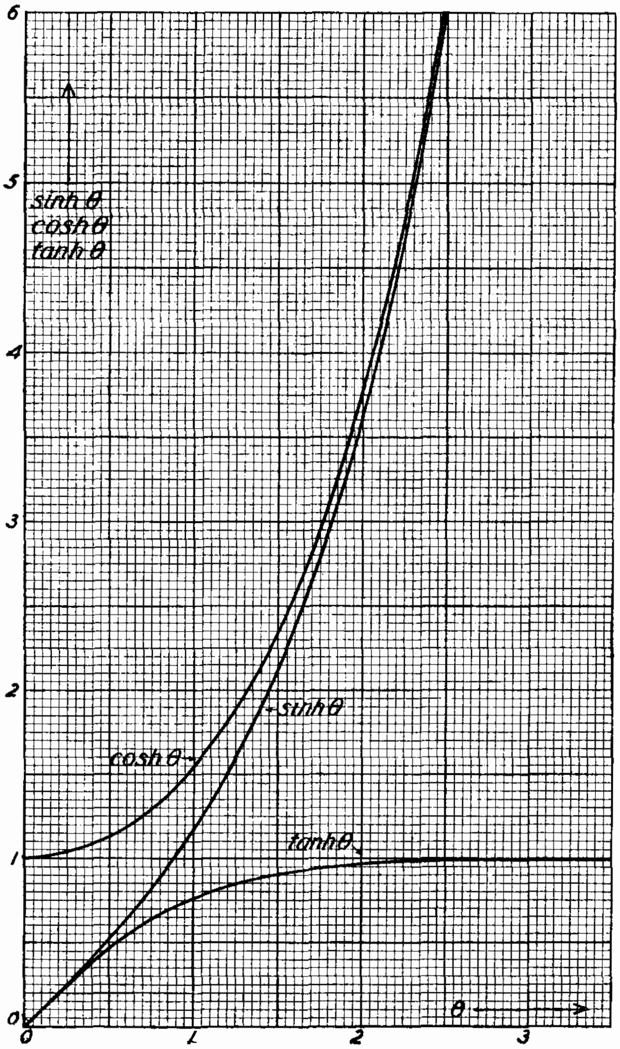


FIG. 1.—CURVES OF SINH θ, COSH θ AND TANH θ.

sent the vector shown in Fig. 2(a) by the symbol :—

$$A, \theta \text{ or } A \,\underline{|\theta}$$

If OP is in the position shown in Fig. 2(b) we represent such a vector by the symbol—

$$A, -\theta \text{ or } A \,\overline{|\theta}$$

In other words, a clockwise rotation from OX is said to generate a positive angle and an anti-clockwise movement a negative angle.

A is called the *modulus* of the vector and θ the *argument*.

Consider Fig. 2(a) and imagine OP to rotate clockwise with uniform angular velocity ω radians per second and that OP is in the position

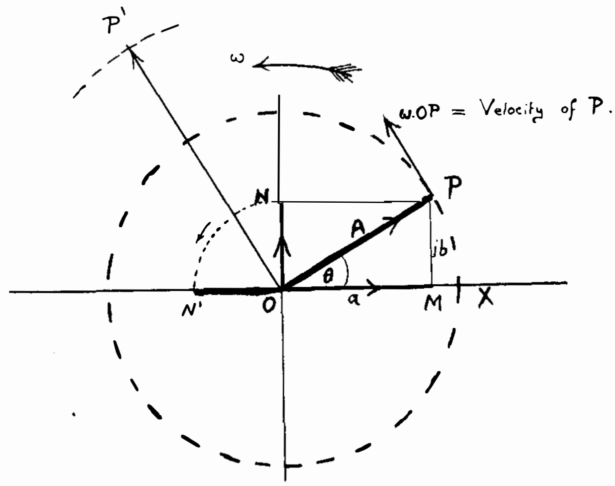


FIG. 2(a).

OP represents a vector quantity of magnitude A, having direction θ with the fixed line OX, the symbolical representations being shown in Table I., first column : $A = \sqrt{a^2 + b^2}$.

shown after t seconds from the initial or zero position OX, *i.e.*, $\theta = \omega t$. Now resolve OP into horizontal and vertical components OM and ON respectively. If OM = a units, ON = b units, then the vector OP = A units can be also represented by the symbols—

$$\sqrt{a^2 + b^2} \,\underline{|\omega t} \text{ or } a + jb$$

where j signifies a positive movement of $\frac{\pi}{2}$ *radians for b and* $\tan \omega t = \frac{b}{a}$

By considering paragraph (c) and the expression—

$$e^{jx} = \cos x + j \sin x,$$

and since $a = A \cos \omega t$, $b = A \sin \omega t$ one can represent the vector OP mathematically by yet another symbol, viz.,

$$Ae^{j\omega t} \text{ or } \sqrt{a^2 + b^2} \,.\, e^{j\omega t}$$

which constitutes a very important form and one which enables many vector operations to be performed more rapidly than by the use of the form $a + jb$.

Similarly if OP is in the position shown in Fig. 2(b) we represent it symbolically by

$$\sqrt{a^2 + b^2} \,\overline{|\omega t} \text{ or } a - jb$$

where $-j$ signifies a negative movement of

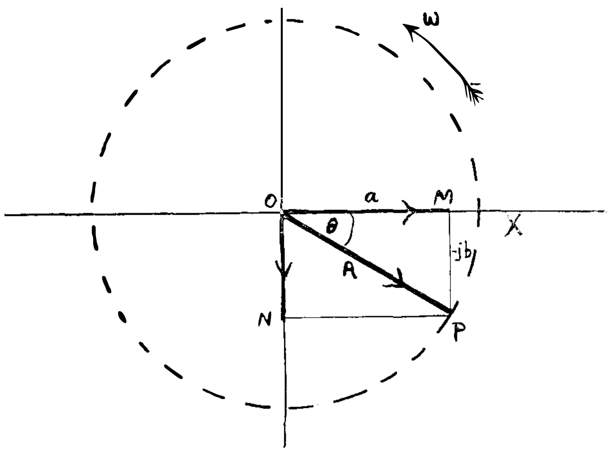


FIG. 2(*b*).

OP represents a vector quantity of magnitude A, having direction $-\theta$ with the fixed line OX, the symbolical representations being shown in Table I., second column : $A = \sqrt{a^2 + b^2}$.

$\frac{\pi}{2}$ *radians for b and tan* $\omega t = \frac{b}{a}$, and in this case the vector OP can be also represented mathematically by the symbol :—

$$Ae^{-j\omega t} \text{ or } \sqrt{a^2+b^2} \,.\, e^{-j\omega t}$$

NOTE.—Any symbol could be used to denote that b were turned through $+90°$ from the direction OX. Thus suppose we let ON $\equiv \eta b$ in Fig. **2**(*a*) where η denotes for b a clockwise rotation of 90° from the direction OX. Then, by this convention, η ON denotes that ON is turned through a further $\frac{\pi}{2}$ radians, and we come to the position $ON^1 = -b$, *i.e.*, $\eta(\eta b) = -b$, *i.e.*, $\sqrt{-1} \times \sqrt{-1} \times b$. Hence the effect of the operation with η (rotation through 90°) can be considered as mathematically equivalent to multiplication by $\sqrt{-1}$. But the usual mathematical symbol for the imaginary quantity $\sqrt{-1}$ is j (see paragraph (*c*)), and therefore it is customary to use j to denote the geometric operation of rotation through 90°.

To summarise the various ways by which a vector may be represented, other than by an actual line, Table I. has been drawn up showing the five principal symbolic methods. The third column indicates the vector operations for which the form is best suited and the following paragraph summarises the principal vector operations required.

TABLE I.

VECTOR REPRESENTATION BY SYMBOLS.

Positive Angles.	Negative Angles.	Suitable for :—
$a + jb$ $\sqrt{a^2+b^2}\,(\cos \omega t + j \sin \omega t)$	$a - jb$ $\sqrt{a^2+b^2}\,(\cos \omega t - j \sin \omega t)$	Addition and subtraction.
$\sqrt{a^2+b^2}\,.\,e^{j\omega t}$ or $A\,.\,e^{j\theta}$ or $\sqrt{a^2+b^2}\;\underline{/\theta}$	$\sqrt{a^2+b^2}\,.\,e^{-j\omega t}$ or $A\,.\,e^{-j\theta}$ or $\sqrt{a^2+b^2}\;\overline{/\theta}$	All operations, except addition and subtraction, such as multiplication, division, etc.—See paragraph (*f*).
$\sqrt{a^2+b^2}\,\tan^{-1}\frac{b}{a}$	$\sqrt{a^2+b^2}\,\tan^{-1} -\frac{b}{a}$	—

(*f*) *Simple Vector Operations.*

(1) *Addition of Vectors* :—

$$(a+jb)+(c+jd)=(a+c)+j(b+d)$$
$$=\sqrt{(a+c)^2+(b+d)^2}\;\underline{/\tan^{-1}\left(\frac{b+d}{a+c}\right)}$$

(2) *Subtraction of Vectors* :—

$$(a+jb)-(c+jd)=(a-c)+j(b-d) \text{ or}$$
$$=(a-c)-j(d-b)$$
$$=\sqrt{(a-c)^2+(b-d)^2}\;\underline{/\tan^{-1}\left(\frac{b-d}{a-c}\right)}$$

(3) *Multiplication of Vectors*:—

$(a + jb)(c + jd)$ must be thrown into the form $Ae^{j\theta} \times Be^{j\phi}$ which gives the single resultant vector—

$$AB\, e^{j(\theta + \phi)}$$

Hence the rule—"*Multiply* the moduli and *add* the arguments."

(4) *Division of Vectors*:—

As before we write $(a + jb) \div (c + jd) = \frac{Ae^{j\theta}}{Be^{j\phi}}$ which gives the single resultant vector—

$$\frac{A}{B} \cdot e^{j(\theta - \phi)}$$

Hence the rule—"*Divide* the moduli and *subtract* the arguments."

(5) *Involution and Evolution of Vectors*:—

$(a + jb)^n = A^n e^{jn\theta}$

$\sqrt[n]{(a + jb)} = \sqrt[n]{A} \cdot e^{j\frac{\theta}{n}}$ *e.g.*, If $n = 2$ this becomes $\sqrt{A} \cdot e^{j\frac{\theta}{2}}$.

Hence to take the square root of a vector—"Obtain the *square root* of the modulus and *halve* the argument."

$$\frac{(a + jb)^n}{\sqrt[m]{(c + jd)}} = \frac{(A \cdot e^{j\theta})^n}{(B \cdot e^{j\phi})^{\frac{1}{m}}} = \frac{A^n}{\sqrt[m]{B}} \cdot e^{j\left(n\theta - \frac{\phi}{m}\right)}$$

(6) *Differentiation of Vectors*:—

$\frac{d}{dt}(Ae^{j\omega t}) = j\omega A \cdot e^{j\omega t}$ and $\because j$ when written in the $a + jb$ form $= 0 + j.1$, which is $= e^{j\frac{\pi}{2}}$, this expression becomes—

$$\omega A \cdot e^{j\left(\omega t + \frac{\pi}{2}\right)}$$

which is another vector 90° of phase ahead of $Ae^{j\omega t}$ and ω times its amplitude.

NOTE.—It is interesting to note that this result can be obtained directly from consideration of the diagram shown in Fig. **2**(*a*) where the rate of change of OP with regard to time is at any instant equal to ω . OP, is tangential as shown by the line PV, *i.e.*, a vector 90° ahead in phase and ω times the amplitude OP, and can be represented by a line to scale such as OP′ at right angles to OP, where OP′ = ω . OP.

(7) *Integration of Vectors*:—

$$\int Ae^{j\omega t} \cdot dt = \frac{A}{j\omega} \cdot e^{j\omega t} = -j\frac{A}{\omega} \cdot e^{j\omega t}$$
$$= \frac{A}{\omega} \cdot e^{j\left(\omega t - \frac{\pi}{2}\right)}$$

which is another vector 90° behind $A \cdot e^{j\omega t}$ and $\frac{1}{\omega}$-times its amplitude.

This result can be obtained by consideration of Fig. **2**(*a*), where the time integral of the vector OP′ is OP, which is a vector 90° behind the phase of OP′, and OP = $\frac{1}{\omega}$. OP′.

(8) *Logarithm of a Vector*:—

$$\log_e(a + jb) = \log_e A \cdot e^{j\theta}$$
$$= \log_e \sqrt{a^2 + b^2} \cdot e^{j\tan^{-1}\frac{b}{a}}$$
$$= \log_e \sqrt{a^2 + b^2} + j\tan^{-1}\frac{b}{a}$$

which is a vector expressed in the form $a + jb$.

(*g*) *Hyperbolic Trigonometry.*

The hyperbolic functions are analogous functions of the area of the hyperbolic sector, to the functions which ordinary trigonometrical ratios bear to the area of the sector of a circle. Thus we have:—

(1) Referring to Fig. **3**(*a*):—

Area of the circle .—... $\frac{x^2}{a^2} + \frac{y^2}{a^2} = 1$

θ (radians) .... $\frac{2 \times \text{area of sector}}{a^2}$

$\sin\theta = \frac{y}{a} = -\frac{1}{2}j(e^{j\theta} - e^{-j\theta})$; $\cos\theta = \frac{x}{a} = \frac{1}{2}(e^{j\theta} + e^{-j\theta})$:

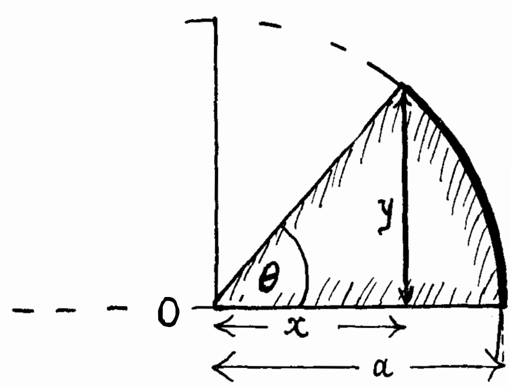


FIG. **3**(*a*).

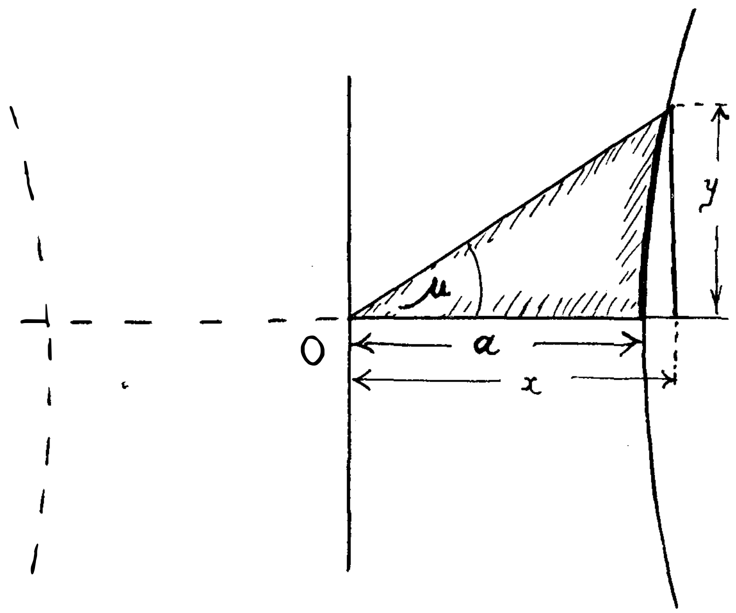


FIG. 3(*b*).

(2) Referring to Fig. 3(*b*) :—

Area of hyperbola ...... $\frac{x^2}{a^2} - \frac{y^2}{a^2} = 1$

μ (hyps) .... $\frac{2 \times \text{area of sector}}{a^2}$

Sinh $\mu = \frac{y}{a} = \frac{1}{2}(e^{\mu} - e^{-\mu})$; cosh $\mu = \frac{x}{a} = \frac{1}{2}(e^{\mu} + e^{-\mu})$

The following list is intended as a resumé of only the principal hyperbolic trigonometrical formulæ used in the solution of transmission problems and which should be committed to memory. For the numerous other formulæ and proofs reference should be made to the text-books indicated at the end of the Section. It will be noticed that similarity exists between the hyperbolic and trigonometrical formulæ, except for sign in some cases.

Principal Hyperbolic Relations required :—

1. Sinh $(a \pm b)$ = sinh a cosh b $\pm$ cosh a sinh b

2. Cosh $(a \pm b)$ = cosh a cosh b $\pm$ sinh a sinh b

3. Tanh $(a \pm b) = \frac{\tanh a \pm \tanh b}{1 \pm \tanh a \tanh b}$

Complex Hyperbolic Angles :—

4. Sinh $(a \pm jb) = \sqrt{\sinh^2 a + \sin^2 b} \; \angle \tan^{-1}\left(\frac{\tan b}{\tanh a}\right)$

5. Cosh $(a \pm jb) = \sqrt{\sinh^2 a + \cos^2 b} \; \angle \tan^{-1} (\tan b \tanh a$

6. Tanh $(a \pm jb)$ when required is best evaluated from the values of sinh $(a \pm jb)$ and cosh $(a \pm jb)$, thus :—

$$\tanh (a + jb) = \sqrt{\frac{\sinh^2 a + \sin^2 b}{\sinh^2 a + \cos^2 b}} \; \angle \tan^{-1} \left(\frac{\frac{\tan b}{\tanh a} - \tan b \tanh a}{1 + \tan^2 b} \right)$$

In (4), (5) and (6) the complex angle is expressed on the right hand side as an ordinary vector quantity, easily interpretable physically, and in the form necessary for the evaluation of numerical examples.

Useful Text-books and References for Section 1.

" Plane Trigonometry " (Parts I. and II.), by S. L. Loney. Published by Cambridge Univ. Press.

" Elementary Algebra " (Parts I. and II.), by W. M. Baker and A. A. Bourne. Published by G. Bell & Sons.

"Elementary Treatise on Conic Sections," by C. Smith. Published by McMillan & Co., Ltd., *or*

"Elements of Co-ordinate Geometry," by S. L. Loney. Published by McMillan & Co., Ltd.

"First Steps in the Calculus," by A. F. Van Der Heyden. Published by Edward Arnold, London.

"Differential Calculus for Beginners," by J. Edwards. Published by McMillan & Co., Ltd.

"Integral Calculus for Beginners," by J. Edwards. Published by McMillan & Co., Ltd.

"Elementary Treatise on Differential Equation," by H. T. H. Piaggio. Published by G. Bell & Sons, London.

"Vector Analysis," by J. G. Coffin. Published by John Wiley & Sons, New York, and Chapman & Hall, Ltd., London.

"Heaviside's Electromagnetic Theory," Vol. I., Chapter III. Published by "The Electrician" Co.

"Alternating Currents," by A. Hay. Published by Harper & Bros., London and New York.

"Hyperbolic Trigonometry," by E. W. Hobson.

For those students not familiar with simple vector operations it is advisable to work concrete examples from some other branch of Science, say, Mechanics—force, velocity, etc.—before applying the principles to the electric circuit. In this connection the following references contain useful information:—

"Applied Mechanics for Beginners," by J. Duncan. Published by McMillan & Co., Ltd.

"Mechanics for Engineers," by A. Morley. Longmans, Green & Co.

HEADQUARTER'S NOTES.

EXCHANGE EQUIPMENT.

The following works have been completed:—

Exchange.	Type.	No. of Lines
Welbeck	New Auto.	8060
Carlton	,,	635
Arnold	,,	450
Beeston	,,	730
Bulwell	,,	540
Addiscombe	,,	2700
Blackpool North Shore ...	,,	785
Blackpool South Shore ...	,,	1745
Fairfield	,,	2700
Rochford	,,	200
Southend	Auto Extn.	Obsn. Equipt.
Portslade	,,	300
Hindhead	New Manual	650
Romford	,,	1780
Scotstoun	,,	2200
Jesmond	Manual Extns.	600
Eastbourne	,,	2120
Didsbury	,,	900
Wembley	,,	1340
Popesgrove	,,	1420
Guildford	,,	940
Rockferry	,,	1040
Woking	,,	400
Cambridge	,,	1480
Lanarkshire C.C.	P.A.B.X.	30
Hollins & Co.	,,	30
Reading University	,,	20
C. Lloyd	,,	20
Strachan & Co.	,,	20
Constructors, Ltd.	,,	20
Crowe & Co.	,,	20
Johnson & Johnson	,,	30

Orders have been placed for the following works:—

Exchange.	Type.	No. of Lines
Rhos	New Auto.	900
Liberton	,,	350
Perivale	,,	4460
Reliance Tandem	,,	—
Colinton	,,	590
Prospect	,,	5700
St. Helens	,,	2100
Prescot	,,	380
Evington	,,	800
Byron	,,	2200
Bedford	Auto Extns.	200
Portslade	,,	300
Western Park	,,	300
Hove	,,	900
Ewell	New Manual	1220
Downland	,,	1000
Eccles	Manual Extn.	560
Bradbury Agnew	P.A.B.X.	Re-arrangements
Johnson & Johnson	,,	30
Price Taylor	,,	20
Widnes Corporation	,,	30
Allmey & Layfield	,,	—

New Rural Automatic Exchanges continue to be opened at the rate of about 10 per month. In the next issue of the Journal it is proposed to include an account of this interesting feature of British telephone progress.

LONDON AND OTHER DISTRICT NOTES.

LONDON DISTRICT.

Growth of Telephone System.

During the quarter ended June 30th, 1930, the nett increase in Exchange lines and Stations was 5,045 and 9,459 respectively. During the same period there was an increase in the local line mileage of 19,300 miles of loop, of which 50 miles were overhead.

New Exchanges.

During the quarter the following automatic exchanges were opened:—

Addiscombe with an initial capacity of 3390 lines
Shepherds Bush ... ... 4000 lines
Fairfield (Croydon) ... ... 2820 lines

The last named exchange is the first to be equipped with meters for registering excess fee calls.

A new C.B. exchange with an initial capacity of 1,020 lines has been opened at Loughton to replace a Magneto Exchange.

It is unique to record the opening in the London Area of a rural automatic exchange. This is situated in a truly rural area—so much so that it was decided not to place a kiosk on the site but to erect it about a quarter of a mile away. The exchange is situated near Passingford Bridge which is on the London-Ongar road three miles beyond Abridge, Essex, and was opened for traffic on Monday, August 18th.

The building is of standard construction and is equipped with one " Unit Auto No. 5." The actual transfers to the new exchange were five subscribers—four from Loughton Exchange and one from Chigwell Exchange—but the exchange opened with ten new subscribers and a Kiosk, making 16 working lines in all. Two junctions are provided to the " parent " exchange at Theydon Bois which is approximately five miles distant.

New T.S.B. Test Room.

Many Engineers throughout the country are familiar with the Test Room in the basement of the Central Telegraph Office, and will therefore be interested in the changes which have recently been made.

The old test room had been in existence for over 30 years and although various modifications were made as necessary in order to adapt it to changing conditions it was realised that the limit of adaptation had been reached, and it was determined to remodel the whole lay-out in a new test room.

The main frame in this test room accommodates the whole of the main and local telegraph and phonogram lines terminated in the C.T.O., a large number of through telegraph and exchange junction circuits and all headquarters exchange lines and telephone extensions connected to the " Official " P.A.B.X.

Two specially designed test desks, each of two positions, have been installed to deal with the telegraph line testing work. The desks are equipped with the usual testing keys, plugs, lamp indicators, voltmeters, but in addition have milliammeters and telegraph galvanometers. The circuits are of course adapted to the special requirements of telegraph circuit testing.

In the new test room is also housed the main chronopher and the sub-chronopher controlling the International Time Signal sent out by radio from the Rugby transmitter.

The transfer of the chronopher and its subsidiary apparatus had to be carried out between two consecutive transmissions of the time signal. This involved much preparation as high precision control clocks had to be shifted to the new room between one hourly signal and the next so that the correction from Greenwich Observatory would not be missed.

The chronopher signalling apparatus was transferred intact, but the connections for the many time and clock circuits and power feeds had to be completed first for the next hourly signal and then for the next International signal. The work was carried through without a hitch.

Excavations in London Wall.

In connection with the growth of the telephone system it has recently been necessary to make excavations in the historic thoroughfare known as London Wall. It was known that somewhere beneath the surface were the remains of the wall which was built by the Romans to surround the ancient City of London although its exact position was uncertain.

Added interest was therefore given to recent duct laying operations by Messrs. Greig and Matthews, the Department's Contractors, who found it necessary to tunnel through a section of the Roman Wall before they could obtain a clear route for a section of 16 octagonal ducts. It is doubtful whether so much of the original Roman masonry and tiling has been brought up to the surface before at one spot and budding archæologists who were members of City Offices had golden opportunities of closely examining some samples of Roman building material.

The tunnelling operations through the wall commenced from the manhole at the junction of London Wall and Moorgate Street at a depth of about 11 feet and extended some 46 feet diagonally through the wall in the direction of Wormwood Street. The wall at this point lies just below the carriageway foundation on the North side of London Wall. It is four feet thick and formed of irregular blocks of Kentish rag stone firmly bound together in a mortar composed of lime and small flints. At roughly each $2\frac{1}{2}$ feet height of wall a layer of three tiles mortared one over the other runs along the entire length, forming a strong course, the tiles being large ones of $17\frac{1}{2}'' \times 12\frac{1}{4}''$ and $1\frac{1}{2}''$ thick. The depth of the wall, or rather height, if it were completely exposed, is not recorded so far as this end of London Wall is concerned, but some time ago building excavations farther along London Wall disclosed the base of the wall at a depth of 30 feet below the street level.

Exposed sections of the Roman Wall in London Wall itself can be seen at All Hallows Church at the Wormwood Street end and at St. Alphage Burial Ground at the Wood Street end.

The subsoil of London Wall is now so congested with sewers and mains of the various undertakers that it is a physical impossibility to lay any more conduits at a reasonable depth unless the course of the Roman Wall is completely followed—a pleasant prospect for the next undertaking that requires mains along this route.

Pneumatic Tubes—Localisation tests for stoppages under the streets.

Although it is generally known that there is a pneumatic tube system under the streets of London for the conveyance of telegraph messages it may be a surprise to many to know that the total length of these tubes exceeds seventy miles. Special precautions are taken when the tubes are laid to ensure that the carriers will pass freely, but faults occur at times owing to the operations of other undertakings causing a fracture or indentation of the tube which is not immediately revealed. A stoppage may also be caused by a defective carrier which sticks in the tube.

It is of importance to locate quickly the exact locality of the stoppage as, apart from the delay to the messages contained in the defective carriers, the tube cannot be used for the despatch of other messages until the defect has been remedied.

A brief description of the method of locating the position of a stoppage may therefore be of interest:—

The apparatus utilised consists of a standard carrier made captive by attaching thereto a length up to eight hundred yards of strong twine wound on a reel similar to that used by anglers and mounted on a small iron frame. An approximation to ascertain in which section of the tube the obstruction exists is first made by sending a free carrier to the fault on pressure or vacuum, and timing it back on vacuum or pressure, the normal transit time for the whole length being already known. The captive carrier is then inserted at a test point nearest to the faulty section and blown or sucked, as the case may be, to the point of the obstruction. The length of string run out is then measured and a street opening made at the point thus found.

Judging by the results obtained by this method, the test may be regarded as a most reliable one. For example two street faults were recently cut out of a tube and the distances indicated from the testing points were 90 and 111 yards respectively. In each case the fault was found at the exact point where the ground was first opened.

The position of a bad leak in a street tube is determined by sealing the far end and allowing the captive carrier to travel to the leak under pressure. If the carrier should travel beyond the leak this will be indicated by the lessened pull on the string which takes place as soon as the leak is passed. The distance to the fault is then found by measuring the string in the same manner as for a tube obstruction.

In order to make these tests it is necessary to have suitable test points on the tubes. At least one such point is provided on all London street tubes and where the tubes run through manholes, pavement boxes, subways and other accessible positions additional test points are available. This naturally simplifies the tests especially in regard to leak faults as the variation in the pull in the string is less easily detected after 400 or 500 yards have been run out.

Promotion.

Mr. W. Day has been promoted to Executive Engineer and transferred to Gloucester. During his period of service in the London Engineering District Mr. Day made many friends and he carries their good wishes with him to his new sphere. Mr. Day will be greatly missed at Institution meetings, Debating Societies and other places where men gather to speak.

Visit to America.

The Superintending Engineer of the London Engineering District is now in the United States where he is examining the methods of providing telephone plant and other matters relating to telephones.

Voice Frequency Key Sending from "A" Positions.

An experimental equipment for a new method of key sending from the "A" positions at manual exchanges direct into the switches at automatic exchanges has been installed at Clerkenwell manual exchange to work into National automatic exchange.

This method uses voice frequency currents of four different frequencies within the range of 425 to 935 cycles per second, for transmitting coded pulses over the junction loop. The frequencies are used either singly or in combinations to obtain the code equivalent of the numerical digit 1 – 0.

The voice frequency currents are received at the automatic exchange on reed tuned relays, designed and manufactured by the Standard Telephone and Cables Company, one relay being provided for each frequency.

The operation of these relays either singly or in combination operates in turn a sender of the standard 4-digit type in a similar manner to the operation of the sender direct from a digit key on a key sender "B" position. The experimental equipment has been installed at five "A" positions at Clerkenwell from which public traffic is routed over junctions worked on the straightforward method into the senders and selectors at National.

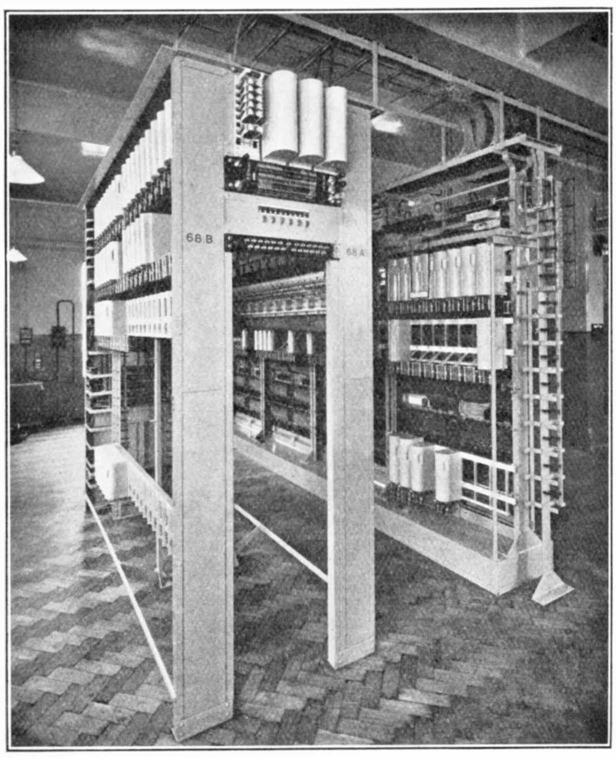
Very satisfactory results have been obtained. Calls completed at the first attempt with the new method have averaged 87.8%.

NORTH MIDLAND DISTRICT.

Four New Strowger Satellite Exchanges for Nottingham.

It was two and a half years ago that Nottingham Telephone subscribers were first inducted into the benefits of Automatic Dial Telephones with the official cut-over of new Automatic exchanges at Central, Sherwood, Arkwright Street, and Basford, totalling 12,500 lines.

These four exchanges were equipped for the British Post Office by Automatic Telephone Manufacturing Company Ltd., Strowger Works, Liverpool, and to them have now been added



Arnold Satellite Exchange: Nottingham.

four additional Strowger satellite exchages—Arnold, Beeston, Bulwell, and Carlton, equipped by the same Company.

All four exchanges are designed to operate on the 5-digit system, and are equipped with homing rotary lineswitches, and discriminating selector repeaters.

The respective capacities are as follows :—

			Present.	*Ultimate.*
Arnold	...	...	500	1400
Beeston	...	...	900	3000
Bulwell	...	...	600	1400
Carlton	...	...	700	2100

All four are satellites to the Main or Central Exchange, the principle of operation being as follows :—

When a subscriber removes his receiver preparatory to dialling he operates the associated line relay. This, in turn, immediately rotates the rotary lineswitch from its home position until it locates a contact connecting with a disengaged discriminating selector repeater.

This found, the lineswitch ceases to hunt and the cut-off relay extends the loop to the discriminating selector repeater. Associated with the latter is a junction finder rotary lineswitch which immediately hunts for a disengaged junction to central.

When found, dial tone is automatically returned to the caller, signalising that dialling may commence.

The whole of the foregoing action takes place within the brief period between lifting the receiver and locating the first digit preparatory to dialling.

Dialling the first digit raises two selector shafts simultaneously to the corresponding level, viz., that of the discriminating selector repeater at the local exchange and that of the first group selector associated with the seized junction at Central. The wipers of both switches then automatically rotate; that of the discriminating selector repeater releases, whilst the first selector at Central hunts for an outlet to a disengaged second selector.

Dialling the second digit again operates the discriminating selector repeater, together with the second group selector at Central. Both shafts rotate.

Should the first two digits imply a local call, the discriminating selector repeater will hunt over the corresponding level for a disengaged third group selector in the local exchange. Simultaneously the junction loop to Central is opened, releasing all switches held there.

The call now proceeds in the usual way, the third, fourth and fifth digits dialled operating the third group and final selectors respectively.

Alternatively, in the case of a call for a number associated with another exchange, having reached the stage of the second digit at which both the shafts of the local discriminating selector repeater and of the second selector at Central are stepped to the same level, the former remains in this position, the local switch simply acting as a repeater for the remainder of the digits dialled, which operate the distant third group and final selectors in the usual way.

Removal of his receiver by the called subscriber reverses the battery on the lines between the final selector and the discriminating selector repeater, thereby causing the meter to operate and record the call against the caller.

Should all junctions to central be engaged the junction finder rotary lineswitch will rotate to its 24th contact and dial tone will be returned to the caller. In the event of a local number being dialled, the call will proceed as usual, but in the case of a call for a number on another exchange, busy tone will be returned after dialling the second digit.

In the case of P.B.X. lines, dialling the first number of the group ensures automatic hunting for a disengaged line and ultimate connection and ringing over that line when found.

Enquiries, trunks, phonograms, etc., are handled by manual operators at Central, whose services are enlisted by dialling " O."

Junctions incoming from other automatic exchanges in the area terminate on third selectors in these satellite exchanges, as do also direct junctions from the manual switchboard at Central. Thus the operators can obtain access to any subscriber by dialling three digits only.

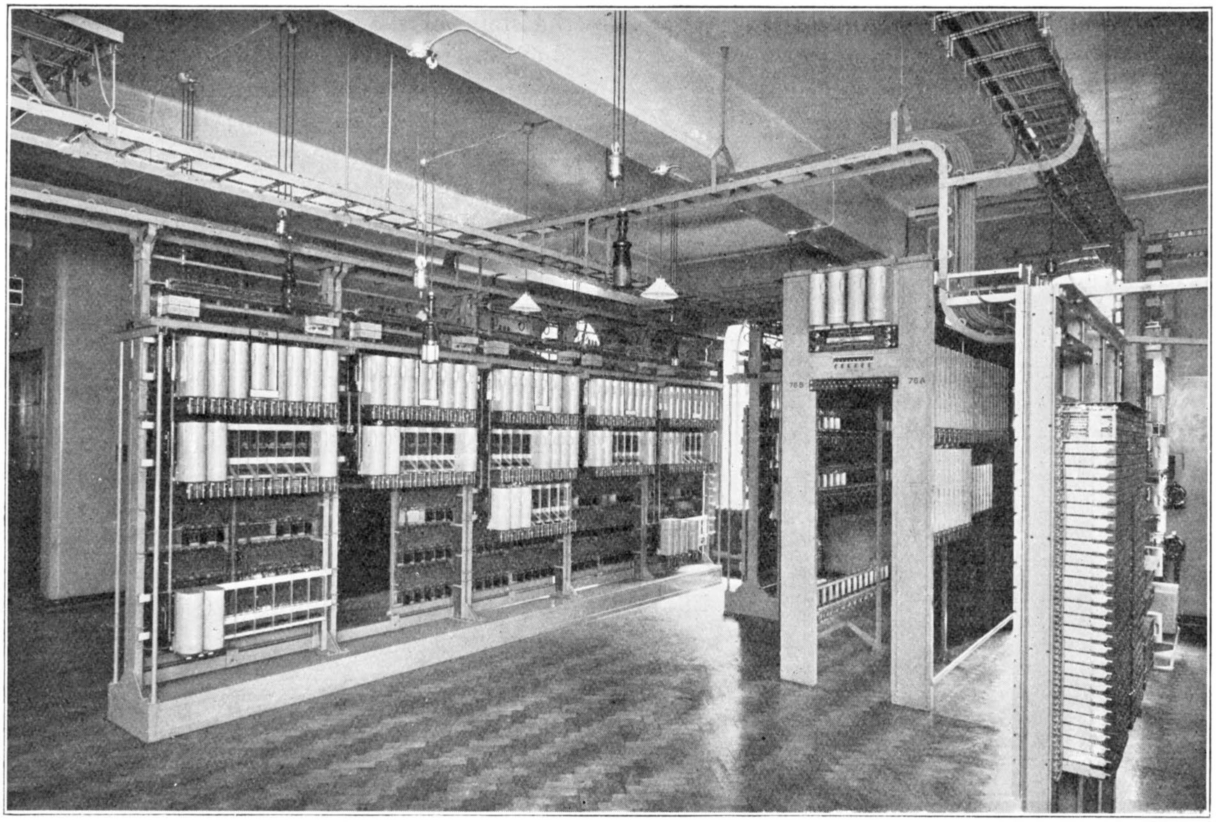
The two preliminary digits for each of the four exchanges are: Arnold 68, Beeston 54, Bulwell 78, and Carlton 58.

The equipment of the satellite exchanges comprises regular and P.B.X. Lineswitch and Final Selector units equipped to the complement of their respective initial capacities, together with composite trunk boards mounting the discriminating selector repeaters and their associated junction finder lineswitches on the " A " side, and on the " B " side, group selectors and coin box repeaters.

Auxiliary equipment comprises M.D.F., Meter Rack, O.G.P. Link Frame, and Test Jack Frame.

Generators of appropriate output, with voltage regulation between 50 and 67 volts.

Control of this plant is from Generator panels mounting ammeter, voltmeter and multi-way switches facilitating readings at various points; generator field rheostat, S.P. circuit breaker, and the usual charge and discharge switches.



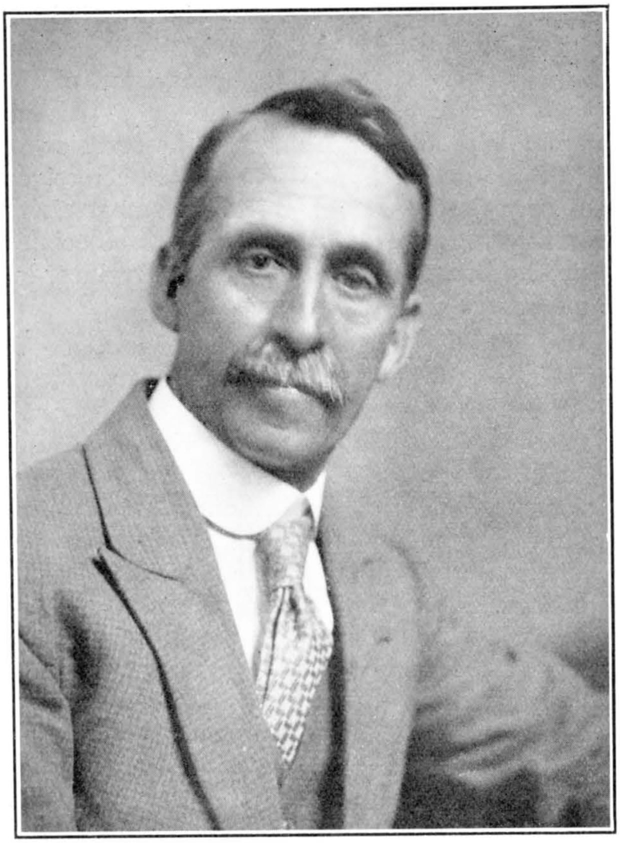
Bulwell Satellite Exchange: Nottingham.

The Power equipments for supplying current to operate the automatic exchange equipment and to energise the subscribers' telephones comprise, in each case, duplicate main batteries of Alton Battery Company manufacture, each battery comprising 25 cells, of an ampere-hour capacity appropriate to the exchange load.

These are kept charged from motor-generator sets, comprising enclosed ventilated squirrel cage motors designed for operating on 400 volts, 3-phase, 50-cycle supply, direct coupled to D.C.

Due provision for future extensions is made in the accommodation for extra battery plates, etc.

The entire equipment of these four new satellite exchanges has been successfully completed by Automatic Telephone Manufacturing Company, Ltd., and they have been placed in service by the Post Office without a hitch. The area now embraces some 15,200 lines. We are indebted to the A.T.M. Co., Ltd., Strowger Works, Liverpool, for the photographs accompanying this description.



MR. H. KEMP.

MR. HARRY KEMP.

On the 6th of August last, Mr. H. Kemp, Executive Engineer, Coventry, retired after 47 years service. He commenced his career in the Post Office at Manchester, where later, in 1895, he was appointed Junior Clerk in the Engineering Branch, when the total clerical force in the Superintending Engineer's Office was five! In 1899 Mr. Kemp became Sub-Engineer at Preston, proceeding to Bangor as Second Class Engineer in 1902, where he remained for over two years during the period when the Post Office was maintaining the "Wireless" Communications between Cemlyn, in Anglesey, and the Skerries Lighthouse—an arrangement consisting of a line of single wire on each side of the water, each earthed at both ends with a telephone in each, a "Conduction" arrangement in effect, and not over reliable in action. The early experiments in spark operated wireless between the South Stack rock at Holyhead, and Howth, were also being carried on whilst Mr. Kemp was at Bangor.

At the re-organisation in 1904 he was transferred to Chester, and in 1908 was promoted to First Class Engineer at Shrewsbury. Early in 1917 Mr. Kemp took over the Coventry Section, filling the vacancy caused by the death of the late Mr. W. J. Stubbs. At this time, twelve months after the great 1916 Snowstorm, there were still over 300 men engaged in the Coventry Section on line repairs.

Mr. Kemp's official activities were many-sided. He probably built more miles of main lines than the majority of present day engineers and it is an open secret to his old staff that, although he has retired from active service, the location of his home, practically in the heart of his last Section, coupled with the use of a recently acquired motor-car, will cause him to preserve an interested and critical eye,—it is to be hoped for many years—for these small monuments, as it were, to his energy in this field of his work. His Staff rather suspected that Mr. Kemp sometimes regarded the extensive road works of recent times not merely as improvements necessitated by modern traffic, but as Heaven-sent inspirations to prevent the construcion of Main Lines from becoming a lost art!

It is interesting to record that during Mr. Kemp's service in the Engineering Branch, he served under ten Superintending Engineers.

On the 15th August a splendidly attended smoking concert was held at Coventry (a large contingent coming over from the Northampton side of the Section) under the Chairmanship of Mr. A. B. Gilbert, Superintending Engineer, when the presentation was made to Mr. Kemp of a handsome gramophone cabinet and collection of records from his own staff and a number of colleagues throughout the North Midland District.

An excellent musical programme which had been arranged, had to be very materially cut down to provide opportunities for all his colleagues and members of the staff who were keen to voice their appreciation of Mr. Kemp's numerous good qualities, and to wish him good luck and happiness in his retirement. Amongst his hobbies are bowling, billiards and gardening, at all of which he excels, and many hopes were expressed that he would live long to enjoy them.

MR. J. R. M. ELLIOTT.

NORTHERN DISTRICT.

MR. J. R. M. ELLIOTT, M.I.E.E.

Mr. John Robert Maddison Elliott, M.I.E.E., Superintending Engineer, Northern District, retired from the service on the 9th August, 1930. He entered the Post Office service as a Telegraph Messenger in 1883, and after successive appointments as Telegraphist, Relay Clerk, 2nd Class Engineer, 1st Class Engineer, Staff Engineer, and Assistant Superintending Engineer reached the rank of Superintending Engineer at the age of 42 years. Probably no one will gainsay that Mr. Elliott and his contemporaries entered the Engineering Department at a propitious time, but at the same time no one will stint their praise of these men who, without the benefits of modern educational facilities, by self-sacrifice, hard work and determination equipped themselves to discharge with credit and distinction the highest duties in the Department.

Mr. Elliott's service in the Department has been varied and his duties have necessitated his residing in many parts of the country. He has served in Wales, Scotland, London, Headquarters and the Provinces, and has carried out work as far afield as the Orkneys, Shetlands and Channel Islands. For his supervision of the signalling arrangements in London, particularly in Westminster Abbey on the occasion of the coronation of King George V, he received the special thanks of Field-Marshal Lord Kitchener. He was for many years associated with the Telegraph Section of the Engineer-in-Chief's Office.

Mr. Elliott returned to his native town of Newcastle-on-Tyne in 1912 to take charge of the Northern District. His intimate knowledge of the District, and his friendship with the Municipal officials in the area were no doubt of great assistance, but he had excellent administrative ability. Co-operation and helpfulness are nowhere more strongly evidenced than in the Northern District and, whilst this is partly due to most of the supervising officers being local products and more or less contemporary, it is more attributable to the even-handed manner in which Mr. Elliott has administered his District. No class was given preferment, all felt that they received fair treatment, and all worked harmoniously together. It must be said, however, that Mr. Elliott had a leaning towards the junior members of the staff whom he sought to encourage on all occasions, and the I.P.O.E.E. meetings were exploited to serve this purpose. It is an open secret that, whenever possible, junior members opened and occupied the forefront of the discussions.

As Chairman of the Northern Centre, Mr. Elliott took a keen personal interest in I.P.O.E.E. activities. He endeavoured to maintain the interest of all ranks by making the programme as representative as possible and by enlisting the services of lecturers from all the classes comprising the membership. A popular innovation introduced by Mr. Elliott was the provision of light refreshments at the Centre meetings, which met a long felt need in the case of members from the outlying areas, and in these circumstances the meetings served to provide a pleasant means for social intercourse.

Another successful feature introduced by Mr. Elliott was the "Summer Outing." This annual gathering of members, wives and friends has taken place in the month of July for the last five years, and has been the outstanding social event in the District. No one entered into the spirit of these outings more than "the Governor" and the atmosphere of good fellowship and courteous consideration which contributed so much to the unqualified success of these outings was in great measure due to his influence. The measure of Mr. Elliott's interest in I.P.O.E.E. activities is reflected in the record of 100% membership which the Centre has maintained for a number of years.

If genius be the capacity for taking infinite pains, then J. R. M. Elliott was a genius. His patience was phenomenal. He never tired of detail and when Unit Costing was re-introduced into the Department in 1919 Mr. Elliott came into his own, and was not satisfied until he had evolved a system of definitely ascertaining the cost of maintaining each item of plant at every lineman's centre, with the result that any abnormality in cost could be readily found and remedial measures necessary immediately applied. The system is fully described in his paper "The Control of Labour Costs" (I.P.O. E.E. printed paper No. 94).

No charitable appeal passed Mr. Elliott unnoticed. In his early years he was keenly interested in the Post Office Clerk's Benevolent Fund and this year he had the intense satisfaction of seeing a scheme, initiated by himself, for endowing a bed in the Newcastle Infirmary in the name of the Post Office staff, brought to successful fruition.

His long association with the Northern District made him a well-known personality with the public in matters relating to the Telephone Service, and he was frequently in demand at public functions, and he never lost an opportunity of advancing the Department's interests.

Mr. Elliott will probably admit that his tenure of office in the Northern District has been very happy. His relations with all ranks of the staff, with the Municipal Authorities, and with the public utility companies, have been most cordial. His kindly disposition has endeared him to all he came in contact with, and like Abu Den Adhem he might well say "I pray thee then write me as one that loves his fellow men."

Mr. F. G. C. Baldwin.

Mr. Francis G. C. Baldwin, M.I.E.E., Superintending Engineer, Northern District.

Mr. Francis G. C. Baldwin has been appointed Superintending Engineer of the Northern District, as from the 10th August.

Mr. Baldwin was educated at the Modern School, Barnsley, and the Sheffield Technical School. His first appointment was with Messrs. Thos. Nash & Sons, Inspecting and Testing Engineers, Sheffield. He continued his training in Science and Electrical Engineering at the Institution which subsequently became the Technological Department of the Sheffield University.

He entered the service of the National Telephone Company in 1896, and was appointed Engineer at Sheffield in 1899. For several years he officiated as Lecturer and Demonstrator in Electrical Engineering at the evening classes held at the Sheffield Technical School.

In October, 1906, he was appointed District Engineer for Birmingham, which at that time had 26 Telephone Exchanges, approximately 14,000 subscribers and 52,000 miles of wire, of which nearly 40,000 miles was underground. He superintended the first comprehensive scheme of practical commercial line loading (with Pupin Coils) executed in this country.

In September, 1909, he was appointed Assistant Metropolitan Engineer, and when the Inventory of the National Telephone Company's plant was commenced in 1910, he assumed charge as Acting Metropolitan Engineer of the whole of the external plant in the Metropolitan Area under the superintendence of Mr. C. B. Clay. At that time the National Telephone Company's plant in the Area embraced 61 Telephone Exchanges, 141,100 telephone stations and a wire mileage of 293,970.

Mr. Baldwin's first appointment with the Post Office was in London as Sectional Engineer of the City External Section in 1912. In December, 1913, he was promoted to the rank of Assistant Superintending Engineer of the Northern District at the early age of 35 years. Mr. Baldwin was admitted an Associate of the Institution of Electrical Engineers in 1904, became Associate Member in 1906 and Member in 1919. He has served on the committee of the N.E. Centre for a number of years and was the Chairman of the Centre in 1922. Mr. Baldwin is well known as a writer and lecturer and he has read many papers before various Centres of the Institution of Electrical Engineers and the Institution of Post Office Electrical Engineers, of which the following are perhaps the most notable :—

"Some Considerations in the Manipulation of Telephone Dry Core Cables."

"Telephone Exchange Transfers and their Organisation." (Fahie premium awarded).

"The Progress and Potentialities of the Telephone in the United Kingdom."

"Scientific Organisation and the Post Office Engineering Department."

He is the author of "The History of the Telephone in the United Kingdom" (published by Chapman & Hall in 1925), a notable volume in the bibliography of the profession.

In addition he has delivered lectures on such diverse subjects as Geology and Colour Photography.

Due to his 16 years' service in the Northern District as Assisting Superintending Engineer, Mr. Baldwin has an intimate knowledge of the plant and he is personally acquainted with most of the staff, who hold him in high esteem and regard.

Mr. John Robert Andrews, M.I.E.E.

Before the publication of these notes Mr. John Robert Andrews, M.I.E.E., Executive Engineer, Newcastle South Section, will have retired after 48 years' service.

Mr. Andrews rose from the rank of Telegraph Messenger to Executive Engineer and will finish his service in the same town as he began. Although threatened with a serious breakdown in health whilst at Cambridge, his transfer to Newcastle in 1921 effected a wonderful recovery and he will lay aside official responsibilities looking more like a man of 50 than 61 years of age.

Mr. Andrews was a musician of outstanding ability, and as a church organist, choral conductor and pianist he has achieved more than local fame. In his earlier years his musical activities occupied a great deal of his time, but in later years his services have been much more in demand on account of his high office as Chairman of the Freemen of Newcastle-on-Tyne, and his name is a household word on Tyneside. It may be said quite definitely that the Freemen have never possessed a more courageous, progressive or successful leader than J. R. Andrews, and it must also be admitted that never in the history of local politics were the outstanding abilities of such a man more needed in order that the rights and privileges of the public might be adequately safeguarded. No civic function is complete without the presence of J. R. Andrews, and no toast list is satisfied without the fluency, satire, and witticisms which are characteristic of his speeches.

Officially he will probably be best known by his constant endeavour to economise and to keep down costs, and he is proud to recall that since he took over the Newcastle South Section his savings, based on the Provincial Average Cost for Maintenance and on the standard rates for construction costs, have reached a considerable figure.

Mr. Andrews was a fearless administrator, and the patch of carpet in front of his table has a somewhat worn appearance. At the same time any of his staff in difficulties or in distress never hesitated to ask his advice or seek his assistance, because these were always forthcoming and invariably in a very practical and particularly helpful manner.

Mr. Andrews is a man of dynamic energy

and it is perhaps just as well for his health's sake that a commercial concern has already commandeered part of his time when he retires, and that his municipal activities are likely to expand.

A social function is being organised by the Newcastle South Section to bid farewell to Mr. Andrews. When he retires, the Department will lose a zealous servant and the Northern District one of its outstanding personalities.

Summer Outing.

The Summer Outing took place on the 8th July and like its four predecessors was an unqualified success. The party of members and friends numbered 68, and thoroughly enjoyed the visit to Rokeby Park and "the meeting of the waters." The outing was so arranged this year that members in outlying parts of the District were enabled to participate, and under the genial guidance of the Chairman, Mr. J. R. M. Elliott, everybody entered into the spirit of the picnic and spent a happy day.

Mr. G. F. Bellwood, M.I.E.E.

The retirement of George Francis Bellwood, M.I.E.E., Executive Engineer of the Technical Section, has withdrawn a particularly valuable member from the Northern Centre. Only those responsible for the working of the Centre can adequately appreciate the extent of the services rendered to the I.P.O.E.E. by Mr. Bellwood. He has read papers on such subjects as—

- "Breakdown Organisation."
- "C.B.S. Multiple Exchanges."
- "Some practical points in relation to Main Underground Cable work."
- "Through Signalling on Trunk and Junction Circuits."
- "Central Battery Systems with modifications."
- "Trunk Signalling."

His paper on "The Centralisation of Cord Repairs" was printed for unrestricted circulation (Paper No. 91).

In addition to his active personal interest in the I.P.O.E.E. activities, Mr. Bellwood exerted himself to encourage the junior members of the staff to offer papers and join in the discussions, and there are many officers in various parts of the country who will readily admit that their initial participation in I.P.O.E.E. proceedings was due to the practical assistance and encouragement given to them by Mr. Bellwood. Probably no one was better equipped for the role of mentor than Mr. Bellwood. He has taught City & Guilds classes in Telegraphy, Telephony and allied subjects continuously for 22 years and a large number of men of all ranks who have passed through his classes will testify with grateful thanks to the thoroughness, efficiency and patience of his teaching.

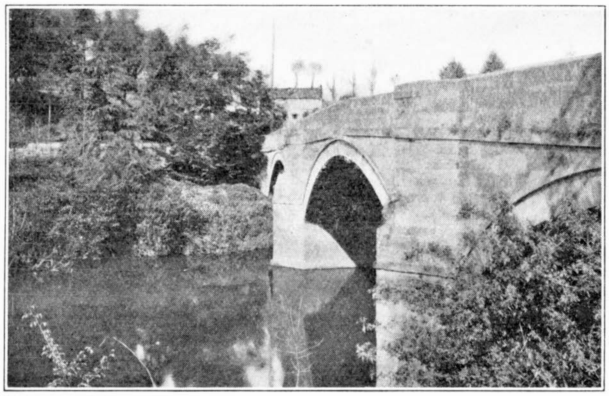
Mr. Bellwood is an energetic personality and although he never spared himself physically or mentally whilst in harness, he leaves the Service with a physical fitness which is the envy of men 10 to 15 years his junior, and only this year spent his holiday on a walking tour.

Before these notes appear Mr. Bellwood will have been presented with some tangible token of the esteem, regard and affection with which he is held by all ranks in the Northern District.

Damage by Floods in North-East Yorkshire.

For several days before the 23rd July last, the people in North-East Yorkshire were very much concerned regarding the threatened damage due to the rising of the rivers through continuous rain. The market town of Stokesley and the villages round the neighbourhood were gradually being flooded through the overflowing of the River Leven. In the main street at Stokesley the water was in some parts nearly waist-deep, and the floor of the Post Office was awash. The water was slowly creeping up the switchboard and the M.D.F., but on the 23rd the "tide" reached its height without doing serious damage.

In the valley of the Esk, however, the Department were not so fortunate, for here, as many visitors to Whitby and its neighbourhood know, the river flows through a narrow picturesque valley. This confined the floods to the course of the river and consequently caused the water to rise very rapidly. There are numerous stone bridges spanning the river between Glaisdale and Whitby, and the arches were soon taking "full bore" and as the floods increased, the weight of water was so great that several of the bridges were unable to stand the pressure any longer. As each bridge gave way, the inevitable rush of water which followed added to the strain already sustained by the others, so that they also gave



SLEIGHTS BRIDGE BEFORE THE FLOOD.

way. One of these was the railway bridge at Grosmont.

The greatest damage came early on the morning of July 23rd, when the bridge carrying the main road at Sleights gave way. This bridge carried the water supply to Whitby and the Department's underground pipe and cables. Just below Sleights the valley widens out towards Ruswarp. Here numbers of picturesque bungalows were flooded to the roof and the gardens were submerged. Ruswarp Bridge, which is an iron structure, stood the strain, allowing the water to pass over it.

The Post Office and Telephone Exchange at Sleights is situated at the end of the bridge on the left bank of the river, and before the bridge broke the water was already pouring into the building.

When the writer arrived on the scene just before noon, the flood had already fallen two feet, but still it was not possible to see any of the masonry of the fallen bridge—the whole was completely submerged. This will give some idea of the depth of the flood.

The cables crossing the bridge carried the junctions from Whitby to Goathland and also the lines to the villages of Grosmont, Glaisdale and Lealholm, so the job on hand was to find out the extent of the damage and restore the service as soon as possible.

An inspection of the cables at the junction box outside the P.O. showed that when the bridge broke it had dragged the cable joints right to the mouth of the duct and severed the lead in both cables, and as this chamber had been under water it was obvious the cable would have to be cut inside the exchange. This was immediately done and the end sealed up. The extent of the damage across the river was not known then, but it was expected that here again the cable would have been dragged and broken at the first joint, which was at a buried coupling, Fig. 1, D.

To the people of Whitby the severing of the water mains was a very serious business. The holiday season was just reaching its height and there were several schools and public institutions where water was a vital necessity and any protracted delay must have led to worse difficulty in sanitation. The local Council had called in the aid of an engineer who was engaged on work in the vicinity. He undertook to get a trestle bridge over to carry new water mains, and an offer was made to the Department which permitted the laying of a new cable across the proposed structure.

This seemed to be an easy way out of the difficulty, but, unfortunately, by the following day, the 24th, very little progress had been made, although the lifeboat rocket crew had been up and " fired " a line across.

It was then decided that the best course to effect a restoration of the telephone service would be to erect a pole on each bank below the broken bridge and take an aerial cable over. During the 24th the water had gone down considerably, so that it was possible to see the masonry of the old bridge in mid-stream.

The contractor got to work and during the night of the 24th-25th managed to get a very temporary bridge across, the operations being illuminated during the night by the powerful

TEMPORARY BRIDGE TO CARRY WATER MAINS, BUILT BY THE R.E'S.

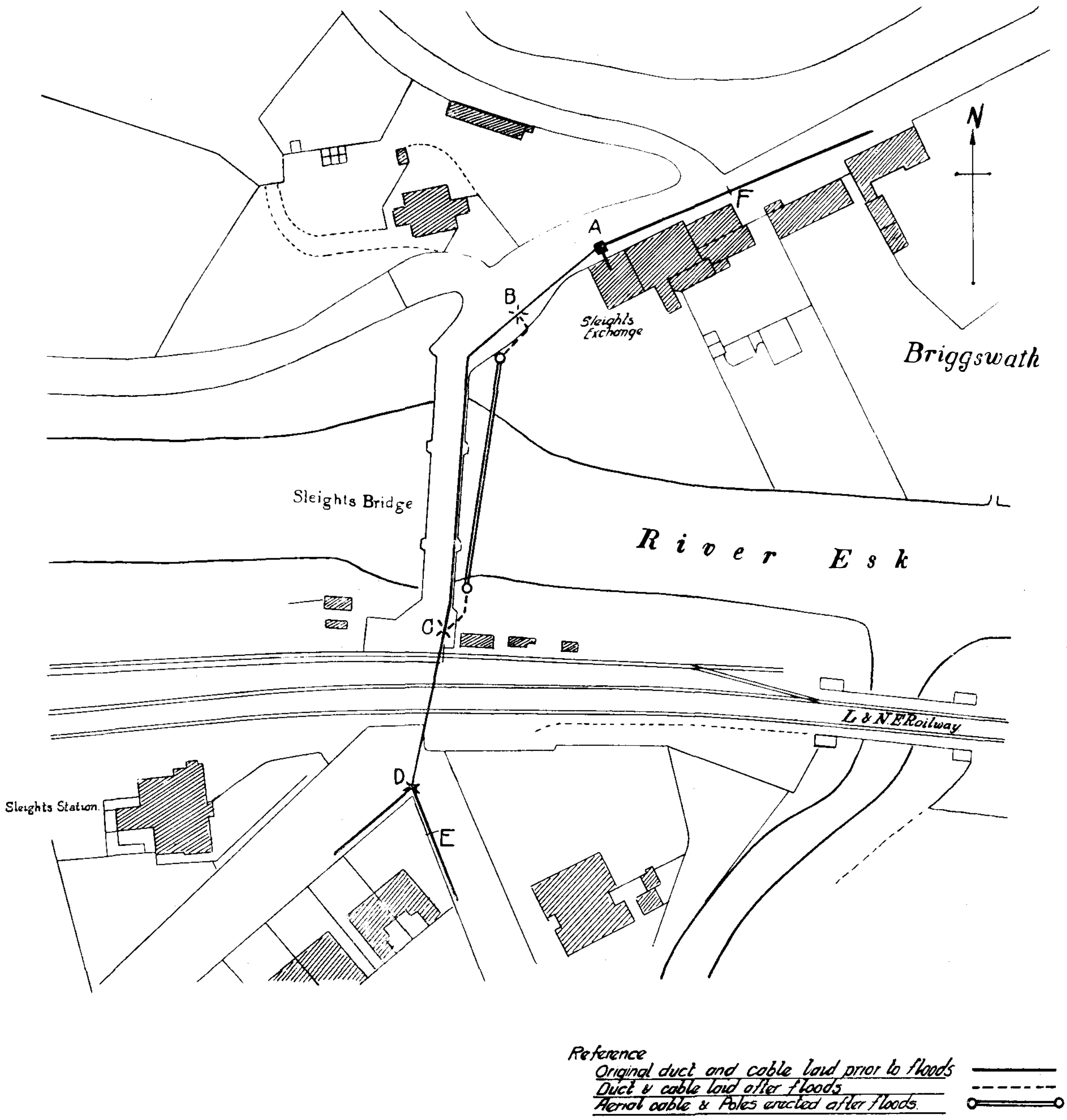


Fig. 1.—Cable Route Plan.

head-lights of stationary motor cars. The bridge was constructed mainly of larch trees felled and brought from a plantation nearby, and it was quite an experience walking over it. Peculiar stories have been told of the rope bridge at Carrick-a-Reed, and the sensation caused by its swaying laterally, whilst at the same time one also has the feeling it is rising and falling as a boat on a choppy sea. Similar sensations were experienced here. However, the bridge was a considerable help for the men passing across during operations. The two poles and three steel suspending wires were erected on the 24th and the cable was drawn across, jointed, and all circuits working on the 25th. The sections of cable it was necessary to renew were Fig. 1, F, A, B, C, D, E.

The temporary bridge was not suitable for carrying the water mains, and it was subsequently arranged that the Royal Engineers should take over the job of strengthening the structure and joining up the water supply. This was done during Sunday, the 27th.

The first photograph, taken from the right bank, shows the bridge before the flood, and the second, taken from the left bank, shows the Royal Engineers busy "consolidating the position" after the water supply was re-connected. The Department's aerial cable is seen to the left of this photograph.

S.B.T.

SOUTH LANCASHIRE DISTRICT.

Mr. A. J. Pratt, M.I.E.E., Sectional Engineer, Liverpool External Section, has been elected Chairman of the Mersey and North Wales (Liverpool) Centre of the Institution of Electrical Engineers, for the Session 1930-31. His address at the opening meeting on October 20th will be given under the title "The development of a Telephone System," and will be illustrated by a cinematograph film.

FEDERATED MALAY STATES.

Extracts from the Annual Report on the Posts and Telegraphs Department for year 1929:—

Telegraphs.

During the year 438,249 telegrams were despatched and 463,492 telegrams were delivered, being an increase of 2.2 per cent. in the number of telegrams despatched and an increase of 2 per cent. in the number delivered, as compared with 1928. The revenue derived from telegrams was $445,398. The revenue shows a decrease of $20,880 or 4.5 per cent. from that of 1928. The value of telegrams sent free of charge for Government Departments was $41,906, a decrease of $8,563.

Keyboard perforators, for use in conjunction with Wheatstone sets, were introduced at one or two of the larger telegraph offices and have proved of value in facilitating the rapid and accurate transmission of telegraph traffic. The use of typewriters for the reception of telegrams was further extended, with satisfactory results.

In conjunction with the Eastern Extension Australasia and China Telegraph Company, Limited, arrangements were again made for the acceptance at any telegraph office in the Federated Malay States of "Christmas and New Year Greeting Telegrams," for a long list of countries, at rates which approximated to one-quarter of the ordinary charges.

The number of countries with which Daily Letter Telegrams are exchanged was added to during the year, and a new service or Week-end Letter Telegrams, at a cost of 25 cents a word, was introduced between this country and Great Britain and Ireland.

Telephones.

The number of direct exchange lines connected to the telephone system on the 31st December, 1929, was 5,075, an increase of 541 as compared with 1928. In addition there were 2,403 miscellaneous circuits, such as extension lines, extension bells, private lines, private bell or alarm circuit and tell tale clock circuits maintained by the Department, as compared with 2,177 in 1928.

The revenue derived from telephones was $1,352,935, an increase of $156,151 over 1928. The junction and trunk revenue amounted to $463,155, an increase of $78,241 over the previous year.

Six new public exchanges were opened for service during the course of the year.

On the 31st December, 1929, 65 public telephone exchanges were in service in the Federated Malay States; 95 public call offices available at post offices and postal agencies throughout the country, and there were 37 applicants waiting for connection to the telephone system; all of these were of recent date.

The average number of originated calls per direct exchange line per day was 12.7, an increase of approximately 12.4 per cent. on the average figure for 1928.

The average total numbers of originated calls per day throughout the Federated Malay States telephone system during the year were:

Local calls 51,740
(increase over 1928, 26 per cent.)
Junction calls 4,960
(increase over 1928, 77 per cent.)
Trunk calls 4,540
(increase over 1928, 5 per cent.)

Total originated traffic... ... 61,240
(increase over 1928, 27 per cent.)

The approximate total originated telephone traffic during the year was as follows:

Local calls	15,056,000
Junction calls	1,443,000
Trunk calls	1,321,000
Total originated calls ...	17,820,000

Progress was made with the arrangements for the provision of a new exchange of the automatic type to replace the existing Kuala Lumpur Exchange. The contract for the installation of the necessary equipment was placed with Messrs. Ericcsons Telephone Manufacturing Company, Limited, of Beeston, Nottingham, England, in September, 1929. The new building required to house this equipment was well advanced by the end of the year under review.

The " Carrier Current " system of telephony was brought into service between Kuala Lumpur and Ipoh on the 1st June, 1929, providing thereby three additional speech channels between these two exchanges. These channels have worked quite satisfactorily for the period during which they were in service during the year, and effected the much needed improvement required in the speed of service between the exchanges concerned.

The question of providing direct telephonic speech channels between Singapore, Kuala Lumpur and Bukit Mertajam was re-opened during the year with a view to introducing at the end of the year " Carrier Current " working between those exchanges. Definite proposals were made by this Department to both the Straits Settlements and Federated Malay States Governments, for establishing this service as soon as possible. At the end of the year those proposals were still under the consideration of the Governments.

Engineering.

On the 31st December there were 3,084 miles of telegraph and telephone lines and 24,607 miles of overhead wire in the Federated Malay States, of which 21,444 miles were telephone wires. In addition there were 144 miles of underground cables containing 13,100 miles of single wire line. These figures do not include the poles and lines maintained for its own use by the Railway Department. The Posts and Telegraphs Department also owns and maintains 123 miles of line and 611 miles of wire in Johore. It also maintained in 1929 two miles of pole line for Kedah and 1,020 miles of wire for Johore.

The underground system was considerably extended during the year, particularly in the Kuala Lumpur area where, in connection with the installation of the new Automatic Telephone Exchange, a great deal of work was done in rearranging and extending underground cables. The total additional cable laid during the year amounted to 23 miles, giving an additional single wire mileage of over 1,672 miles.

Wireless.

One hundred and nineteen temporary licences for the use of wireless receiving apparatus were issued during the year and three experimental transmitting licences.

The British official news broadcast from the wireless station at Rugby in England, received at Penang Wireless Station and retransmitted from Penang by land-line for delivery to local newspapers on payment of a monthly fee, averaged 22,780 words a month.

The Petaling Hill Wireless Station in Kuala Lumpur was practically rebuilt in the course of the year, and a half kilowatt short-wave set was installed there on a permanent basis. A store, workshop and quarters for the operating staff have been built on the site. This station is now in daily communication with the various wireless stations in Pahang.

As part of the Flood Emergency Scheme, wireless stations were maintained throughout the year at Kuala Pahang, Kuala Lipis, Kuantan, Mentakab and Temerloh. Whenever the land-line to Kuantan is interrupted, telegraph traffic between Kuala Lumpur and Kuantan is disposed of by means of wireless; and the normal route for telegraph traffic between the Federated Malay States and Trengganu is now *via* the Kuala Lumpur and Kuantan wireless stations.

A wireless station, equipped with a half kilowatt set, was opened at Port Swettenham on the 1st April, for communication with ship stations. It was maintained in satisfactory operation up to the end of the year.

Two low-power medium-wave wireless stations were erected for the Police Department, one at Port Swettenham and the other at Pulau Ketam, to provide telephonic communication beween these two places.

CURRENT LITERATURE.

The Journal of the Institution of Electrical Engineers, Vol. 68, No. 402, June, 1930.

Instrument Transformers. J. G. Wellings and C. G. Mayo. Deals in a general way with the whole field of instrument transformer work, as far as power work is concerned.

An Investigation of Earthing Resistances. P. J. Higgs (from the N.P. Laboratory). The phenomena of polarisation and endosmose were investigated. Earthing resistances of small electrodes depend directly on the resistivity of the surrounding soil. Some electrodes of extensive area, viz., water pipes, lead sheath of a large cable and steel structures were also tested. The smallest resistance obtained was that of a water pipe. The differences between A.C. and D.C. measurements were investigated.

A Thermionic Valve Potentiometer for Audio Frequencies. W. P. Stuart. A description is given of a method of measuring audio-frequency potential vectors with the aid of valves. A method of estimating the admittance between the input potential terminals is described.

An Accurate Method of Testing Bent Permanent Magnets. C. E. Webb and L. H. Ford (from the N.P. Laboratory). The application of the search coil method of measuring H to the testing of bent magnets by the use of jointed coils is fully described.

Vol. 68, No. 403, July, 1930.

Recent Developments in the Protection of Three-Phase Transmission Lines and Feeders. T. W. Ross and H. G. Bell, M.Sc.Tech. Difficulties and methods of overcoming them are discussed and methods of Protection reviewed.

Some Developments of the Piezo-electric crystal as a Frequency Standard. H. J. Lucas. Some observed errors in quartz resonators are dealt with. The use of the improved crystal as a control element in a valve-maintained source of oscillations. A complete calibration equipment of a multi-vibrator system with a range of 1-6000 kc in steps of 1 kc per second is shown.

A New Null Method of Testing Instrument Transformers and its Application. G. F. Shotter. Paper describes some of the common methods and that of the author.

Some Accessory Apparatus for Precise Measurement of Alternating Current. R. S. J. Spilsbury, B.Sc., and A. H. M. Arnold, Ph.D. (from the N.P. Lab.). Paper describes apparatus for obtaining for purposes of measurement a voltage proportional to, and in phase with, a given alternating current.

Precise Testing of Current Transformers. A. H. M. Arnold, Ph.D. (from the N.P. Lab.).

An Analysis of Heating Tests on Electrical Machines. Edward Hughes, Ph.D., B.Sc.

Determination of the Final Temperature-Rise of Electrical Machines from Heating Tests of Short Duration. Edward Hughes, Ph.D., B.Sc.

Vol. 68, No. 404, August, 1930.

The Jet-Wave Rectifier: The Experimental and Theoretical Basis of its Design. Prof. Jul. Hartmann, Dr. Tech. Paper describes the device, a purely mechanical one for high-power rectification.

The Nature and Extent of the Oscillations produced in a Rotary Convertor on Fluctuating Loads and on Short Circuit. H. Cotton, D.Sc.

The Production of Uniform Illumination over Large Areas. H. R. S. McWhirter, B.Sc. (Eng.).

Hysteresis Measurements on Straight Bars and Strips. C. E. Webb, B.Sc., and L. H. Ford, B.Sc. (from the N.P. Lab.). A companion of results obtained by using search coils on bars and strips with those for rings of similar material shows good agreement when compensating magnetising windings are employed at each point on the loop. A drum controller to perform the switching operations is described.

An Investigation of the Frequency Variations in Induction Watt-Hour Meters. A. E. Moore, M.Sc., Tech., and W. T. Slater, M.Sc., Tech.

Some Developments of the Thermionic Voltmeter. E. B. Moullin, M.A. The paper describes the various ways in which a 3-electrode valve should be used in a thermionic voltmeter.

Recent Developments in Direction-Finding Apparatus. R. H. Barfield, M.Sc. Describes (1) a 4-aerial direction-finding system erected near the Radio Research Station, Slough, and

(2) two distinct types of portable short wave direction-finding apparatus.

Journal of the American Institute of Electrical Engineers.

Vol. XLIX., No. 6, June, 1930.

1928 Lightning Experience on 132 Kv Lines of the American Gas and Electric Coy. Philip Sporn.

Voltage Irregularities in D.C. Generators. J. T. Fetsch.

Co-ordination of Insulation as a Design Problem. G. D. Floyd.

Development of a 2-wire Supervisory Control System with Remote Metering. R. J. Wensley and W. M. Donovan. Automatic telephone relays are used.

Recording Fast Transient Phenomena with Cathode Ray Oscillograph in Free Air as well as in High Vacuum. M. Knoll. An available method for taking photographs outside the vacuum was found to be the employment of an electron permeable window (Lenard window) of the size of the oscillogram to be made.

A New Transmission Line Construction. Post Type Towers. Percy H. Thomas. Describes modern power line construction methods.

Transformer Ratio and Differential Leakage of Distributed Windings. R. E. Hellmund and C. G. Veinott. Paper develops the necessity for the concept of " differential leakage " where transformer action takes place between two unequally distributed windings.

Vol. XLIX., No. 7, July, 1930.

An Electron Tube Telemetering System, Parts 1 and 2. A. S. Fitzgerald. Paper describes a varying frequency telemetering system, which is not limited to electrical readings but may readily be applied to any deflection instrument. The accuracy is not affected by changes in the impedance of the channel of transmission and is equally suitable for wire conductors, carrier or radio.

Dancing Conductors. A. E. Davison. The phenomenon of vibrating cables is discussed. Much experimental work has to be done before definite conclusions as to causes can be reached.

Radio Telephone Service to Ships at Sea. William Wilson and Lloyd Espenschied. Paper discusses the American end of the ship-to-shore radio telephone system and also that on the Leviathan.

Rural Line Construction in Ontario. R. E. Jones. A rural power distribution scheme of about 6,000 miles in operation.

The Transmission Characteristics of Open-Wire Telephone Lines. E. L. Green. Values of the primary transmission constants are presented and the factors that govern these in practice are discussed. Data are given for a frequency range from 0 to 50,000 cycles.

Vol. XLIX., No. 8, August, 1930.

Annual Reports of Technical Committees: Power Transmission and Distribution; Protective Devices; Electric Welding; Application to Marine Work; Automatic Stations; Power Generation; General Power Applications.

Long Distance Cable Circuit for Program Transmission. A. B. Clark and C. W. Green. A system of cable networks has been developed and given a trial on a looped-back circuit 2,200 miles long. It transmits ranges of frequency and volume somewhat in excess of those handled by the open wire-circuits now used for program work and also in excess of those handled by present-day radio broadcasting systems when no long distance lines are involved.

A New Portable Oscillograph. Claude M. Hathaway. A portable oscillograph, designed by the G.E.C., Schenectady, simple in operation and is of particular value to scientific and engineering schools.

Mutual Impedances of Ground Return Circuits. Some experimental studies. A. E. Bowen and C. L. Gilkeson. Some of the results of the work of the Joint Development and Research Sub-Committee of the National Electric Light Association and Bell Telephone System on the mutual impedances of ground return circuits.

Rationalisation of Transmission Insulation Strength. Part II. Philip Sporn.

Two-Way Television. Part I. Image Transmission System, Part II. Synchronisation, Part III. Sound Transmission System.

BOOK REVIEWS.

"Alternating Current Bridge Methods." By B. Hague, D.Sc. (Lond.), Ph.D. (Glas.), D.I.C., A.C.G.I., M.I.E.E., M.A.I.E.E., F.P.S.L. Second Edition. 391 pages. Sir Isaac Pitman & Sons, Ltd. Price 15/- net.

The author has revised and enlarged the previous edition. The book deals with fundamental principles, description and theory of apparatus, classification of bridge networks, as well as the choice of a bridge method for specific measurements and the necessary precautions to be taken. As in the first edition, the scope of the work is limited to the consideration of measurements up to several thousand cycles per second only.

The star-mesh transformation theorem is used with advantage in the chapter dealing with the symbolic theory of alternating currents. In the later chapters of the book little more consideration has been given to impurity effects in mutual inductances, and to the effect of earth capacities in standard condensers, than formerly. Screening problems are dealt with briefly, but there is room for a fuller discussion of those cases where elaborate screening arrangements are necessary.

The references given throughout the text and the bibliography, which enhanced the value of the first edition of the book, have been continued and extended in the present edition.

"Definitions and Formulæ" for Students (Electrical Installation Work). By F. Peake Sexton, A.R.C.S., A.M.I.E.E., M.I.E.I. Published by Sir Isaac Pitman & Sons, Ltd. Price 6d. net.

This little book of 26 pages contains many tables and formulæ useful for those engaged on electrical installation work. The definitions, due to the size of the booklet, are brief but useful.

"A Study of the Induction Motor." By F. T. Chapman, D.Sc. (Eng.), Lond., M.I.E.E., A.M.I.C.E. 289 pp. Published by Messrs. Chapman & Hall. Price 21/-.

The author has dealt very fully with the subject with the exception of commutator motors which have been omitted to keep the book within reasonable limits.

Special attention has been given to the harmonic analysis of the air-gap field in developing the theory of the induction motor and it is shown that generally the fundamental field alone is of any practical importance in the transfer of power across the air-gap. From this the author derives a new definition of the dispersion coefficients of the windings, and develops methods for their calculation. In developing the fundamental equations an assumption is made that the magnetic circuit may be replaced by a smooth stator and rotor with iron of infinite permeability, the length of the air-gap being corrected to allow approximately for the slots and the saturation of the iron. The effects of these are investigated fully later.

Separate chapters are devoted to single phase, synchronous, squirrel cage, and multispeed motors: also to motors connected in cascade and the Hunt motor. Finally practical calculations are given showing the application of the methods which have been developed in the earlier chapters.

The book is well arranged and illustrated, and should appeal more especially to designers, engineers and senior students interested in the more advanced theory of the induction motor.

J.McG.

"Post Office Engineering Department Technical Instructions." Published by His Majesty's Stationery Office, Adastral House, Kingsway, London, W.C.2.

Readers of the Journal will be interested to know that a very comprehensive series of Technical Instructions has been issued during the past twelve months. The titles and prices of the separate publications are given below:—

Technical Instructions XXV.
Automatic Telephone Exchange Systems.
- Part 4. The Non-Director system. Text 6d. Diagrams 6d.
- Part 5. Siemens No. 16 system. Text 4d. Diagrams 1/-.
- Part 6A. The Director system. System H. Text 6d. Diagrams 6d.
- Part 6B. The Director system. System W. Text and Diagrams 3d.
- Part 6C. The Director system. System C. Text and Diagrams 3d.

Part 6D. The Director system. System S.
Text and Diagrams 4d.
Part 6E. The Director system. System E.
Text and Diagrams 3d.
Part 8. P.B.X. Final Selectors.
Text 6d. Diagrams 1/-.
Part 13. Traffic Recording.
Text and Diagrams 6d.
Part 14B. Rural Automatic Exchanges.
Text and Diagrams 9d.

Technical Instructions XXXII.
Subscribers' Circuits and Apparatus.
Part 1. Fundamental Circuit Arrangements.
Text and Diagrams 1/-.
Part 3. Party Lines.
Text 9d.

Technical Instructions XXXIV.
Public Exchange Conversions.
Part 3. Conversion of Subscribers Apparatus to Automatic Working.
Text 2/6.

Technical Instructions XXV, Part 4, describes the Strowger step-by-step system for Non-Director exchanges and gives full details of the circuit operation which takes place on a local call for each one of the different types of exchange equipment installed by the various contractors.

Part 5 gives a description of the fundamental principles of the Siemens No. 16 system together with an outline of the circuit operation of various classes of calls.

Part 6A opens with a general description of the principles of the Director system and concludes with a detailed description of the operation of typical circuits employed in exchanges installed by the Automatic Telephone Manufacturing Company.

Parts 6B, 6C, 6D and 6E give circuit descriptions of the Director apparatus installed by Messrs. Standard Telephones and Cables, General Electric Company, Siemens Brothers Brothers and Ericssons respectively. These parts are supplementary to Part 6A.

Part 8 provides an exhaustive description of the various final selector arrangements adopted to cater for groups of P.B.X. lines.

Part 13 describes the various means adopted for recording the traffic flowing through automatic exchanges. The facilities provided for traffic metering are described in an appendix.

Part 14B gives a detailed description of the Unit, Auto, No. 5 which is installed in Rural Automatic Exchanges. Details relating to the installation and maintenance of the equipment are given and the operation of the circuits employed is described.

Students of Automatic Telephony should find these parts, particularly Parts 4, 5, 6A, 8, 13 and 14B, exceedingly useful in assisting to an understanding of this subject which forms an ever increasing aspect of the duties of a Post Office engineer.

Technical Instructions XXXII, Part 1, describes the principles employed in the circuits of subscribers apparatus required for direct exchange lines connected to common and local battery systems. Part 3 describes the circuit arrangements and the method of operating both 2-party lines and rural party lines.

The list of the titles of the various parts into which this instruction is sub-divided, given on page 2 of each part, holds out the promise of providing the student of telephony with a very complete text-book on the subject of subscribers' apparatus.

Technical Instructions XXXIV, Part 3, sets forth details of the scheme employed for the conversion of subscribers' apparatus to automatic working.

The conversion of exchanges from one system to another takes an important place in the work of the Post Office Engineering Department and the list, on the inside title page, of the titles of the various parts of this instruction indicates that when the whole of the parts are published they will form a valuable addition to the technical library of the Post Office engineer.

The Technical Instructions set a fine standard of reproduction and the photographs and diagrams used by way of illustration are particularly clear.

Civil Servants will be interested to learn that Mr. Samuel McKechnie, the editor of the "Civil Service Arts Magazine," has written a book, which will be published next month, entitled "The Romance of the Civil Service."

This interesting volume deals with all the main activities of this vast organisation, and Mr. Philip Snowden has provided a foreword.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	Grade.	Promoted to	Date.
King, R. T.	Executive Engineer, E.-in-C.O.	Assistant Staff Engineer, E.-in-C.O.	14-11-30
Edgerton, T. H.	Executive Engineer, London District.	Assistant Suptg. Engineer, London District.	20-11-30
Hunter, H. J.	Executive Engineer, S. Wales District.	Assistant Suptg. Engineer, S. Wales District.	1-9-30
Jack, J. A.	Assistant Engineer, Scot. West District.	Executive Engineer, Northern District.	To be fixed later.
Stone, A. E.	Assistant Engineer, London District.	Executive Engineer, London District.	1-10-30
Peck, H. G. S.	Assistant Engineer, E.-in-C.O.	Executive Engineer, London District.	20-11-30
Stanton, J. D.	Assistant Engineer, E.-in-C.O.	Executive Engineer, E.-in-C.O.	14-11-30
Balchin, G.	Assistant Engineer, E.-in-C.O.	Executive Engineer, S. East District.	13-11-30
Atkins, W.	Assistant Engineer, S. Mid. District.	Executive Engineer, Northern District.	To be fixed later.
Darke, J.	Assistant Engineer, E.-in-C.O.	Executive Engineer, N. Mid. District.	31-8-30
Linsell, F. A.	Assistant Engineer, S. Mid. District.	Executive Engineer, N. East District.	To be fixed later.
Jarrett, E. J.	Assistant Engineer, N. Wales District.	Executive Engineer, Northern District.	To be fixed later.
Ogden, E.	Assistant Engineer, S. Wales District.	Executive Engineer, S. Wales District.	To be fixed later.
Glover, D. W.	Inspector, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	22-7-30
Young, D.	Chief Inspector, S. Mid. District.	Assistant Engineer, S. Mid. District.	To be fixed later.
Wood, G. E.	Chief Inspector, London District.	Assistant Engineer, London District.	18-6-30
Gardner, A. J.	Chief Inspector, London District.	Assistant Engineer, E.-in-C.O.	18-6-30
Bagley, T.	Chief Inspector, N. Mid. District.	Assistant Engineer, Scot. West	To be fixed later.
Hargreaves, T.	Chief Inspector, E.-in-C.O.	Assistant Engineer, E.-in-C.O.	To be fixed later.
Hazlewood, H. A. S.	Skilled Workmen, Class I. E.-in-C.O.	Inspector, E.-in-C.O.	9-12-28
Trussler, H.	Skilled Workmen, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	21-7-29
Thomas, H. C.	Skilled Workmen, Class I., E.-in-C.O.	Inspector, E.-in-C.O.	3-11-29
Findlay, W.	Skilled Workmen, Class I., Rugby Radio Station.	Inspector, Rugby Radio Station.	5-1-30
Middleditch, E. G. H.	Skilled Workmen, Class I., Portishead Radio Station.	Inspector, Leafield Radio Station.	To be fixed later.
Pocock, D. G.	Skilled Workmen, Class I., Rugby Radio Station.	Inspector, Rugby Radio Station.	6-6-30
Thomas, C. F.	Skilled Workmen, Class II., St. Albans Radio Station.	Inspector, St. Albans Radio Station.	13-6-29
Lane, A. E. R.	Skilled Workmen, Class I., Testing Branch.	Inspector, Testing Branch.	24-1-29
Durston, E. A.	Skilled Workmen, Class I., S. West District.	Inspector, S. West District.	5-7-30
Wright, A. R. T.	Skilled Workmen, Class I., S. West District.	Inspectors, S. West District.	13-7-30
Treglown, P. G.			24-8-30
Hoare, J. H.			17-6-30
Marsden, B.	Skilled Workmen, Class I., N. Mid. District.	Inspector, N. Mid. District.	20-5-28
Chadwick, J.	Skilled Workmen, Class I., S. Lancs. District.	Inspector, S. Lancs. District.	To be fixed later.
Brown, R.	Skilled Workmen, Class I., Scot. West District.	Inspector, Scot. West District.	16-8-30

DEATHS.

Name.	Rank.	District.	Date.
Johnson, E.	Chief Inspector.	London.	7-8-30

Retirements.

Name.	Rank.	District.	Date.
Elliott, J. R. M.	Superintending Engineer.	Northern.	9-8-30
Roach, C. G.	Asst. Superintending Engineer.	S. Western.	31-7-30
Best, F. W.	Asst. Superintending Engineer.	N. Wales.	31-7-30
Haynes, J. H.	Asst. Superintending Engineer.	S. Wales.	31-8-30
Stuart, D.	Assistant Staff Engineer.	E.-in-C.O.	9-7-30
Smith-Bunney, T.	Executive Engineer.	London.	30-6-30
Nichols, A. R.	,, ,,	N. Mid.	31-7-30
Scott, W.	,, ,,	S. Wales.	31-7-30
Bellwood, G. F.	,, ,,	N.	30-6-30
Andrews, J. R.	,, ,,	N.	31-8-30
Tattershall, C. E.	,, ,,	London.	30-9-30
Kemp, H.	,, ,,	N. Mid.	6-8-30
Harrison, W. L.	Assistant Engineer.	London.	31-7-30
Pittman, W. C.	,, ,,	N. Mid.	20-7-30
Stiles, W. E.	Chief Inspector.	London.	29-6-30
Houchin, R. E. H.	,, ,,	S. Mid.	21-6-30
Booth, R.	,, ,,	S. Lancs.	30-6-30
Winter, J.	,, ,,	N. Ireland.	15-8-30
Harrison, G. H. W.	Inspector.	S. West.	16-6-30
Corke, H. J.	,,	S. Lancs.	26-5-30
Doubrowsky, N. J.	,,	London.	30-6-30
Jennings, N. J.	,,	London.	30-6-30
Anderton, W. H.	,,	S. East.	13-7-30

Appointments.

Name.	From	To	Date.
Richards, C. E.	Probationary Assistant Engineer, Research Section, E.-in-C.O.	Assistant Engineer, Research Section, E.-in-C.O.	22-7-30
Haliburton, F. C.	Probationary Inspector, N. Mid. District.	Inspector, N. Mid. District.	1-6-30

CLERICAL ESTABLISHMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Robinson, W. D.	Executive Officer, E-in-C.O.	Staff Officer, E.-in-C.O.	17-5-30
Brown, B. M.	Executive Officer, E-in-C.O.	Staff Officer, E.-in-C.O.	5-6-30
Buxton, A. D.	Acting Executive Officer, E.-in-C.O.	Executive Officer, E.-in-C.O.	17-5-30
Wilson, P. A. V.	Clerical Officer, E.-in-C.O.	Executive Officer, E.-in-C.O.	5-6-30
Murray, C. E.	Clerical Officer, E.-in-C.O.	Acting Executive Office, E.-in-C.O.	5-6-30
Edwards, A. W.	Clerical Officer, London District.	Higher Clerical Officer, London District.	
Chubbock, J. H.	Clerical Officer, London District.	Higher Clerical Officer, London District.	1-7-30
Shorter, A. E.	Clerical Officer, S. Mid. District.	Higher Clerical Officer, N. Mid. District.	24-8-30
Anderson, C.	Clerical Officer, S. Lancs. District.	Higher Clerical Officer, S. Lancs. District.	8-8-30
Barratt, D.	Clerical Officer, N. West District.	Higher Clerical Officer, S. Lancs. District.	24-8-30
Ferguson, W. N.	Clerical Officer, N. Wales District.	Higher Clerical Officer, N. Wales District.	1-9-30
Williams, D.	Higher Clerical Officer, N. Wales District.	Staff Officer, S. West District.	1-9-30

RETIREMENTS.

Name.	Rank.	District.	Date.
Morris, G. L.	Higher Clerical Officer.	N. Midland.	7-6-30
Scrafton, C. D.	" " "	N. Midland.	8-7-30
Watson, W. G.	" " "	S. Western.	20-7-30
Claydon, T. A.	" " "	London.	31-5-30
Harris, W. T.	Staff Officer.	S. Western.	31-8-30

I.P.O.E.E. PROGRAMME, 1930-31.

LONDON CENTRE.

1930.
21 Oct. Exhibition of official films.
11 Nov. L. L. Tolley.
"Testing of paper for use in Telegraph Systems."
9 Dec. *To be arranged.*
1931.
13 Jan. F. R. Perris.
"Secondary Cells."
10 Feb. W. R. Tyson.
"The Equipping of Automatic Exchanges."
10 Mar. H. Faulkner, M.I.E.E., G. T. Evans.
"Development in Telegraph Technique as applied to Radio Circuits."
12 May. W. W. N. Chew.
"Making the most of Automatic Telephone Plant; the development of Traffic Measurement."

Informal Meetings.
1930.
28 Oct. H. S. Pate.
"Auto v. Manual Working, Some comparisons of Costs."
25 Nov. A. F. E. Evans.
"The Development of Key Sending from "A" positions."
1931.
27 Jan. H. W. Fulcher, A.M.I.E.E.
"Ventilation of Telephone Exchanges."
24 Feb. E. H. Slattery.
"Public Wayleaves."
24 Mar. R. T. Robinson, A.M.I.E.E.
"Motor Transport."
28 Apr. G. A. Barratt.
"Superannuation Acts."
Visits :—
Croydon Aerodrome.
Post Office (London) Railway.
Post Office Research Station, Dollis Hill.

S. LANCS. CENTRE.

1930.
13 Oct. T. E. Herbert, M.I.E.E.
Chairman's Address.
10 Nov. A. J. Pratt, M.I.E.E.
"The development of a telephone system." (Illustrated by cinema film).
15 Nov. W. T. Leeming, A.M.I.E.E., and H. M. Turner.
"Maintenance Loads and Costs."
1931.
12 Jan. *To be arranged.*
9 Feb. —
"Manchester Auto Exchanges."
9 Mar. *To be arranged.*
30 Mar. *To be arranged.*

NORTH WESTERN CENTRE.

1930.
E. S. Ritter, M.I.E.E., D.F.H. (*E.-in-C.O.*).
"Picture Telegraphy."
T. F. Levens.
"Rural Automatic Exchanges."
A. Diggle.
"Rochdale Automatic Exchange—Some special features."
1931.
S. Upton, A.M.I.E.E.
"Unit Costs—their use in the control of expenditure and as an aid to supervision of works."
W. T. Palmer and E. H. Jolley (*E.-in-C.O.*)
"Cable Testing Methods."
Visit to Leyland & Birmingham Rubber Co.'s Works, Leyland.

NORTH MIDLAND CENTRE.

1930.
6 Oct. J. R. Milnes.
(1) "Secondary Cells Maintenance."
(2) "Cable Corrosion."
3 Nov. —
"Teleprinters."
1 Dec. *To be arranged.*
1931.
5 Jan. A. S. Ritter, M.I.E.E., D.F.H. (*E.-in-C.O.*).
"Picture Telegraphy."
2 Feb. Col. A. S. Angwin, D.Sc., M.C.T.D., M.I.E.E. (*E.-in-C.O.*).
"The P.O. Radio Telephony Stations."
2 Mar. C. A. Carpenter.
"Unit Construction Costs."
Visit to Messrs. Ericssons Telephone Works, Beeston.

NORTH WALES CENTRE.

1930.
8 Oct. W. E. Radford.
"Electrolysis."
10 Nov. B. Lynn (*E.-in-C.O.*).
"Straightforward Trunking."
10 Dec. —
"Exhibition of official and other films."
1931.
10 Jan. Capt. N. F. Cave-Browne-Cave, B.Sc., M.I.E.E.
"Some important materials and their characteristics."
13 Feb. G. H. Garrier.
"Some thoughts on electrons."
13 Mar. R. Sheppard.
"The Birmingham Automatic Scheme."

SOUTH MIDLAND CENTRE.

1930.
8 Oct. J. E. Taylor, M.I.E.E.
"Maxwell, Heaviside-Einstein."
5 Nov. S. D. Pendry.
"Economical Construction and Maintenance."
Capt. F. A. Linsell, M.I.E.E., M.C.
"Trunking in Automatic Exchanges."
1931.
7 Jan. S. Moody.
"Telephoning Rural Areas."
4 Feb. *To be arranged.*
4 Mar. *To be arranged.*

SOUTH WALES CENTRE.

1930.
— Oct. Visit to Messrs. Lysaughts Steel Works, Newport.
— Nov. W. Day, M.I.E.E.
"Some notes on the conversion of the London Telephonic network from Manual to Director working."
— Dec. E. A. Pearson.
"Waste, with general reference to Engineering work and design."
1931.
— Jan. H. C. A. Linck.
"Construction and operation of Teleprinters No. 3A."
— Feb. S. G. Joscelyn.
"The Drawing Office and its functions."
— Mar. A. E. Filey and R. D. Fuse.
"Rural Automatic Exchanges."

SOUTH WESTERN CENTRE.

1930.
14 Oct. D. A. Barron.
"Revolutionary External construction."
11 Nov. A. Bucklitsch.
"Maintenance Works and Costs."
9 Dec. Exhibition of Official films.
1931.
6 Jan. *To be arranged.*
10 Feb. F. V. Ford and R. S. Cooper.
"Four-wire repeaters."
10 Mar. W. T. Palmer and E. H. Jolley (*E.-in-C.O.*).
"Developments in relation to cable Testing Methods."

EASTERN CENTRE.

1930.
— Sept. Visit to the Baldock Radio Station.
— Oct. F. Guest.
"The Southend Transfer."
— Dec. Exhibition of Official films.
1931.
— Jan. F. R. Perris (*E.-in-C.O.*).
"Secondary Cells."
— Feb. *To be arranged.*
— Mar. *To be arranged.*

NORTH EASTERN CENTRE.

1930.
14 Oct. J. Shea.
"Improved Methods of Overhead Construction" with exhibition of official films.
11 Nov. *To be arranged.*
9 Dec. *To be arranged.*
1931.
— Jan. *To be arranged.*
— Feb. R. B. Graham, A.M.I.E.E.
"Notes on the Construction and Maintenance of Rural Auto Exchanges."
— Mar. W. W. B. Crompton, A.M.I.E.E.
"Plant Records."

NORTHERN CENTRE.

1930.
— Oct. F. G. C. Baldwin, M.I.E.E.
Chairman's Address.
— Nov. Capt. N. F. Cave-Browne-Cave, B.Sc., M.I.E.E. (*N. Wales*).
"Sound and Hearing."
— Dec. Thos. Davidson.
"Rural Automatic Exchanges."
1931.
— Jan. T. Richards.
"Secondary Cells—Installation and Maintenance."
— Feb. W. Clothier.
"Internal Combustion Engines—their use in the P.O.E. Dept."
Visit to Newcastle Automatic Exchange.

SCOTLAND EAST CENTRE.

1930.
— Nov. H. Burgher.
"Underground development schemes."
— Dec. —
"Short papers and exhibition of official films."
1931.
— Jan. J. Patrick.
"Free wayleaves."
— Feb. —
"Short papers and exhibition of official films."
— Mar. *To be arranged.*
— Apr. —
"Short papers and exhibition of official films."

SCOTLAND WEST CENTRE.

1930.
6 Oct. R. MacWhirter, B.Sc.
"Rectification with special reference to Exchange Battery charging."
3 Nov. H. G. S. Peck, B.Sc. (Hons.), A.M.I.E.E. (*E.-in-C.O.*).
"The Director System in London."
1 Dec. Informal.
Subject and speakers to be arranged.
1931.
2 Feb. Informal.
Subject and speakers to be arranged.
2 Mar. A. Thomson.
To be decided.
The Official films are also to be shown on various dates above.

N. IRELAND.

1930.
7 Oct. A. J. Arden (Post Office Surveyor, Belfast).
"Organisation of the British Post Office Mail Service."
4 Nov. Exhibition of Official Films.
2 Dec. W. S. French.
"Telephone plan number extensions and local difficulties in connection with."
1931.
6 Jan. A. H. Jacquest, A.M.I.E.E.
"An introduction to cable balancing."
3 Feb. W. S. Keown.
"An investigation into the susceptibility of S.A. Ducts to damage."
9 Mar. E. S. Ritter, M.I.E.E., D.F.H. (*E.-in-C.O.*).
"Picture Telegraphy."
7 Apr. W. S. Colston.
"Special underground construction in Belfast."

THE INSTITUTION OF P.O. ELECTRICAL ENGINEERS.

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