THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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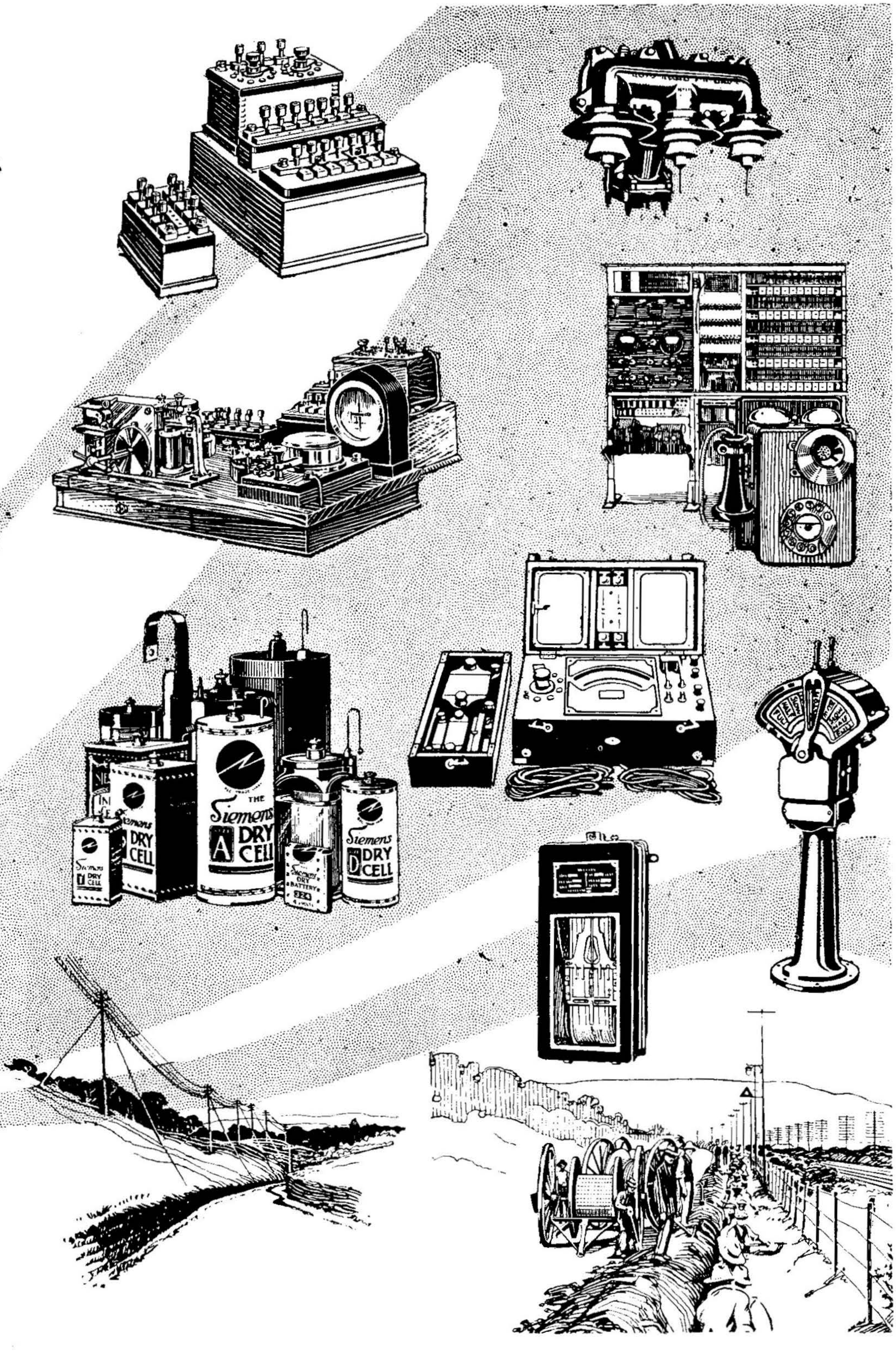
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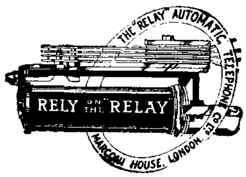

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THE
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AN INTERNATIONAL 5-UNIT TELEGRAPH CODE.

A. C. BOOTH.

PROBABLY no one knows the number of different telegraph codes that have been in use from time to time since signalling was first brought into use, which was of course many hundreds of years before the introduction of the electric telegraph. Even within the last few decades there have been several new telegraph codes, but generally speaking there are only three primary codes in use, viz., the Morse code, the Hughes code and the 5-unit code. The first and third have their variations, as for instance the American and Continental Morse, the latter having additional characters represented by combinations of 5 or 6 dots and dashes for use in different countries such as in Japan. Fig. 1 gives a comparative list of the two alphabets; the asterisk shows where the codes differ, viz., 11 times in the alphabet and nine times in the figures.

The American Morse is not suitable for machine telegraphy, *i.e.*, for Wheatstone working, with or without the addition of alphabetical keyboard perforators or printing instruments. Because of this disadvantage and its greater liability to errors it will in time undoubtedly give place to the Continental Morse code, but at considerable cost and trouble.

The spacing between the elements of letters of two lengths, the second being the equivalent of a letter space, or if made shorter it introduces an additional space unit intermediate between our first and second space signals. In either case it is productive of many errors through being misunderstood for one or the other. In fact the accuracy depends to a great extent on

MORSE CODES.

AMERICAN. CONTINENTAL.

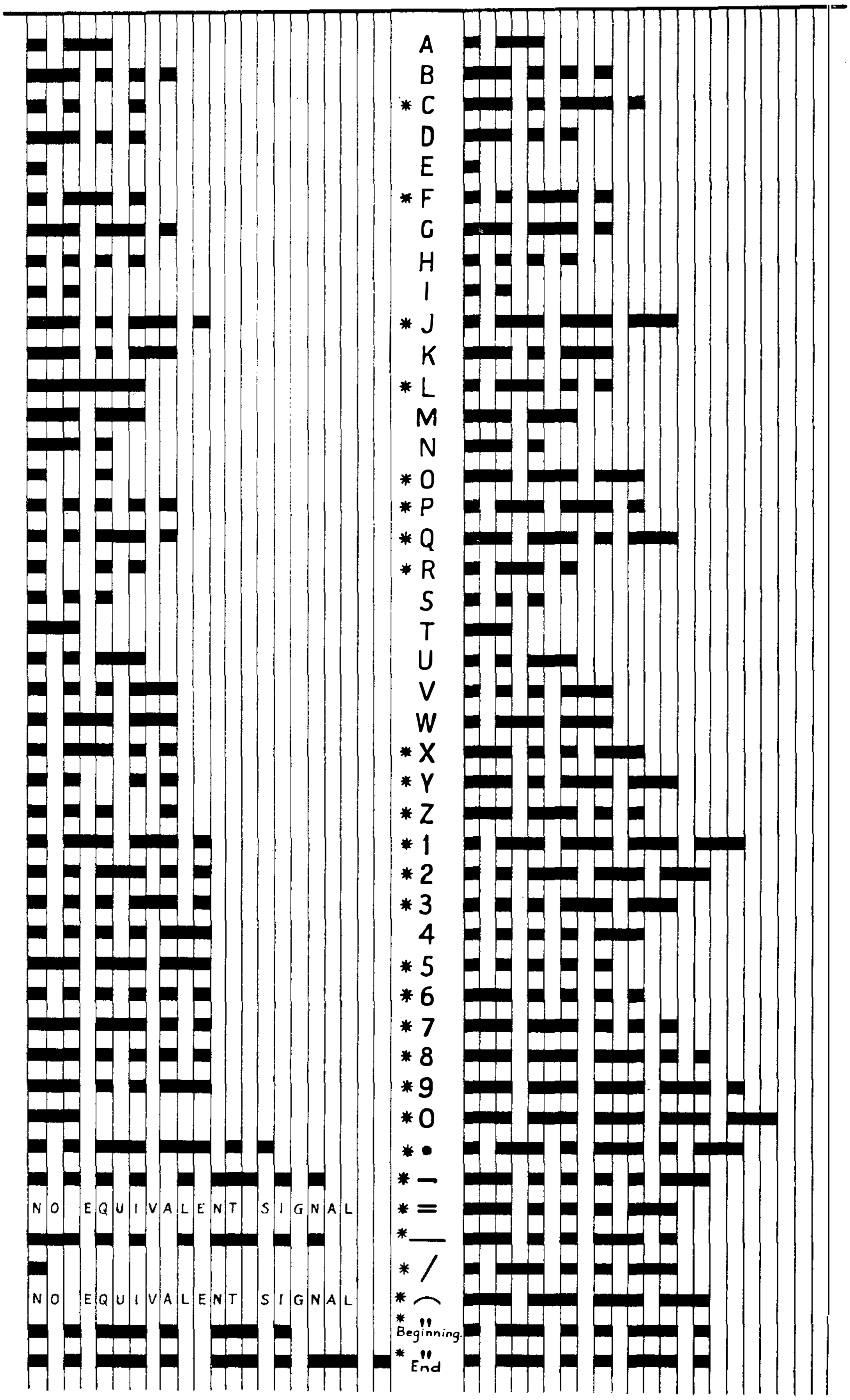


FIG. 1.

the ability of the receiving operator to make an intelligent guess of what is intended.

Details of the exact lengths of signals and spaces used in the Continental Morse code are as follows:—

(1) The "Dot" is the unit signal.
(2) The Dash is three times the length of the Dot.
(3) The space in the elements of a letter is the same length as a "Dot."
(4) The space between letters is three times the unit space, or the same length as a dash.
(5) The space between words is five times the length of a unit and not six as is sometimes stated.

It would therefore be a great all-round advantage to obtain as quickly as possible an agreement among all Telegraph Administrations to an International 5-unit code.

In this country we have in use three primary and two secondary 5-unit codes. The three primary ones are those of the Baudot, Murray, and Siemens; the two secondary ones are modifications of the first two for use on inland circuits, making the following five different 5-unit codes in use by the British Post Office:—

(1) Baudot original on Foreign circuits.
(2) Baudot modified on Inland circuits.
(3) Murray original on Western Electric, Kleinschmidt and Morkrum apparatus.
(4) Murray modified on Murray Duplex Multiplex.
(5) Siemens' original on London-Berlin circuits.

The Baudot system was the first to use the 5-unit code to any large extent, and was practically the only user of such a code for some 40 years. On this account and because of its fairly extensive use it is entitled to minimum alteration, but in some respects it is not so suitable to present day requirements as some of the later adaptations of the 5-unit code. There should, however, be no insurmountable difficulty in bringing the modern ones into line with the major portion of the Baudot code, provided the latter is modified slightly in a few signals to meet essential present day requirements.

The chief objection to any alteration of the Baudot code is, of course, the fact that many hundreds of operators will have to train themselves in the altered signals, whereas the modern 5-unit codes all use alphabetical keyboard perforators or signallers which are quite independent, so far as the sending operators are concerned, of any re-allocation of signals.

The accompanying table (Fig. **2**) shows the Baudot, Murray and Siemens' codes, from which it would appear that the signals of

BAUDOT 5 UNIT A														MURRAY 5 UNIT B							SIEMENS 5 UNIT C						
KEYBOARD NUMBERS 5	4	1	2	3	INLAND		FOREIGN		1	2	3	4	5			1	2	3	4	5			1	2	3	4	5
		o			A	1	A	1	o					A		o	o				A	.		o	o		
	o			o	B	8	B	8			o	o		B	?	o			o	o	B	/		o		o	o
	o	o		o	C	9	C	9	o		o	o		C	(		o	o	o		C	'	o	o	o		o
	o	o	o	o	D	0	D	0	o	o	o	o		D	²	o			o		D	&	o				o
			o		E	2	E	2		o				E	3	o					E	3	o	o	o		
	o		o	o	F	5/	F	F/=		o	o	o		F	1/	o		o	o		F	!	o		o	o	
	o		o		G	7	G	7		o		o		G	3/		o		o	o	G	"	o	o		o	o
	o	o	o		H	¹	H	H/=	o	o		o		H	4/			o		o	H	;	o	o			o
			o	o	I	3/	I	O/=		o	o			I	8		o	o			I	8	o				
	o	o			J	6	J	6	o			o		J	7/	o	o		o		J	=		o			o
o	o	o			K	(	K	(	o			o	o	K	9/	o	o	o	o		K	§				o	
o	o	o	o		L	=	L	=	o	o		o	o	L	/		o			o	L	+	o	o	o	o	
o	o		o		M	)	M	)		o		o	o	M	'			o	o	o	M	?		o			
o	o		o	o	N	£	N	№		o	o	o	o	N	—			o	o		N	—	o	o			
		o	o	o	O	5	O	5	o	o	o			O	9				o	o	O	9	o			o	o
o	o	o	o	o	P	+	P	%	o	o	o	o	o	P	0		o	o		o	P	0		o	o		o
o	o	o		o	Q	/	Q	/	o		o	o	o	Q	1	o	o	o		o	Q	1			o		o
o	o			o	R	—	R	—			o	o	o	R	4		o		o		R	4				o	o
o				o	S	7/	S	;			o		o	S	¹	o		o			S	:			o	o	
o		o		o	T	²	T	!	o		o		o	T	5					o	T	5					o
		o		o	U	4	U	4	o		o			U	7	o	o	o			U	7		o	o	o	
o		o	o	o	V	'	V	'	o	o	o		o	V	)		o	o	o	o	V	)	o		o	o	o
o			o	o	W	?	W	?		o	o		o	W	2	o	o			o	W	2	o			o	
o			o		X	9/	X	,		o			o	X	£	o		o	o	o	X	(		o		o	
				o	Y	3	Y	3			o			Y	6	o		o		o	Y	6	o		o		
o		o	o		Z	:	Z	:	o	o			o	Z	.	o				o	Z	,	o		o		o
	o				FIG SPACE	FIG SPACE	FIG SPACE	FIG SPACE				o		FIG SPACE	FIG SPACE	o	o		o	o	FIG SPACE	FIG SPACE		o	o	o	o
o					LTR SPACE	LTR SPACE	LTR SPACE	LTR SPACE					o	LTR SPACE	LTR SPACE			o			LTR SPACE	LTR SPACE			o	o	o
o		o			—	.	t/=	.	o				o	LINE PAGE	LINE PAGE				o		ϕ	ϕ			o		
o	o				✳	✳	✳	✳				o	o	✳*	✳*	o	o	o	o	o	✳	✳	o	o		o	
		o	o		/	1/	É	&	o	o				COL	COL		o				▌	▌	o	o	o	o	o
																					▌	▌					

* 1 2 3 4 5 gives invisible correction on page printers & ✳ on slip printers.

FIG. 2.

the two latter had been allocated intentionally to differ from the others as much as possible, but it is a fact that the allocation was made in all three cases on a sound practical basis. The Baudot code was allocated for easy remembrance and easy operation by the sending operators, the Murray was based on the frequency of use of letters in the English language, and the Siemens' on the frequency of use of letters in the German language. The large number of present day business telegrams, consisting of ten-letter code words made up with a high proportion of the less frequently used letters, entirely destroys the basis of the allocation of both the Murray and Siemens' alphabets.

In view of the comparatively small number of the Murray and Siemens' sets in use as compared with the Baudot sets and the number of trained Baudot operators, there should be far less trouble and far less cost incurred with alterations to these codes than with alterations to the Baudot code.

However, it would be well to hear arguments from all parties concerned, and as our Journal has a world-wide circulation the Board of Editors will welcome contributions to such a discussion from all interested parties.

THE RONALDS' ELECTRIC TELEGRAPH.

A. C. BOOTH.

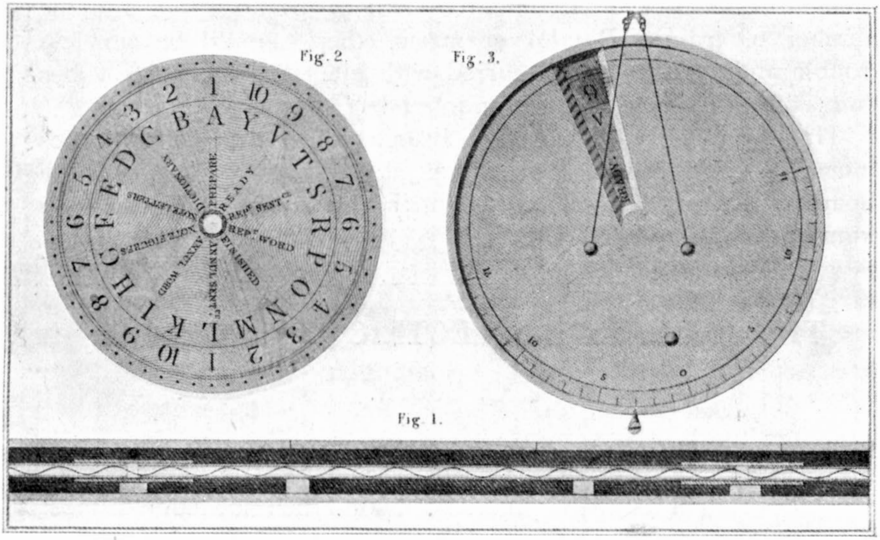
COL. SIR ANDREW OGILVIE, K.B.E., C.B., has drawn the attention of Major Purves to this very interesting instrument, which because of its age is probably beyond the knowledge of most if not all present day telegraph men. A brief description may therefore be of interest.

As far back as 1823 a book was printed for R. Hunter, 72, St. Paul's Churchyard, London, giving a full description by Francis Ronalds of an arrangement for an electrical telegraph. A copy of this book is held in the Engineer-in-Chief's Library and is numbered H. 267, should any reader desire to obtain further information than can be given in this short article. The book also gives a description of other electrical apparatus, which, however, is not of sufficient telegraphic interest to need further comment here.

In the course of the description there are many paragraphs of exceptional interest on the possible developments of the telegraph, of its obvious weaknesses and means for overcoming them, which show most conclusively that Ronalds was an experimenter of a very high order, had the gift of excellent foresight and was in advance of his time as a practical telegraph man.

Briefly, his arrangement was the rotation, by means of clock-work, of two discs carrying the letters of the alphabet. The discs were obscured from view, with the exception of a small portion sufficient to show one letter at a time. This portion formed the "reading" position for the receiving operator, who was notified when to read the passing letters by a change in the electrical condition of the line wire connecting the two stations.

At that time the frictional electrical machine was the most suitable generator available, and it was used to charge a well-insulated underground line connected at the other end to a pith-ball electroscope, causing the pith-balls to diverge.



THE RONALDS' TELEGRAPH APPARATUS AND CABLE.

A signal was given by momentarily "earthing" the sending end, thus causing the pith-balls to fall together. The discs had, of course, to work in "unison," and a method of making any correction when necessary was arranged for by rotating the disc carrying the observation window. The connecting land line was to be laid "underground" and was to consist of a bare wire threaded through glass-tubes fitted with expansion joints, in which soft wax was used to keep out water. The glass tube was protected by a wooden-trough well-lined inside and outside with pitch.

The apparatus was actually worked over a short experimental line some 500 feet long, but there is no information available as to whether it was ever used on any longer line. It is very doubtful whether the insulation could ever have been brought up sufficiently high to allow of a frictional machine to act on a pith-ball electroscope at the end of a line, say fifty miles in length.

(As a matter of interest the pith-ball electroscope was recently tried on an aerial line between London and North Walsham, a distance of about 120 miles, and satisfactory functioning was obtained several times a minute by earthing the line momentarily at the sending end, when a voltage of about 200 obtained from a Megger Testing instrument was used, thus proving that the device was really a practicable low speed telegraph. The insulation of this aerial line would probably be many times higher than that on an underground line of similar length constructed in accordance with Ronalds' scheme).

He provided gas-pistols for calling purposes. When a message had to be sent the wire was electrified and a spark passed through the gas-pistol at the distant end, causing a loud report. He also devised a method of code signalling to lessen the work of operating. He realised the liability of interference to his underground line by an enemy or by mischievously disposed persons, to avoid which he suggested burying the pipe six feet deep in the middle of the road and the provision of alternative routes; then, if rogues still caused interruptions to his wire, he states:—"Hang them if you can catch them, damn them if you cannot, and mend it immediately in both cases."

He arranged for testing points, which he named "provers," along the line, for finding positions of faults and he states, "Any sorry little twopenny post *cove* might take a canter on his Rozinantuolo, and, on his arrival at a prover perform the operation on it in less time than I have employed to describe the manner of its performance." Alongside this footnote there is written in pencil in rather old-fashioned writing the word "Prophetic?"—evidently by a reader of many years ago.

Looking backward across the space of close on 100 years of progress the Ronalds' Telegraph would appear to have held the germ of that very practical and successful instrument which is still in use in its hundreds on the Continent of Europe, viz., the Hughes Printing Telegraph. One must allow for the deficiences of that time in regard to the production of electricity by a frictional machine, but the fact remains that the indications of the intended letters of both the Ronalds and the Hughes is achieved by a single change in the electrical condition of the connecting line, at the moment when the required letter had arrived at a particular position. The dial and its arrangement seem to have been the predecessor of that still in use on the Wheatstone ABC instrument.

The following few extracts from Ronalds' book are worth recording without comment:—

"'Dr. Watson and his friends, Lord C. Cavendish, Mr. Martin Foulks, Dr. Bevis, Mr. Graham, Dr. Birch, Mr. P. Duval, Mr. Trembly, Mr. Ellicot, Mr. Robins, Mr. Short and some other gentlemen, so long ago as the year 1748, proved that electrical shocks might be conducted through long circuits with *immeasurable* velocity. These indefatigable and ingenious experimentalists founded the present commonly received axiom amongst electricians that no perceptible space of time is required to transmit electric signs through conductors of any extent; and Mr. Cavallo in his 'Complete Treatise on Electricity' has suggested a method of conveying intelligence by passing *given numbers of sparks* through an *insulated* wire in given spaces of time. Some German and American *savans* first projected galvanic or voltaic telegraphs by the decomposition of water, etc. But the other form of the fluid appeared to me to afford the most accurate and practicable means of conveying intelligence, and in the summer of 1816 I *amused* myself by wasting, I fear, a great deal of time and no small expenditure in trying to prove by experiments on a much more extensive scale than had hitherto been adopted the validity of a project of this kind. I believe I succeeded to the entire satisfaction of several very eminent scientific friends, and I am sure *they* will at least acquit me of wishing to claim the smallest share of originality which does not belong to me. The *result seemed* to be that that most extraordinary fluid or agency, electricity, may actually be employed for a more practically useful purpose than the gratification of the philosopher's inquisitive research, the schoolboy's idle amusement, or the physician's *tool*; that it may be compelled to travel as many hundred miles beneath our feet as the subterranean ghost which nightly haunts our metropolis, our provincial towns, and even our high roads; and that in such an enlightened country and obscure climate as this its travels would be productive of, at the least, as much public and private benefit."

. . . .

"Why has no *serious trial* yet been made of the qualifications of so *diligent* a courier? And if he should *be* proved competent to the task, why should not our kings hold council at Brighton with their ministers in London? Why should not our government govern at Portsmouth almost as promptly as in Downing Street? Why should our defaulters escape by default of our foggy climate?

. . . .

Let us have *electrical conversazione offices* communicating with each other all over the kingdom, *if we can*."

. . . .

"How far *it* and subsequent experiments and observations may warrant the prosecution of further and more extensive undertakings, for the purpose of *endeavouring* to establish ELECTRIC TELEGRAPHS, remains for the consideration of those whom it may concern, and who may deem the subject worthy of consideration."

. . . .

"Lord Melville was obliging enough in reply to my application to him, to request Mr. Hay '*to see me on the subject of my discovery,*' but before the nature of it had been yet known, except to the late Lord Henniker, Dr. Rees, Mr. Brande, and a few friends, I received an intimation from Mr. Barrow to the effect '*that telegraphs of any kind were then wholly unnecessary and no other than the one then in use would be adopted.*'"

TELEPHONE INDUCTION COILS.

H. J. GREGORY, B.Sc.

IN the writer's article on the "Carbon Transmitter," in this Journal of July, 1920, the principle of considering the transmitter as a generator of alternating current having a definite E.M.F. and internal impedance equal to its D.C. resistance was described. Following on from this, calculations are now given which enables the output from a subscriber's instrument to be estimated and the most suitable induction coil for a given circuit to be obtained.

L.B. Induction Coil.

The L.B. Induction Coil will be dealt with first, as it is a simple transformer.

The operation of the L.B. Instrument is illustrated by Fig. 1. The transmitter is considered as a source of A.C. producing an E.M.F. of E volts at a mean speech frequency $f = \frac{\omega}{2\pi}$. The primary

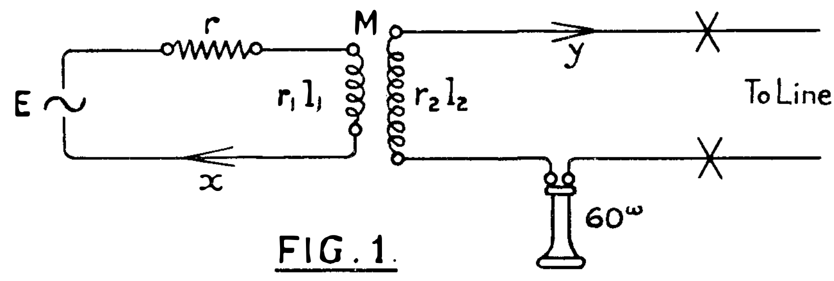


FIG. 1.

circuit will therefore contain an E.M.F. of E volts in series with a resistance r ohms equal to the sum of the resistance of the transmitter and the internal resistance of the primary battery. It has been found by experiment that the direct current in the primary circuit has no appreciable effect upon the impedance of the windings of the induction coil, and it will therefore be neglected.

If r_1 = resistance in primary circuit,

l_1 = self induction of primary winding,

x = current (A.C.) in primary circuit,

y = ,, ,, ,, secondary ,,

r_2 = total resistance in secondary circuit,

l_2 = ,, self induction in ,, ,,

M = mutual induction between primary and secondary circuits.

It should be noted that $(r_2 + j\omega L_2)$ includes the impedance of the secondary winding, receiver and the sending end impedance of the line. In the case of a line whose impedance has a negative angle, it is considered as a resistance and a negative reactance.

The equations for the whole circuit will be:—

$$l_1 \frac{dx}{dt} + M \frac{dy}{dt} + r_1 x = E \sin \omega t. \quad \text{(1)}$$

$$M \frac{dx}{dt} + l_2 \frac{dy}{dt} + r_2 y = 0. \quad \text{(2)}$$

Solving these equations for x and y, we get

$$x = \frac{E \sin(\omega t + \alpha)}{\sqrt{R^2 + (L\omega)^2}} \quad \text{(3)}$$

$$y = \frac{M\omega}{\sqrt{r_2^2 + (l_2\omega)^2}} \times \frac{E \sin(\omega t + \beta)}{\sqrt{R^2 + (L\omega)^2}} \quad \text{(4)}$$

where

$$R = r_1 + \frac{(M\omega)^2 R^2}{r_2^2 + (l_2\omega)^2} \quad \text{(5)}$$

$$\omega L = \omega L_1 - \frac{(M\omega)^2 \omega L_2}{r_2^2 + (L_2\omega)^2} \quad \text{(6)}$$

and $\tan \alpha = \frac{L\omega}{R}$; $\tan(\alpha - \beta) = \frac{r_2}{l_2\omega}$.

Magnetic Leakage.

As the Mutual Induction will be modified by magnetic leakage, it will be advisable to investigate this and determine to what extent magnetic leakage occurs.

The condition for no magnetic leakage may be expressed by the well known formula

$$M = \sqrt{l_1 l_2} \quad \text{(7)}$$

or, if the Ratio of Transformation, *i.e.*, $\frac{\text{Secondary turns}}{\text{Primary turns}} = n$ is known, we may alternatively write

$$M = n l_1 \quad \text{(8)}$$

From the impedances of the windings a value for M may thus be calculated for the ideal condition, but it is necessary to know M under practical conditions, and it may be obtained as follows:—

In equation (3), when the secondary is on open circuit, the denominator is evidently $\sqrt{r_1^2+(l_1\omega)^2}$, but when the secondary circuit is closed and its resistance and inductance are respectively r_2 and l_2, the apparent impedance of the primary circuit is changed, so that its resistance and inductance are now R and L, according to equations (5) and (6). If, therefore, these new values for R and L are measured for known values of r_2 and l_2, we can calculate the true value of M.

The method is illustrated by the following data taken from a $1^{\omega}/25^{\omega}$ induction coil at 800 cycles per sec.:—

Open Circuit Test.

P.D. impressed on primary winding = ·297 volts.
Current in primary circuit = 11·7 m.a. lagging 85°.
Terminal P.D. produced in secondary winding = ·875 volts.
∴ Impedance of primary winding = 25·3 $\underline{/85^\circ}$.
∴ L_1 = ·00498 henries.
Impedance of secondary winding with 1 m.a. = 240 $\underline{/81{\cdot}4^\circ}$.
∴ L_2 = ·0475 henries.
∴ from (7) M = $\sqrt{\cdot00498\times\cdot0475}$ = *·0154 henries.*

Evidently the mutual inductance with the secondary on open circuit will be from (8)—

$$M=\frac{\cdot875}{\cdot297}\times\cdot00498=\cdot0147 \textit{ henries.}$$

Test with Coil in Circuit shown in Fig. 1.

P.D. impressed on primary winding = ·294 volts.
Current in primary circuit = 11·67 m.a., lagging 67°.
P.D. across secondary winding = ·828 volts.
Current in secondary circuit = 1·213 m.a., leading 11° 14.
∴ Impedance of primary winding = 25·2 $\underline{/67^\circ}$.
= *9·85 + jω ·00464.*

Impedance of secondary load = $\dfrac{\cdot828}{\cdot001213}\ \overline{\backslash 11^\circ\ 14'}$.

∴ Total impedance of secondary circuit = *705 + jω ·021.*
Referring to equation (5).
R = 9·85 ohms. r_1 = 2·62 ohms.
r_2 = 705 ohms. l_2 = ·021 henries.
Calculating M from (5) we get

M = ·0145 henries.

These tests show that magnetic leakage has reduced the mutual inductance by about 6%, and also that it is practically the same whether the secondary circuit is open or closed. Tests on other coils with secondary circuits of various impedances have given very similar results. From a number of tests it has been concluded that the true value of the mutual inductance is obtained if M from formula (7) is reduced by 6% for $1^{\omega}/25^{\omega}$ coils and 12% for $1^{\omega}/150^{\omega}$ coils.

$$\left.\begin{array}{ll}\therefore \text{ For } 1^{\omega}/25^{\omega} \text{ coils} & M = \cdot 94\sqrt{L_1 L_2} \\ \text{and for } 1^{\omega}/150^{\omega} \text{ coils} & M = \cdot 88\sqrt{L_1 L_2}\end{array}\right\} \qquad \ldots (7a)$$

From this and the open circuit tests we may infer that the shape of the coil greatly influences magnetic leakage, and that these coils might be improved in this respect if they were wound on a longer bobbin and made thinner.

Optimum Windings for L.B. Induction Coils.

Primary Winding

In the article on the "Carbon Transmitter," it was shown that we shall get the maximum output from a transmitter when its resistance is equal to the effective resistance of the circuit to which it is connected. The effective resistance of the load on a L.B. transmitter will be from equation (5)

$$R = r + r_1 + \frac{(M\omega)^2 r_2}{r_2^2 + (l_2\omega)^2}$$

where r is the resistance of the primary battery

and r_1 ,, ,, ,, winding.

The optimum primary winding will therefore be such that

$$R_T = r + r_1 + \frac{(M\omega)^2 r_2}{r_2^2 + (l_2\omega)^2}$$

where R_T is the resistance of the transmitter.

Tests on a number of similar coils at 800 cycles per second showed that the effective resistance of the primary winding on open circuit is about 0·1 of its reactance. If magnetic leakage is neglected we may write the equation

$$R_T = r + 0{\cdot}1\,\omega l_1 + \frac{\omega l_1\, \omega l_2\, r_2}{r_2^2 + (\omega l_2)^2} \qquad \ldots (9)$$

where l_1 = inductance of the primary winding

and l_2 = ,, ,, secondary winding.

Assuming that the resistance of the primary battery and the conditions of the secondary circuit are known, we can obtain the inductance l_1 of the optimum primary winding from this equation.

Secondary Winding (Sending only).

The problem is to find the value for the secondary winding which will produce a maximum current y for a given current x in the primary circuit.

From equations (3) and (4) we have

$$\frac{y}{x} = \frac{M\omega}{\sqrt{r_2^2 + (\omega l_2)^2}}$$

If Z_2 = Impedance of the secondary winding of the coil,

Z_L = Impedance of the circuit connected to it,

$\sqrt{r_2^2 + (\omega l_2)^2}$ is the magnitude of the vector sum of Z_2 and Z_L.

Neglecting magnetic leakage M will be proportional to the square root of the self-inductance of the secondary winding ($M = \sqrt{L_1 L_2}$), and for identical types of coil M is approximately proportional to $\sqrt{Z_2}$. We may therefore write—

$$y = \text{Constant} \times \frac{\sqrt{Z_2}}{Z_2 + Z_L}$$

From this we find that y will be a maximum when

$Z_2 = Z_L$ ....(10).

i.e., The optimum winding for the secondary has an impedance equal to that of the circuit to which it is connected.

Secondary Winding (Sending and Receiving).

A double ended circuit will now be considered, having at each end an L.B. instrument similar in all respects. The secondary winding is in series with the receiver, so that any increase in its impedance will reduce the receiving efficiency, although it might increase the sending efficiency. It is evident, therefore, that the secondary winding has to be a compromise between these two effects.

For a given current x in the sending end primary circuit, we have from equations (3) and (4)—

$$\frac{y}{x} = \frac{M\omega}{\sqrt{R_2^2 + (\omega L_2)^2}}$$

If Z_2 = Impedance of the secondary winding of the coil.

Z_L = Sending and Impedance of the line.

Z_r = Impedance of the receiver.

$\sqrt{R_2^2 + (\omega L_2)^2}$ is the magnitude of the vector sum of Z_2, Z_L and Z_r.

Making the same approximations as in the previous case, we have—

$$y = \text{Constant} \times \frac{\sqrt{Z_2}}{(Z_2 + Z_L + Z_r)}$$

The impedance of the secondary winding of the coil at the receiving end will be modified due to the primary circuit being closed, and its precise value can be obtained from (5) and (6), but in order to avoid complication the value of Z_2 will be taken to be the same for the receiving end as the sending end. The value for Z_2 obtained by the calculations will then be the mean for the open and closed primary circuit conditions.

The terminal impedance of the Instrument at the receiving end will be $(Z_2 + Z_r)$, and if Z_0 is the characteristic impedance of the line, the current in the receiving end instrument will be—

$$y_1 = \frac{yZ_0}{Z_0 \sinh\theta + (Z_2 + Z_r)\cosh\theta}$$

If we take the simplest case, *i.e.*, a long line where $\sinh\theta = \cosh\theta$, the received current $y_1 = \dfrac{yZ_0}{(Z_0 + Z_2 + Z_r)\sinh\theta}$

and since $\mathbf{Z}_L$ will then be equal to Z_0

$$y_1 = \text{Constant} \times \frac{Z_0\sqrt{Z_2}}{\sinh\theta\,(Z_0 + Z_2 + Z_r)^2}$$

Since this is the current in the receiver at the receiving end, the optimum secondary winding for both ends of the line will have an impedance Z_2, such that $\dfrac{\sqrt{Z_2}}{(Z_0 + Z_2 + Z_r)^2}$ is a maximum.

All the quantities in this expression are vectors. It will be convenient to consider $Z_0 + Z_r$ as one vector $Z_{or}\underline{|\phi_2}$, and the secondary winding impedance as $Z_2\underline{|\phi_1}$. The expression that must be a maximum may also be—

$$\frac{Z_2}{(Z_2 + Z_0 + Z_r)^4} =$$

$$= \frac{Z_2\underline{|\phi_1}}{(Z_2\cos\phi_1 + jZ_2\sin\phi_1 + Z_{or}\cos\phi_2 + jZ_{or}\sin\phi_2)^4}$$

$$= \frac{Z_2\ \phi_1}{[Z_2\cos\phi_1 + Z_{or}\cos\phi_2 + j\,(Z_2\sin\phi_1 + Z_{or}\sin\phi_2)]^4}$$

and as we are concerned only with the magnitude

$$= \frac{Z_2}{[Z_2\cos\phi_1 + Z_{or}\cos\phi_2)^2 + (Z_2\sin\phi_1 + Z_{or}\sin\phi_2)^2]^2}$$

Differentiating with regard to Z_2, which is the only variable, and equating to zero, we obtain the equation—

$$3Z_2^2 + 2Z_2\,Z_{or} \times \cos(\phi_1 - \phi_2) = Z^2_{or} \quad \text{...........................}(11)$$

ϕ_1 has been assumed as constant for varying values of Z_2. This is approximately correct for coils of a similar type, as shown in the following figures obtained from several L.B. induction coils having the same primary winding in each case, but different ratios of transformation. As an approximation, the mean value of ϕ_1 for the two conditions, *i.e.*, 67°, may be taken.

Ratio of Transformation.	Impedance of Secondary Winding at 800v. and 1 m.a.	
	Primary circuit open.	With 30ω resistance across primary winding.
1 to 3	240 $\angle 81.5^\circ$	200 $\angle 49.5^\circ$
1 to 3.7	342 $\angle 83^\circ$	285 $\angle 51.5^\circ$
1 to 4	392 $\angle 84^\circ$	315 $\angle 50.5^\circ$
1 to 4.7	540 $\angle 84^\circ$	440 $\angle 51^\circ$
1 to 5.7	1163 $\angle 82^\circ$	975 $\angle 52^\circ$
1 to 6.3	1257 $\angle 82^\circ$	1108 $\angle 55^\circ$

It may be of interest to work out the case for the standard L.B. transmission testing circuit.

Characteristic Impedance for Standard Cable $= 571{\cdot}4 \,\overline{|43^\circ\ 16'} = Z_0$,

Impedance of 60ω Bell Receiver $= 212 \,\underline{|50^\circ} = Z_r$,

$\therefore Z_{or} \angle \phi_2 = 597 \overline{\backslash 22^\circ\ 30'}$.

Taking the value for ϕ_1 as $\angle 67^\circ$ and putting these values in equation (11).

$$3Z_2^2 + 2Z_2 \times 597 \cos(67^\circ + 22^\circ\ 30') = 597^2$$

the solution of this equation is $Z_2 = 344$.

The 1 : 4 coil is the nearest for this figure.

Speech tests with some of the coils from which the impedance measurements given above were taken, gave the following results:—

With a junction line of 30 miles of standard cable, a 60ω Bell Receiver at each end, and 30ω resistance representing the transmitter at the receiving end,

Ratio of Transformation.	Combined Sending and Receiving Allowance.
1 to 3	−0.2 S.M.
1 to 3.7	+0.4 ,,
1 to 4	+0.8 ,,
1 to 4.7	−0.6 ,,

These tests confirm that the 1 : 4 coil is the best.

L.B. Induction Coil Connected as an Auto-Transformer.

Auto-transformers are sometimes used in power circuits for transformation at low voltages. As the secondary winding is merely a tap of a portion of the primary winding, both the primary and secondary circuits flow through the secondary. These currents are nearly opposite in phase, so the resultant current is the difference between them. This enables a smaller gauge wire to be used for the secondary winding than for the usual type.

When the auto-transformer connection is applied to the L.B. Induction Coil, it is found that its power efficiency is substantially improved although the currents in the winding are so small. Obviously in this case the secondary winding really consists of the two windings in series and the primary will be the tap portion, but for the following calculations, however, it will be more convenient to consider the windings as separate.

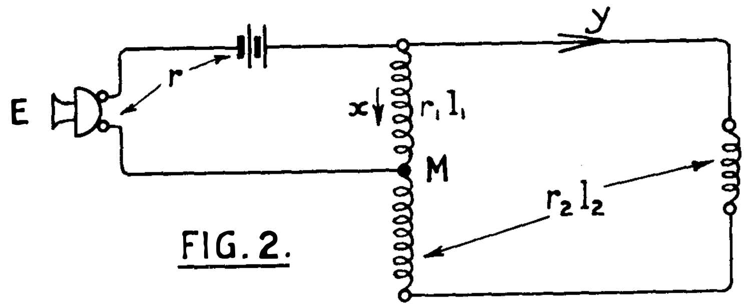


FIG. 2.

If E sin ωt = E.M.F. of the transmitter.

r = resistance of (transmitter + primary battery).

x = resultant current in primary winding (A.C. only).

y = current in secondary circuit.

$r_1 + j\omega l_1$ = impedance of primary winding with secondary open circuit.

$r_2 + j\omega l_2$ = impedance of secondary circuit.

= impedance of (secondary winding + receiver + line).

M = Mutual inductance between the two windings.

The current supplied by the transmitter will be the sum of x and y as the primary winding and secondary circuit are evidently connected to the transmitter in parallel. We may, therefore, write two equations, one for the path of current through the battery and primary winding, and the other through the battery, secondary winding, receiver and line. These equations will be—

$$r(x-y)+r_1x+l_1\frac{dx}{dt}-M\frac{dy}{dt}=E\sin\omega t. \quad\text{(12)}$$

$$r(x+y)+r_2y+l_2\frac{dy}{dt}-M\frac{dx}{dt}=E\sin\omega t. \quad\text{(13)}$$

Actually the two windings must be joined up so as to assist inductively, but we are here considering the windings as being in parallel, so that M must be made negative in the above equations.

Solving these equations for x and y we get:—

$$x = E\sqrt{\frac{(r_2^2 + \omega^2 l_2^2) + \omega M(\omega M + 2\omega l_2)}{[r(r_1 + r_2) + r_1 r_2 + \omega^2 M^2 - \omega^2 l_1 l_2]^2 + [r(\omega l_1 + \omega l_2 + 2\omega M) + r_1 \omega l_2 + r_2 \omega l_1]^2}} \quad \ldots(14)$$

$$y = E\sqrt{\frac{(r_1^2 + \omega^2 l_1^2) + \omega M(\omega M + 2\omega l_1)}{[r(r_1 + r_2) + r_1 r_2 + \omega^2 M^2 - \omega^2 l_1 l_2]^2 + [r(\omega l_1 + \omega l_2 + 2\omega M) + r_1 \omega l_2 + r_2 \omega l_1]^2}} \quad \ldots(15)$$

C.B. Induction Coils.

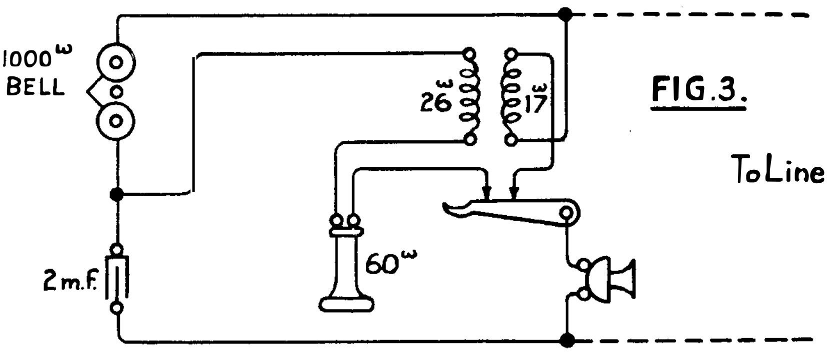


FIG. 3.

In the case of the C.B. Instrument, the feeding current to the transmitter is supplied *via* the line, so that it is necessary to connect the receiver to the line through a transformer. The secondary circuit of this transformer is also connected to the line, but the 2 M.F. condenser prevents most of the direct current from passing through the receiver. The condenser incidentally helps to neutralise the inductance of the secondary circuit. The impedance of the 1000 ohm bell to speech currents is so high that its effect is negligible as regards transmission.

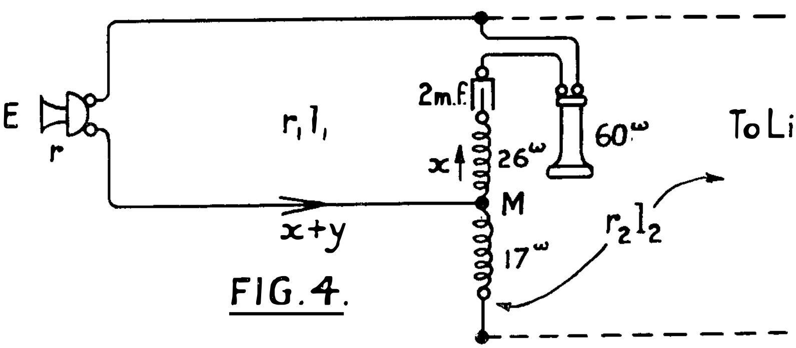


FIG. 4.

Sending.

In order to study the operation of the C.B. Induction Coil when talking, the circuit is re-arranged and shown in Fig. 4.

The 1000 ohm bell is omitted and the receiver is placed on the other side of the 2 M.F. condenser. The two windings are connected in series so as to assist inductively, as indicated in Fig. **3**. It is now easily seen that the C.B. induction coil operates as an auto-transformer, which accounts for the fact that if the windings are joined up incorrectly the transmission efficiency is very seriously reduced. The 26 ohm winding has about 1400 turns and the 17 ohm winding 1700 turns, so that the ratio of transformation of the coil is about $1 + \frac{1400}{1700}$, *i.e.*, 1 to 1·7.

Equations (12), (13), (14) and (15) for the auto-transformer may be applied to the C.B. induction coil, except that the quantities in those expressions will have to be modified.

$E \sin \omega t$ = E.M.F. of the transmitter.

r = Resistance of the transmitter.

x = Resultant current in the 26 ohm winding.

y = current sent to line.

$r_1 + j\omega l_1$ = impedance of (26 ohm winding + condenser + receiver).

$r_2 + j\omega l_2$ = impedance of (17 ohm winding + line).

M = mutual inductance between the 26 ohm and 17 ohm windings.

There will be two equations, one for the current path through the 26 ohm winding, condenser and receiver and the other through the 17 ohm winding and line.

$$r(x+y) + r_1 x + l_1 \frac{dx}{dt} - M\frac{dy}{dt} = E \sin \omega t.$$

$$r(x+y) + r_2 y + l_2 \frac{dy}{dt} - M\frac{dx}{dt} = E \sin \omega t.$$

These equations are identically the same as (12) and (13), consequently their solutions will be identical with (14) and (15).

The following particulars were taken from a $17^{\omega}/26^{\omega}$ C.B. induction coil, the measurements being made with 1 m.a. at 800 cycles per second.

17 ohm winding—Effective resistance 45·5 ohms. Inductance ·158 henry.

26 ohm winding—Effective resistance 38·5 ohms. Inductance ·0695 henry.

Inductance of both windings in series when assisting inductively ·434 henry.

Inductance of both windings in series when opposing ·023 henry.

If L_1 and L_2 are the inductances of 17 ohm and 26 ohm windings, respectively, and M = mutual inductance between them, we have from these results—

$$L_1 + L_2 + 2M = \cdot 434 \text{ henry.}$$
$$L_1 + L_2 - 2M = \cdot 023 \quad ,,$$
$$\therefore \quad M = \cdot 103 \text{ henry.}$$

The condition for no magnetic leakage is that

$$M = \sqrt{L_1 L_2}$$
$$= \cdot 105 \text{ henry.}$$

Similar tests on several of these coils show that magnetic leakage reduces the mutual inductance by about 2%, *i.e.*, $M = \cdot 98\sqrt{L_1 L_2}$. They are better in this respect, probably owing to their being longer in proportion to the diameter than is the case with L.B. coils.

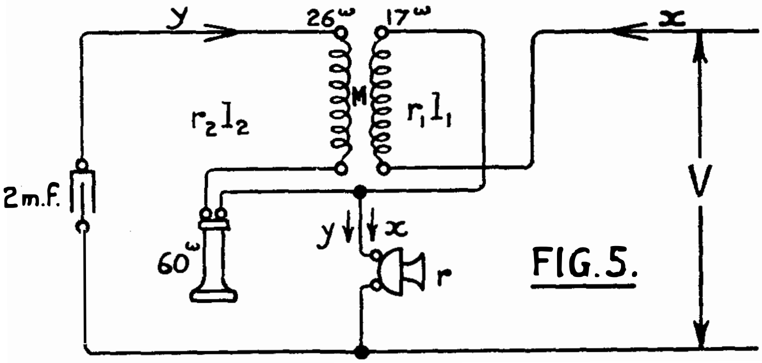


FIG.5.

Receiving.

When receiving, the C.B. induction coil operates as an ordinary transformer, but both primary and secondary currents pass through the transmitter. The 17 ohm winding is now the primary and if V is the *p.d.* impressed on the instrument terminals, the current supplied is x and the current in the receiver is y.

The equations will be—

$$r(x+y) + r_1 x + l_1 \frac{dx}{dt} - M\frac{dy}{dt} = V \sin \omega t. \quad \text{.....................(16)}$$

$$r(x+y) + r_2 y + l_2 \frac{dy}{dt} - M\frac{dx}{dt} = 0. \quad \text{.............................(17)}$$

Solving these equations for x and y, we get

$$x = V\sqrt{\frac{(r+r_2)^2 + \omega^2 l_2^2}{[r(r_1+r_2) + r_1 r_2 + \omega^2 M^2 - \omega l_1 \omega l_2]^2 + [r(\omega l_1 + \omega l_2 + 2\omega M) + r_1 \omega l_2 + r_2 \omega l_1]^2}}$$

$$\text{Sin}\left[\omega t + \tan^{-1}\left(\frac{\omega^2 M^2 \omega l_2 - \omega l_1(r_2^2 + \omega^2 l_2^2) - r(r_1 \omega l_2 + r_2 \omega l_1) + r\omega l_2(r_1+r_2) - r(r_1+r_2)(\omega l_1 + \omega l_2 + 2\omega M)}{\omega^2 M^2 r_2 + r_1(r_2^2 + \omega^2 l_2^2) + r(r+r_2)(r_1+r_2) + r\omega l_2(\omega l_1 + \omega l_2 + 2\omega M) + r(r_1 r_2 + \omega^2 M^2 - \omega l_1 \omega l_2)}\right)\right] \text{...(18)}$$

The magnitude of y in terms of x is—

$$y = x\sqrt{\frac{r^2+\omega^2 M^2}{(r+r_2)^2+\omega^2 l_2^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(19)$$

where r = resistance of the transmitter.

$r_1 + j\omega l_1$ = impedance of 17 ohm winding.

$r_2 + j\omega l_2$ = impedance of (26 ohm winding + condenser + receiver).

The terminal impedance of the instrument is $\frac{V}{x}$ and may be obtained from (18).

This equation is rather complicated, but there is an approximate method of calculating the terminal impedance by means of formulæ (5) and (6), which will be sufficiently accurate. Both primary and secondary currents pass through the transmitter, so that if the induction coil is considered as an ordinary transformer, this transmitter resistance must, for calculation purposes, be increased by about 100%, as the current through it is about double that in the other portions of the circuit. Actually, the approximation consists of increasing the transmitter resistance in the proportion $\frac{x+y}{x} = 1 + \frac{y}{x}$.

In order to test this approximation we may take the C.B. coil mentioned above as an example.

From the figures given above,

Impedance of 17 ohm winding $= 45{\cdot}5 + j790$
,, ,, 26 ,, ,, $= 38{\cdot}5 + 347{\cdot}5$
,, ,, 60 ohm Bell Receiver $= 136 + j162$
,, ,, 2 M.F. condenser at 800 cycles per second $= -j100$

The transmitter may be taken as 50 ohms resistance.

$$\therefore\ r = 50 \text{ ohms.}$$
$$r_1 + j\omega l_1 = 45{\cdot}5 + j790$$
$$r_2 + j\omega l_2 = 38{\cdot}5 + j347{\cdot}5 + 136 + j162 - j100$$
$$= 174{\cdot}5 + j409{\cdot}5$$
$$\omega M = {\cdot}98\sqrt{347{\cdot}5 \times 790} = 515.$$

Putting these values in equation (18) we obtain the terminal impedance $= \frac{V}{x} = 579\ \overline{/33{\cdot}9^{\circ}}$.

Now using the approximate method we have from (19) $\frac{y}{x} = 1{\cdot}13$.

The figure for the transmitter resistance should, therefore, be increased from 50 to $50\,(1 + 1{\cdot}13) = 106{\cdot}5$, and a formulæ (5) and (6) we have—

$r_1 = 45 \cdot 5 + 106 \cdot 5 = 152$

$\omega l_1 = 790$

$r_2 = 174 \cdot 5 + 106 \cdot 5 = 281$

$\omega l_2 = 409 \cdot 5$

$\omega M = 515$

$\therefore R = 466$ and $\omega L = 333$

$\therefore$ Terminal Impedance $= 466 + j333 = 573 \,/\, 35 \cdot 6^{\circ}$

which is not very different from that obtained by the complicated equation (18).

SUMMARY.

1. The magnetic leakage of the present standard types of induction coil has been measured and the Mutual Inductance may be calculated from $M = K\sqrt{L_1 L_2}$,

where $K = \cdot 96$ for $1^{\omega}/\ 25^{\omega}$ L.B. coils.

$= \cdot 88$ for $1^{\omega}/\ 150^{\omega}$,, ,,

$= \cdot 98$ for $17^{\omega}/\ 26^{\omega}$ C.B. coils.

2. The output from L.B. coils may be obtained from formulæ (3), (4), (5), and (6).
3. The optimum primary winding may be obtained from equation (9).
4. The optimum secondary winding for sending only has an impedance equal to that of the circuit to which it is connected.
5. The optimum secondary winding for sending and receiving in a circuit with identical instruments at each end is given by equation (11).
6. The output from an L.B. coil when connected as an auto-transformer is given by formulæ (14) and (15).
7. The C.B. induction coil is shown to be an auto-transformer, and formulæ (14) and (15) may be used to obtain the output when sending.
8. The Terminal Impedance of L.B. and C.B. coils may be calculated from formulæ (5), (6), and (19).

MEASUREMENT OF THE STANDARD CABLE EQUIVALENT OF TRUNK CIRCUITS.

By C. Robinson, B.A.

With the introduction of telephonic repeaters it has become necessary to develop a commercial method of measuring the standard cable equivalent of trunk circuits. Two types of testing set have been designed in the Research Section of the Engineer-in-Chief's Office for this purpose by the writer, with the co-operation of Mr. C. A. Beer. The first is intended for measuring the overall transmission efficiency of a circuit without employing a return loop and will be used for making periodical maintenance tests and in tracing faults. The second is for measuring the transmission efficiency of a return loop and will generally be used for ascertaining the improvement given by a repeater on artificial lines.

General principles of measurement.

An alternating voltage with a frequency of about 800 p:s and of a pre-arranged value is applied to the sending end of the circuit. The voltage is measured across the receiving end closed with the characteristic impedance of the line. From this the ratio of the sent to the received voltage ($V_s : V_r$) can be found. The attenuation length (Bl) is then calculated from the relation:—

$$Bl = \log_e \frac{V_s}{V_r}$$

Range and type of measuring instruments.

The following voltages have been taken as representing the values occurring in practice:—

Maximum voltage at sending end	... ...	3	volts.
Minimum voltage at receiving end	(on 25 S.M. circuit)	0.14	,,
Maximum ,, ,,	(on 10 S.M. ,,)	1.03	,,

At the sending end a thermo-couple with a pointer-galvanometer in the couple circuit is used. For the receiving end there is no suitable direct-reading instrument available. It was therefore decided to use a thermionic rectifying device such as that shown on Fig. **1**. Here V is a triode the grid of which is connected through the input transformer T to the priming battery C. The filament is heated by current from the battery B. The anode is connected through a galvanometer G to the battery A. Across the galvanometer G is connected a battery D and a high resistance P, by means of which the deflection of G may be made zero when there is no alternating voltage applied to the grid. The voltages of A and B are chosen to be such a value that the triode acts as a rectifier. When an alternating voltage is applied to the grid a current passes through the galvanometer G. The relation between the voltage impressed on the primary winding of the input transformer and the current through the galvanometer is shown by the curve on Fig. **1**.

A more sensitive arrangement is obtained by employing an amplifying triode in addition to the rectifier, as shown on Fig. **2**. The curve on this figure gives the relation between impressed volts and current in G for this arrangement. The single triode system appears to give sufficient sensitivity and has been used hitherto.

The impedance of the primary winding of the input trans-

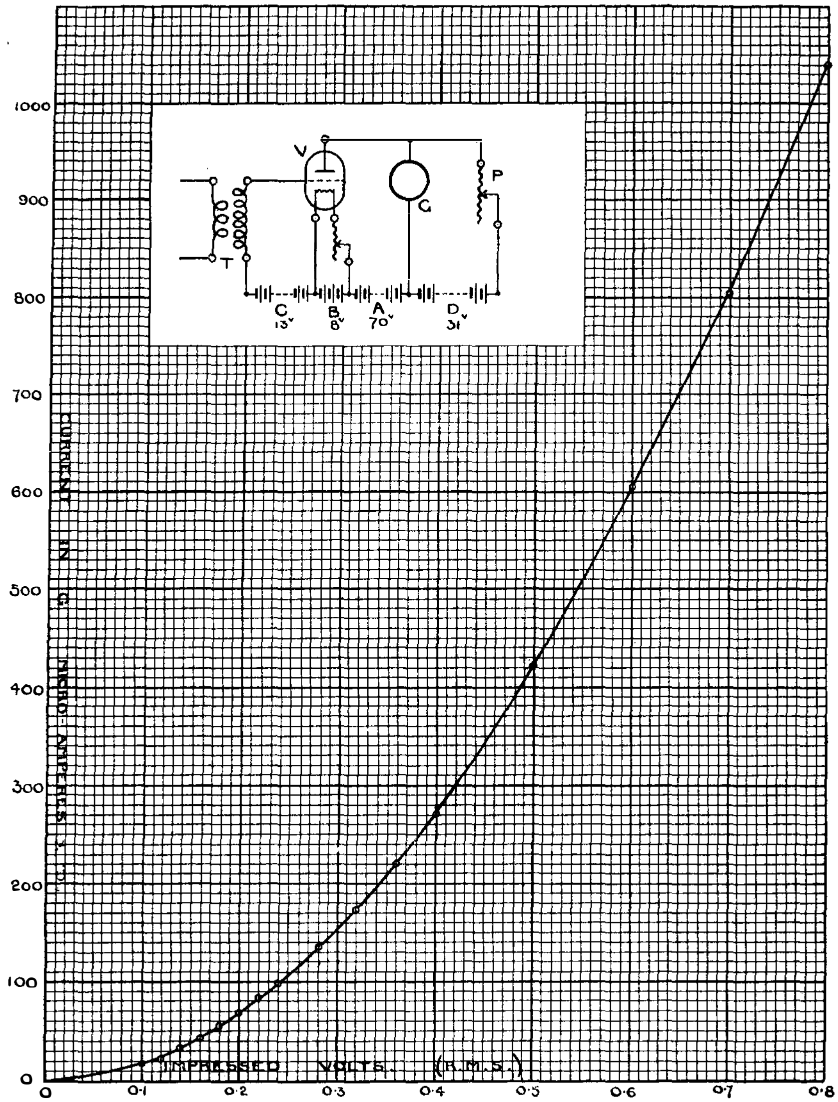


FIG. 1.

former must be large compared with the resistance across which it is connected. The impedance of the transformer used is about 50,000 $\backslash\overline{68^{\circ}}$ vector ohms at a frequency of 800 p : s. This condition also involves priming the grid negatively to at least as high a voltage as the maximum of the alternating voltage applied to the grid. This is found to be about 13 volts.

The indications of the galvanometer are found to vary very little with changes of frequency. The error due to this cause is negligible.

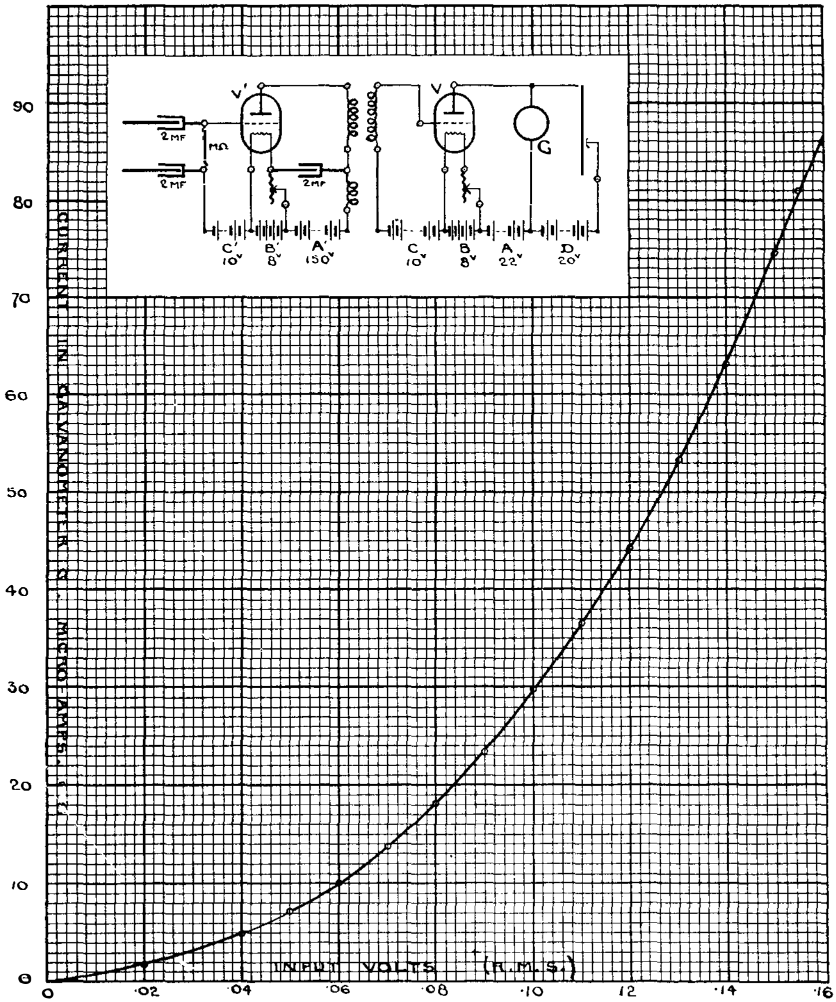


FIG. 2.

"Overall Test"; General Method of making the measurements.

A simplified diagram is shown on Fig. 3. The oscillator A_1 supplies power to the sending end of the circuit. The voltage applied to the line is regulated by means of the rheostat $R_1R'_1$ and measured by the voltmeter V In order that the impedance of the transmitter may be nearly equal to that of the line a section of artificial line L is inserted. The attenuation length of L has been chosen to be 1.60944. This length is sufficient to make the impedance practically correct and also has the effect of making the voltage at V five times that applied to the circuit itself. This voltage can be measured more easily than the smaller value actually impressed on the line. The characteristic impedance of L must be the same as the impedance of the line under test taking into account the terminal transformer, when one is employed.

At the receiving end the circuit is closed with a resistance Z_1, approximately equal to the characteristic impedance of the line. The voltage across this resistance is indicated by means of the

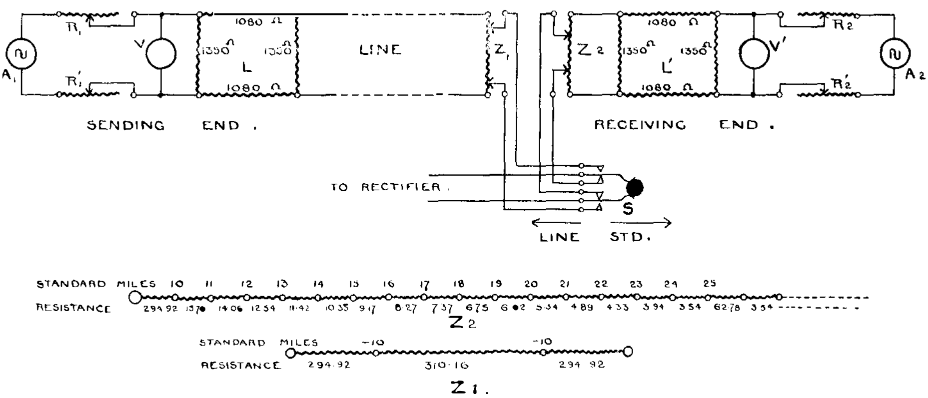


FIG. **3**.

rectifier and galvanometer. In order to express this reading as a function of the voltage V_s at the sending end, a voltage equal to V_s is applied to a potentiometer Z_2. A switch S is provided by means of which the rectifier can be connected alternately across Z_1 and across a known proportion of Z_2. When the two galvanometer readings are equal the voltage at the receiving end is equal to the known proportion of V_s. The potentiometer Z_2 may be calibrated to read directly in standard miles as shown on the lower portion of Fig **3**.

Complete Testing Set.

The connections of the complete set are shown on Fig. **4**. The following modifications to the simple arrangement have been introduced:—

(1) Switch K_1 for changing over from the sending end to the receiving end condition.

(2) Check of A.C. voltmeter V_1. The accuracy of the method

depends directly on that of the voltmeter V_1. Means are therefore provided for checking V_1 against the D.C. voltmeter V_2. By means of the switch K_2 the two voltmeters can be connected in parallel across the adjustable portion of the slide wire Z_3. The sliding contact is moved until V_2 indicates the testing voltage. The position of the pointer of V_1 is then marked by means of a movable hand provided for that purpose.

(3) A voltmeter and switch is provided for checking the voltages of the various battery supplies, etc. The connections to the multiple-point switch are not shown on the diagram.

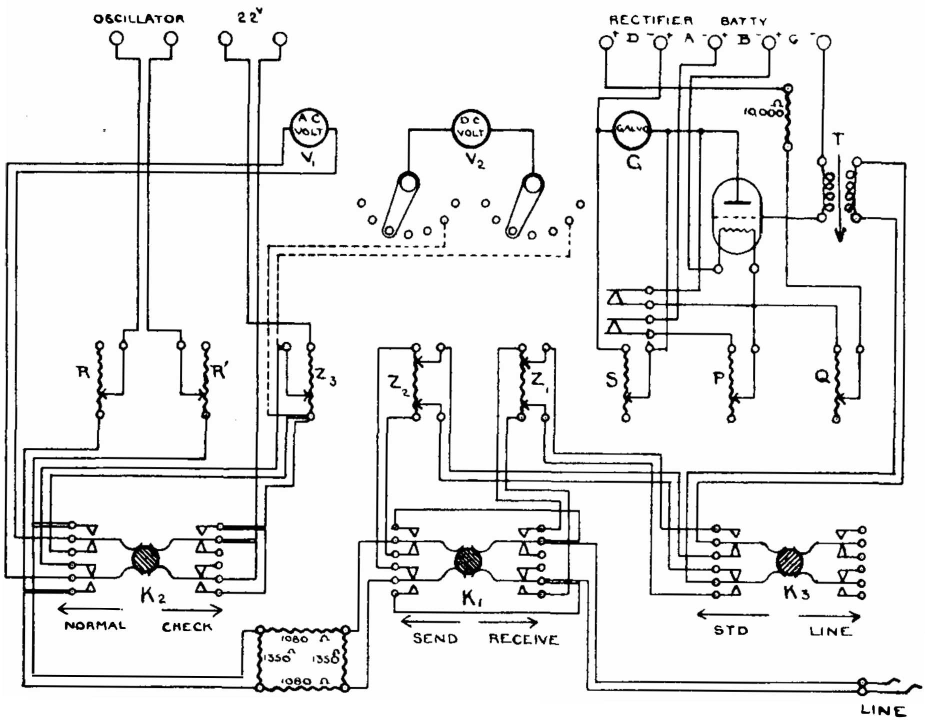


FIG. 4.

(4) *Galvanometer Shunt.*

In order to prevent the heating current of the triode being switched on when the galvanometer is not shunted and so possibly causing damage to the galvanometer, the arrangement shown diagramatically at S on Fig. 4 is employed. The contacts above S are disconnected only when the shunt arm is in the "off" position; where the galvanometer is short-circuited. When the filament and zero adjusting batteries are switched on the galvanometer must be short-circuited and the resistance Q should be adjusted to maintain the deflection of the galvanometer at zero as the shunt resistance is increased.

Potentiometer subdivisions.

The potentiometer Z_2 is divided into sections representing steps of 1 standard mile over a range of 10 to 25 S.M. For circuits under 10 S.M. in length a portion only of the received voltage will be measured, connection being made to potentiometer Z_1 at points representing an addition of 10 S.M. This point is marked − 10 S.M. and indicates that 10 S.M. should be deducted from the reading given on Z_2. This provides for circuits from 0 to 25 standard miles in length.

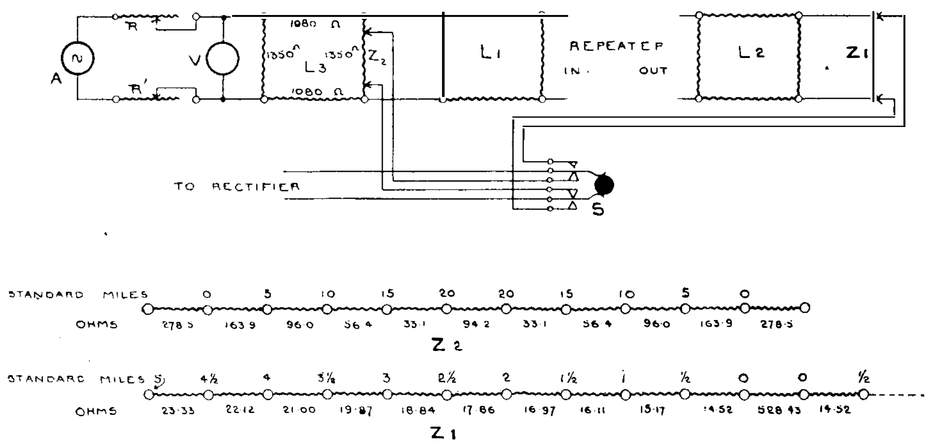


FIG. 5.

LOOP TEST.

General method of making measurements.

The essential difference between this and the previous test is that both ends of the circuit are available at one point. The sent and received voltages can therefore be measured on the same instrument. A simplified diagram of the testing arrangement is shown on Fig. **5**. The oscillator A supplies power to the sending end of the circuit through the section of artificial cable L_3. L_1 and L_2 are two lengths of artificial cable between which the repeater is connected. The receiving end is closed with a resistance Z_3 equal to the characteristic impedance of the line. The resistances Z_1 and Z_2 are suitably divided as potentiometer slides.

The amplifier-rectifier can be connected by means of a switch S to the adjustable portions of Z_1 and Z_2. These are calibrated as shown on the lower part of Fig. **5**, so as to read directly the standard cable equivalent of the circuit. It will be seen that the potentiometers read to half a standard mile.

Complete Testing Set.

The connections of the complete testing set are shown on Fig. 6. The accuracy of the test does not in this case depend directly on that of the A.C. voltmeter and the arrangements for

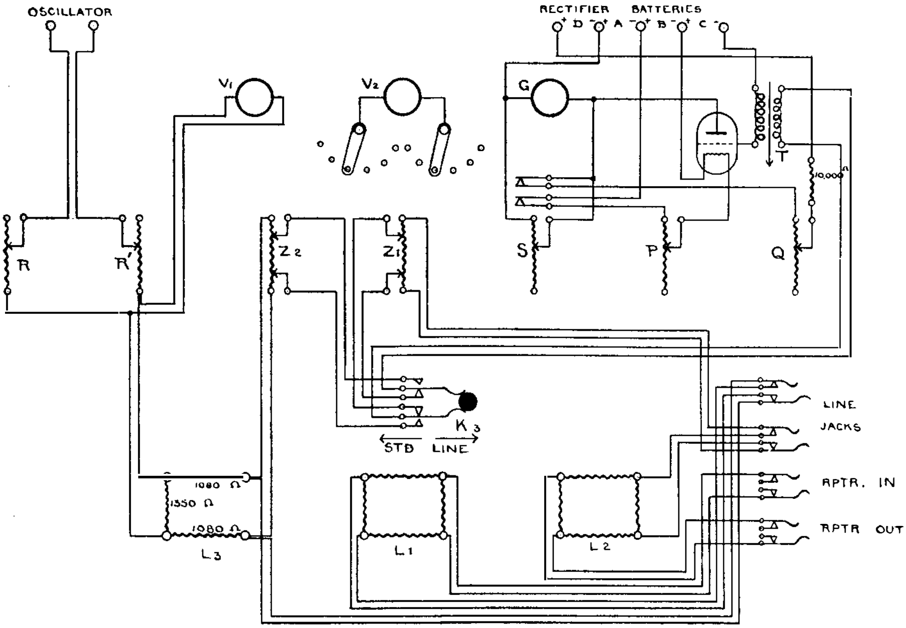


FIG. 6.

checking it have been omitted. Jacks are provided for connecting the repeater in the centre of the artificial lines L_1 and L_2. A second set of jacks is also provided for testing a return loop. The other details of the set are similar to that previously described. Both sets have been designed for a line impedance of 900 ohms, but it is possible to adopt them for use on lines of different impedances.

ON THE CALCULATION OF THE TRANSMISSION EFFICIENCIES OF NON-UNIFORM LINES.

By H. P. FEW.

THE formulæ commonly employed for calculating the transmission efficiencies of non-uniform lines joined in series are cumbersome, and when the number of such lines joined in series exceeds three, the formulæ are so complex as to be altogether unsuited for practical calculations (see J. G. Hill; *Telephone Transmission*, Chapter XIII.). The object of these notes is to obtain formulæ from which the efficiencies of circuits consisting of any number of non-uniform lines joined in series can be calculated to a degree of accuracy sufficient for most practical purposes.

As leading to the more complex case of non-uniform lines we first deal with uniform lines. It will be seen that the method employed involves the subdivision of the line successively into one, two, three, ...n T's or Ω's equivalent to the whole line, and taking the ratio of the sent to the received currents for the circuits so formed.

In Fig. 1 the line is divided into two equal sections with a

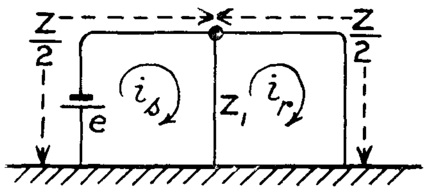


Fig. 1.

single resultant leak at the centre of the line, z and z_1 not necessarily being pure resistances. Applying Kirchhoff's second law, we form the equations—

$$\left(\frac{z}{2}+z_1\right)i_s - z_1 i_r = e$$

$$-z_1 i_s + \left(\frac{z}{2}+z_1\right)i_r = o$$

whence

$$i_s = \frac{\begin{vmatrix} e & -z_1 \\ o & \frac{z}{2}+z_1 \end{vmatrix}}{\Delta}$$

and

$$i_r = \frac{\begin{vmatrix} \frac{z}{2}+z_1 & e \\ -z_1 & o \end{vmatrix}}{\Delta}$$

the denominator Δ for both fractions being the same, but with the value of which we are not concerned. Since the transmission efficiency is equal to the ratio of the sent current to the received current we have—

$$\frac{\dot{i}_s}{\dot{i}_r} = \frac{\begin{vmatrix} e & -z_1 \\ o & \frac{z}{2}+z_1 \end{vmatrix}}{\begin{vmatrix} \frac{z}{2}+z_1 & e \\ -z_1 & o \end{vmatrix}} = 1 + \frac{z}{2z_1} \quad \text{.........................(1)}$$

on reduction. The expression on the right of (1) is often employed as a first approximation for calculating the efficiency of a line. For example, if z and z_1 are 360 and 1000 ohms respectively, from (1) we get 1.18. If we employ the accurate formulæ for a uniform line, we should have—

$$\frac{\dot{i}_s}{\dot{i}_r} = \cosh \sqrt{\frac{z}{z_1}} \quad \text{..(2)}$$

and inserting the assumed values—

$$\frac{\dot{i}_s}{\dot{i}_r} = \cosh \sqrt{\frac{360}{1000}}$$

$$= \cosh 0.6$$

or

$$\frac{\dot{i}_s}{\dot{i}_r} = 1{\cdot}18547$$

using a table of hyperbolic cosines. This result is about ½ per cent. higher than the result 1.18 obtained from the simple formula (1) above.

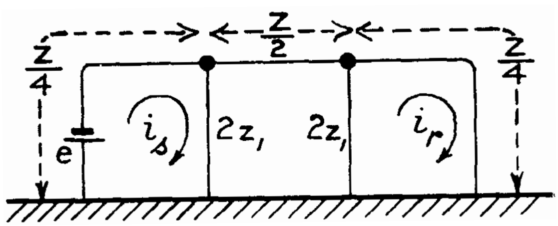


Fig. 2.

In Fig. **2** the line is divided uniformly into three sections. The ratio of the sent to the received current is—

$$\frac{i_s}{i_r} = \frac{\begin{vmatrix} e & -2z_1 & 0 \\ 0 & 4z_1 + \frac{z}{2} & -2z_1 \\ 0 & -2z_1 & 2z_1 + \frac{z}{4} \end{vmatrix}}{\begin{vmatrix} 2z_1 + \frac{z}{4} & -2z_1 & e \\ -2z_1 & 4z_1 + \frac{z}{2} & 0 \\ 0 & -2z_1 & 0 \end{vmatrix}} = 1 + \frac{z}{2z_1} + \frac{z^2}{2\cdot(4z_1)^2} \quad \text{..................(2a)}$$

which is a still closer approximation to the correct formula. Thus, taking the same values for z and z_1, *i.e.*, 360 and 1000 ohms respectively from (2) we get 1.18405, which is about one-tenth of one per cent. too small of the value calculated by the accurate formula.

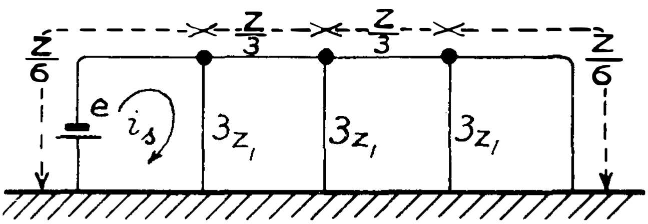


Fig. 3.

In Fig. **3** the line is divided uniformly into four sections. Proceeding in precisely the same way as before, we have—

$$\frac{i_s}{i_r} + 1 = \frac{z}{2z_1} + \frac{z^2}{3(3z_1)^2} + \frac{z^3}{2(9z_1)^3} \quad \text{................................(3)}$$

and using our old values for z and z_1 we get 1.18512, which is less than one one-hundredth per cent. in error.

From inspection of the expressions (1), (2) and (3) it will be gathered that for every additional T or Ω into which the line is divided the resulting expression will more nearly approach the expression for a uniform line until, when the subdivision has been continued indefinitely, we should expect to reach the accurate expression for a uniform line, *i.e.*,

$$\frac{i_s}{i_r} = \cosh\theta = 1 + \frac{\theta^2}{2!} + \frac{\theta^4}{4!} + \frac{\theta^6}{6!} + \text{..............}$$

where $\theta = \sqrt{z/z_1}$.

It was stated above that z and z_1 need not necessarily be pure resistances: as a matter of fact they may comprise any line constants. As an example, take the simple case shown in Fig. **4**, where r is the ohmic resistance, l the inductance, c is capacity, and e is the applied periodic electromotive force. Using operational determinants, we have—

$$\frac{i_s}{i_r} = \frac{\begin{vmatrix} e\varepsilon^{jpt} & -\dfrac{1}{jpc} \\ 0 & \dfrac{r+jpl}{2}+\dfrac{1}{jpc} \end{vmatrix}}{\begin{vmatrix} \dfrac{r+jpl}{2}+\dfrac{1}{jpc} & e\varepsilon^{jpt} \\ -\dfrac{1}{jpc} & 0 \end{vmatrix}}$$

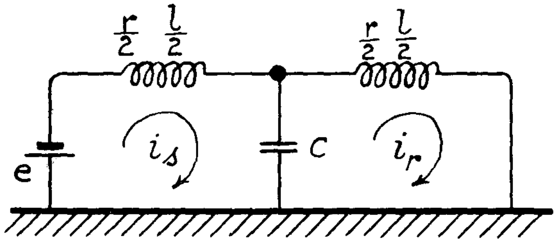


Fig. 4.

which, on reduction, gives

$$\frac{i_s}{i_r} = 1 + \frac{(r+jpl)jpc}{2}$$

and which is of the same form as formula (1) above. Formulæ (1), (2) and (3) above may, therefore, be used whatever be the constants of the line provided that suitable substitutions are made for z and z_1. It should be noted, however, that if a table of hyperbolic functions is available, the calculation from approximate formulæ presents no advantage over calculation from the cosh formula (2) above, and is less speedy.

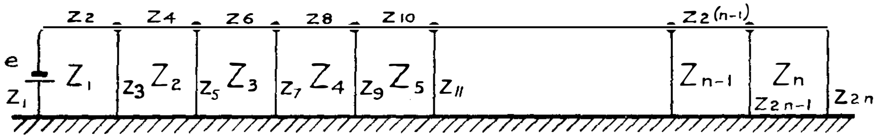


Fig. 5.

Non-Uniform Lines.—In this case the z's and z_1's are all different. In Fig. **5** let Z_1, Z_2, Z_3,.........Z_n be the sums of the constants round the respective meshes, and i_1, i_2, i_3,......i_n be the currents round the meshes, then we can form the following n equations—

$$
\begin{aligned}
&i_1 Z_1 - i_2 z_3 &&= e \\
-&i_1 z_3 + i_2 Z_2 - i_3 z_5 &&= o \\
&\quad - i_2 z_5 + i_3 Z_3 - i_4 z_7 &&= o \\
&\qquad - i_3 z_7 + i_4 Z_4 - i_5 z_9 &&= o \\
&\qquad\quad - i_4 z_9 + i_5 Z_5 - i_6 z_{11} &&= o \\
&\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot && \\
&\qquad\qquad - i_{n-1} z_{2n-1} + i_n Z_n &&= o
\end{aligned}
$$

from which we get,

$$
\frac{i_1}{i_n} = \frac{\begin{vmatrix}
e & -z_3 & 0 & 0 & 0 & . & 0 \\
0 & Z_2 & -z_5 & 0 & 0 & . & 0 \\
0 & -z_5 & Z_2 & -z_7 & 0 & . & 0 \\
0 & 0 & -z_7 & Z_4 & -z_9 & . & 0 \\
0 & 0 & 0 & -z_9 & Z_5 & . & 0 \\
. & . & . & . & . & . & -z_{2n-1} \\
0 & 0 & 0 & 0 & 0 & -z_{2n-1} & Z_n
\end{vmatrix}}{\begin{vmatrix}
Z_1 & -z_3 & 0 & 0 & 0 & . & e \\
-z_3 & Z_2 & -z_5 & 0 & 0 & . & 0 \\
0 & -z_5 & Z_3 & -z_7 & 0 & . & 0 \\
0 & 0 & -z_7 & Z_4 & -z_9 & . & 0 \\
0 & 0 & 0 & -z_9 & Z_5 & . & 0 \\
. & . & . & . & . & . & 0 \\
0 & 0 & 0 & 0 & 0 & -z_{2n-1} & 0
\end{vmatrix}}
$$

which reduces to—

$$
\frac{i_1}{i_n} = \frac{\begin{vmatrix}
Z_2 & -z_5 & 0 & 0 & . & 0 \\
-z_5 & Z_3 & -z_7 & 0 & . & 0 \\
0 & -z_7 & Z_4 & -z_9 & . & 0 \\
0 & 0 & -z_9 & Z_5 & . & 0 \\
. & . & . & . & . & -z_{2n-1} \\
0 & 0 & 0 & 0 & -z_{2n-1} & Z_n
\end{vmatrix}}{\begin{vmatrix}
-z_3 & Z_2 & -z_5 & 0 & . & 0 \\
0 & -z_5 & Z_3 & -z_7 & . & 0 \\
0 & 0 & -z_7 & Z_4 & . & 0 \\
0 & 0 & 0 & -z_9 & . & 0 \\
. & . & . & . & . & -Z_{n-1} \\
0 & 0 & 0 & 0 & 0 & -z_{2n-1}
\end{vmatrix}} \quad \ldots\ldots(4)
$$

Now the numerator of this fraction is a continuant and can be evaluated by well known methods. The denominator has for its constituents zero on one side of its principal diagonal; it is therefore equal to the product of the constituents of the principal diagonal. We may therefore write down the value of (4) in the special notation—

$$\frac{i_1}{i_n} = \frac{Z_2,\ -z_5^2,\ Z_3,\ -z_7^2,\ Z_4,\ -z_9^2, \ldots\ldots\ldots\ldots Z_n}{z_3,\ z_5,\ z_7,\ z_9, \ldots\ldots\ldots\ldots z_{2n-1}}$$

For example, for three lines of different constants joined in series the expression is—

$$\frac{i_1}{i_3} = \frac{Z_2Z_3 - z_5^2}{z_3z_5}$$

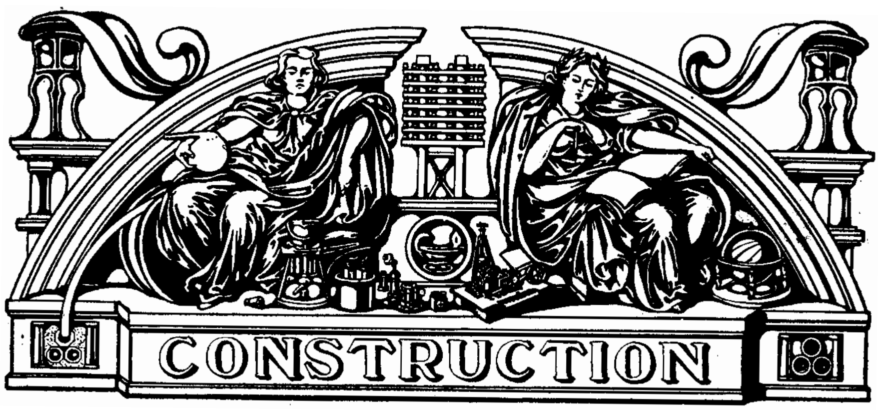
For four non-uniform lines the expression is—

$$\frac{i_1}{i_4} = \frac{Z_2Z_3Z_4 - z_7^2Z_2 - z_5^2Z_4}{z_3z_5z_7}$$

For five non-uniform lines joined in series we have—

$$\frac{i_1}{i_5} = \frac{Z_2Z_3Z_4Z_5 - z_9^2Z_2Z_3 - z_7^2Z_2Z_5 - z_5^2Z_4Z_5 + z_5^2z_9^2}{z_3z_5z_7z_9}$$

and so on. It is probable that the results obtained from formulæ arrived at in this way will be found sufficiently accurate for most practical purposes.



ROAD WIDENING SCHEMES.

INTRODUCTION.

As the Post Office Engineering Department is considerably affected throughout the country by road-widening operations, generally associated with Unemployed Relief Schemes, no doubt the readers of the "The Journal" will be interested in the operations connected with the reconstruction of the "Watling Street" between Dartford and Strood.

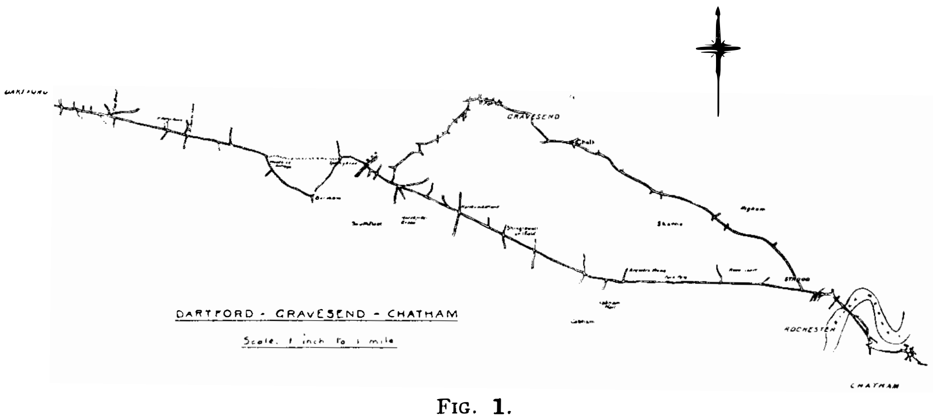


FIG. 1.

This thoroughfare is an old Roman road of a width from 12 ft. to 15 ft., running from Dartford through the parishes of Stonewood, Betsham, Ifield and Cobham. It forms a junction with the Dartford—Gravesend—Strood main road at Strood Hill.

The Post Office has in position a 2-way self-aligning duct along Watling Street, from London to Chatham, with one main cable and the necessary loading manholes.

ROADWAY CONSTRUCTION.

In order to appreciate the difficulties contended with, a brief reference should be made in the first place to the construction of the new road, 100 ft. in width, made up as follows: Centre roadway 40 ft. wide, a 14-foot verge on each side of roadway, an 8-foot pathway on both sides, and then an outer verge of 8 feet on both sides.

The gradients on the existing road are being considerably reduced in some places. The "valleys" are being filled to the extent of from 25 to 30 ft., and the "hills" reduced to a degree varying from 1 foot at some places to 15 feet at others.

PLANT AFFECTED.

The Post Office underground track has been considerably affected, and extensive operations have been necessary to avoid leaving valuable plant very much "in the air," or *vice versa*.

It was originally intended to lay a new 2-way duct throughout, and by means of a new cable (which has been authorised between London and Chatham) to divert thereto, as a temporary measure, the important trunk circuits from the existing composite cable, in order to permit of the withdrawal of the composite cable from the old track and its relaying in the new duct; but, as the plans for the construction of the new road matured, it became evident that other measures would have to be adopted to meet special conditions from time to time.

METHODS ADOPTED.

The methods adopted in different sections have been:

(*a*) The erection of aerial cable, on the American principle, for diversion purposes.

(*b*) The lowering of the 2-way duct containing one main cable.

(*c*) The preservation of the existing track by the construction of manholes with deep shafts.

(*a*) *Erection of Aerial Cable* A pole route was erected consisting of 28-ft. stout poles placed 35 yards apart and liberally stayed.

A suspension wire, consisting of 7/10 steel strand wire, supplied in half-mile lengths, was placed in "Cable Suspension Clamps," carried by a $\frac{5}{8}''$ arm bolt at each pole.

To the "Steel Strand Wire" were fixed (by means of a Bosun's chair) 2" steel rings forming an "aerial duct" into which the cable (75 pr/20 lead-covered paper-core) was drawn by means of a motor winch.

This is the first occasion on which aerial cable has been erected in this country on this principle, and the Engneering Staff, I have no doubt, will be made fully acquaited with the standard procedure in due course.

(*b*) *Lowering 2-way duct and cable.* It will be realised that the use of temporary aerial cable, to replace a main composite cable (8 pr/150 + 24 pr/100 + 48 pr/70 + 5 pr/40), has its limitations; it therefore became necessary to consider an alternative for overcoming difficulties of a lesser degree, where the gradients on the

FIG. 2.

existing road (to be merged into the new road) were not so great; and it was therefore decided that in such cases the 2-way duct and cable should be lowered en bloc from the old to the new road level.

To quote cases in point where two lengths of 198 yards and 184 yards respectively were so treated:—

In the first case the duct and cable were lowered to an average depth of 3 ft., without presenting any difficulty, but in the second case the difference in levels between the old and new roads varied throughout, the maximum difference of 12 feet being in the centre of the length. (See Figs. **2** and **3**).

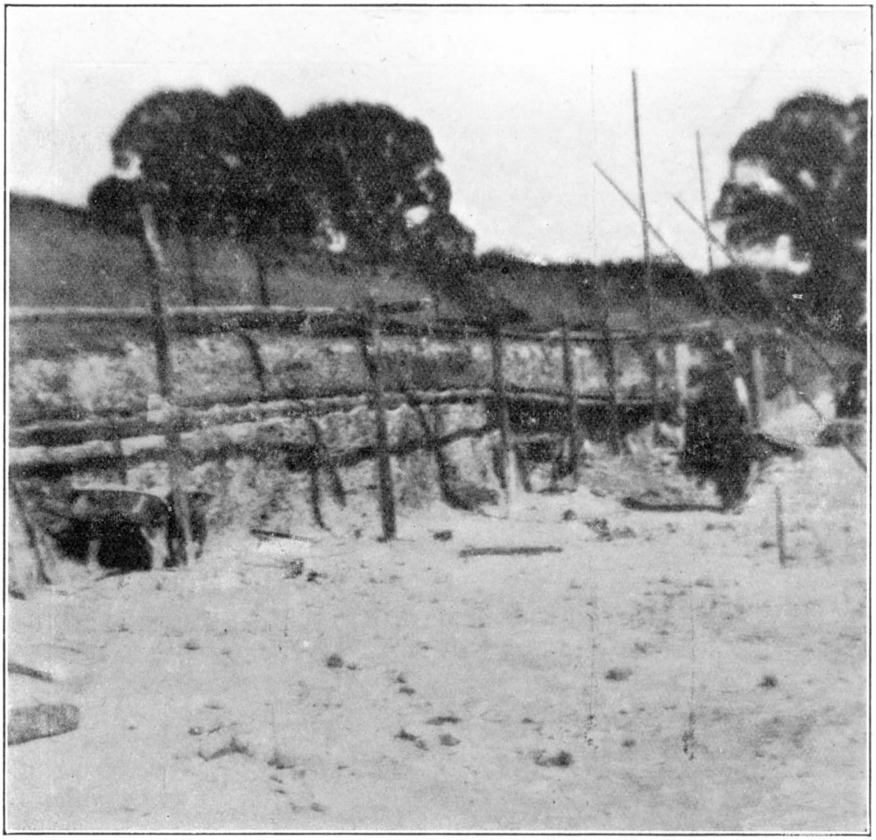


Fig. **3**.

The estimated weight of duct lowered in the 184 yards section was 5 tons 6 cwt., and the cable 2 tons 15 cwts. To this should be added the weight of the scaffold poles used as indicated below, namely, 4 cwts. (approximately): total =8.25 tons.

The method adopted was as follows:—

(1) The contractors for the road construction work excavated the ground from the new road level up to the duct track (see Fig. **2**), and also laid bare the duct by removing the metalled

surface of the road, leaving the duct exposed on a solid wall of chalk.

(2) Scaffolding then was erected on the new road adjacent to the duct track, as shown in the accompanying Fig. 4. Timber bearers were placed horizontally across the old road about 12 ft.

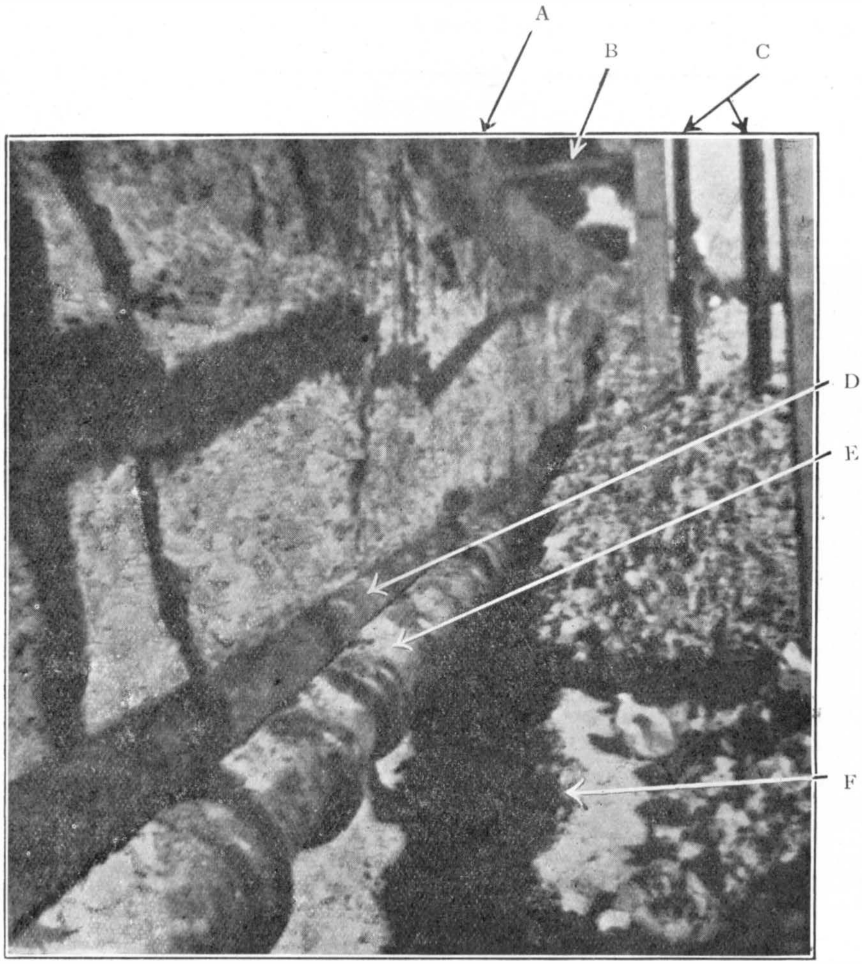


FIG. 4.

A. The original Watling Street level.
B. Timber bearer from scaffolding to old road.
C. Scaffolding on new road to support timber bearer.
D. Scaffolding poles secured to ducts.
E. 2-Way ducts in process of lowering.
F. New trench on new road.

apart, in positions designed to secure rigidity, and the whole was properly secured. Struts were also fixed to the scaffolding and placed in the new road, to prevent shifting (see Fig. 4).

(3) Scaffold poles, of suitable sizes, were secured along the top of the ducts by means of G.I. Wire at both the spigot and socket ends of each duct, and to these scaffold poles 400 G.I. wire tails were fitted and attached to Vices No. 2, and these were in turn secured to the timber bearers above mentioned. (It was found that by passing the 400 G.I. wire tails underneath the duct when lowering, there was a tendency for the duct to "twist," and this was discontinued in favour of attachment to the scaffold pole supports only, prior to the lowering in the second section).

A derrick was then erected at the point of the greatest depth, with blocks and ropes, to assist in the lowering of the duct, but chiefly as a safeguard against a "run" or slipping of any of the vices adjacent to this point.

(4) After everything had been made secure, and the weight of the duct, cable and scaffold poles taken by the Vices No. 2, the chalk subsoil underneath was cut away in six foot sections at the point of greatest depth, by the Department's men; the duct was then lowered (in two six-foot drops) to the new trench.

I should here mention that the trench at the point of the greatest depth was not excavated until the duct had been lowered (six feet) to the position shown in Fig. **2**, as it will be appreciated that a considerable quantity of chalk had to be cut away from underneath the duct in its old position.

The whole length was lowered without a hitch, and a good alignment kept throughout, and, when in its new position, the duct was "set up" where required and the joints re-compounded. A brush and mandril were then passed through the spare duct-way without difficulty.

(5) *Shortening of Route.* As previously indicated, in this section the duct was laid on the old road with a gradient 0′ – 12′ – 0′ (see Sketch No. 1, Fig. **5**). It was therefore necessary to deal with the surplus duct and cable in lowering to the new road level, and this was accomplished by a slight deviation of the trench horizontally at the point of greatest depth.

The accompanying sketches (Nos. A and B, Fig. **5**) illustrate this. At no point was the width of the trench greater than 2′ 6″ to permit this being done.

(*c*) *Manholes with deep shafts.* As the road on which the existing duct is laid will (after the widening operations are completed) be filled in at the majority of the coupling points to depths varying from 1 to 12 feet, it was decided (in order to avoid the expense of laying a new duct) to build manholes with brickwork shafts in all those cases where the "filling in" exceeded 3 feet. For the deeper manholes, *i.e.*, from 10 to 18 feet below the new road surface, 18-inch brickwork and 9-inch joists will be used.

The shafts in all cases will terminate two feet below the road surface. Where these manhole shafts will extend from 6 ft. to 11 ft. below the surface of the road, they will consist of 14-inch brickwork, and in cases of from 2 ft. to 6 ft., of 9-inch brickwork. The manholes will be drained where level permits.

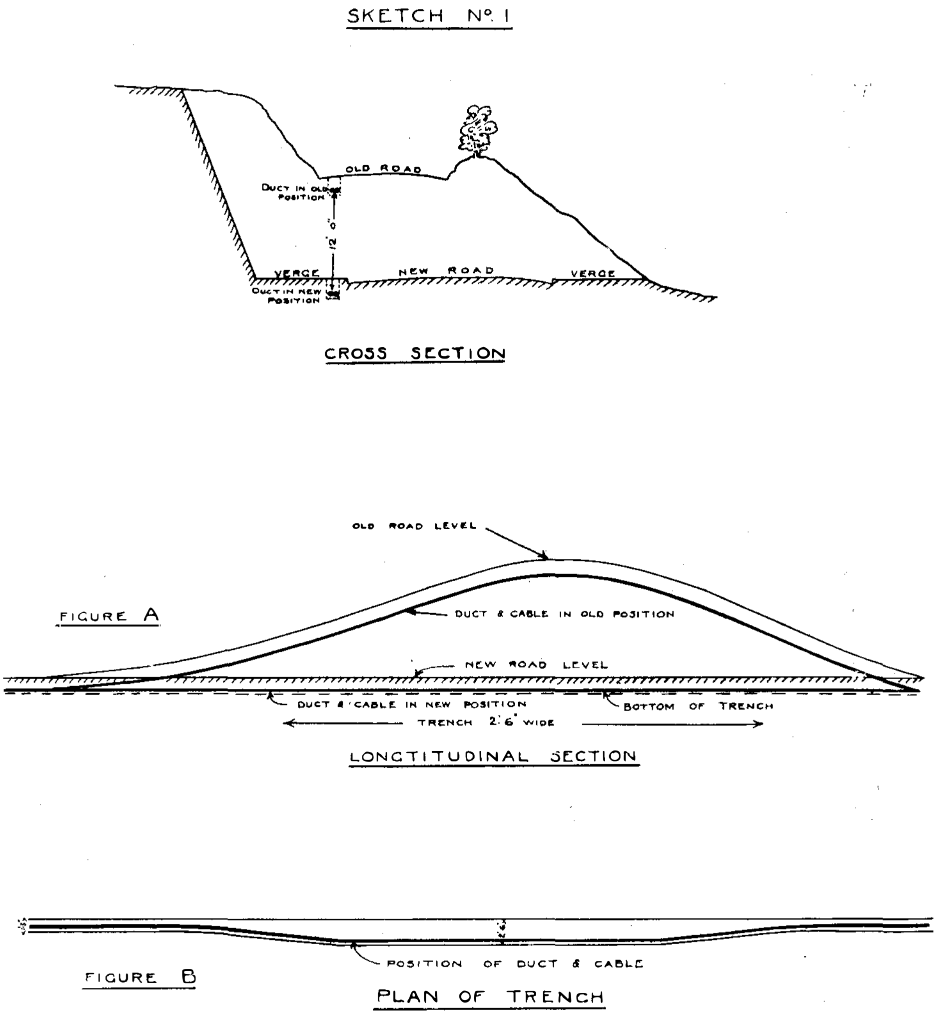


FIG. 5.

Reinforced concrete covers are to be fitted to the shafts at a point two feet below the road surface.

LOWERING DUCT AND CABLE.—MEN EMPLOYED.

The progress of the work was regulated to a great extent by the progress of the road contractors, and in consequence the work was spread over a period of 12 days.

The minimum number of men employed was 4, and the maximum 11; the whole operation, including "Ineffective Time," Supervision, and Watching, being executed in 1099¼ manhours, or an average of 5.97 manhours per yard, as shown in detail below:

Operations covered.—12 days.

Men employed.—Minimum 4, Maximum 11.

Time taken erecting scaffold.—104½ manhours.

Securing scaffold poles to ducts.—82½ manhours.

Excavating new trench 2′ 6″ deep and cutting away chalk under duct.—285 manhours.

Filling in trench after the duct was in position.—81 manhours.

Lowering duct and cable to new position.—111 manhours.

Recompounding duct.—21¾ manhours.

Recover scaffolding.—23½ manhours.

Shifting tools etc.—48 manhours.

Watchman.—249 manhours.

Foreman.—93 manhours.

Total.—1099¼ manhours.

Total cost.—

	£	s.	d.
Labour at 1/6¾ per hour	84	2	10
Hire of material and lorry	7	2	0
Incidentals	2	3	3
	£93	8	1

A word of appreciation for the hearty spirit of co-operation on the part of the Ministry of Transport and the Contractors (Messrs. Sir R. McAlpine & Sons) should be expressed.

G. W. CRADDUCK,
Chief Inspector.

Canterbury Section.
July 25th, 1922.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

MILEAGES AND TELEPHONE STATIONS FOR EACH ENGINEERING DISTRICT AS AT 30th JUNE, 1922.

Telephone Stations.	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages.				Submarine (Land miles).
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	
328,549	558	2,245	52,313	374	London	17,570	18,636	1,191,567	21,186	
51,400	2,066	18,679	47,283	1,973	S.E.	2,208	9,846	145,324	15,340	
41,778	4,884	20,308	35,622	1,378	S.W.	11,989	1,961	76,037	1,967	
33,123	9,465	25,715	33,960	4,094	E.	12,111	15 084	37,124	12,546	
57,564	9,457	36,638	40,723	2,724	N. Mid.	8,116	13,953	95,852	63,656	
45,858	5,355	24,731	45,896	4,433	S. Mid.	6,494	8,237	113,604	82,867	
39,145	5,501	24,624	35,936	2,805	S. Wales	5,101	10,355	62,667	17,654	
55,347	9,330	21,538	35,661	5,138	N. Wales	11,655	17,412	95,814	9,492	
98,666	3,148	16,157	45,074	3,244	S. Lancs.	9,729	34,426	233,617	27,330	
49,020	6,430	24,489	34,797	2,465	N.E.	5,413	13,244	105,279	22,818	
49,853	4,323	26,280	39,687	2,702	N.W.	9,136	15,872	100,688	14,150	
31,478	3,007	14,077	21,570	2,140	N.	2,554	4,978	51,730	5,730	
13,635	5,547	5,045	10,047	241	Ireland	120	54	27,045	235	
41,423	5,954	19,110	28,413	1,701	Scot. E.	1,383	5,036	75,183	3,377	
62,844	7,374	21,899	39,458	240	Scot. W.	11,414	12,427	169,016	18,771	
999,683	82,399	301,535	546,440	35,652	**Total.**	114 993	181,521	2,580,547	317,119	
984,044	83,013	297,406	537,141	35,597	Figures on 31st Mar., 1922.	118,264	184,583	2,575,362	320,426	

The above figures exclude Ireland South, now under the control of the Irish Free State.

WIRELESS

INTERNATIONAL RESEARCH COUNCIL.

THE first meeting of the International Union of Scientific Radio-Telegraphy was held at Brussels in the last fortnight of July, and considerable progress was made towards the adoption of the statutes to govern the operations of the Union. Its purposes are summarised as follows:—

(1) To promote the scientific investigation of problems relating to Radio-telegraphy.

(2) To initiate and organise the conduct of researches which depend on co-operation between different countries, and to provide for their scientific discussion and publication.

(3) To facilitate the establishment of common methods of measurement, as well as the comparison and standardisation of measuring instruments.

National and Standing Committees have been formed, but the direction of the work will be under the control of the General Assembly, which will, as a rule, hold an ordinary meeting once every three years. The Royal Society is the body in this country affiliated to the International Research Union. The Society has appointed the following gentlemen to serve on the National Committee:—Sir R. Glazebrook (Chairman), Mr. A. A. C. Swinton, Dr. J. E. Murray, Dr. A. C. Mitchell, Dr. F. E. Hackett, Prof. J. Joly, Dr. W. H. Eccles, Dr. E. W. Marchant, Prof. C. L. Fortescue, Mr. F. E. Smith, Dr. G. C. Simpson, Sir J. Petavel, Mr. E. H. Shaughnessy and Admiral Jackson (Secretary).

The finances of the Union and voting powers of the various countries affiliated were discussed and the procedure approved. Reports of research work were submitted by the various National representatives, and we have pleasure in reproducing the following important results, written up for us by Major Lee, which were submitted to the convention by Mr. E. H. Shaughnessy.

THE MEASUREMENT OF RADIATION.

By MAJOR A. G. LEE, M.C., B.Sc.

AMONGST the many problems of interest to the wireless engineer, that of the range of a station of given power is one of the most important. It is obviously one of the most fundamental problems in the design of new stations, as the engineer requires to know primarily the power he has to provide in order to give a service over the distance required.

The problem was first tackled experimentally by Duddell and Taylor in 1905, in their experiments in Bushey Park and on the Post Office cable ship "Monarch." Since that time contributions have been made to the subject theoretically or experimentally by Sommerfeld, Austin, Cohen, Fuller and many others.

Austin and Cohen, as the result of their work, have obtained an empirical formula which gives the voltage induced in the receiver as a function of the distance from the transmitter, the current in, and the height of the transmitting aerial. This formula, known generally as the Austin-Cohen formula, is fairly accurate when considered as a mean value of results likely to be obtained over sea, but experience shows that variations from day to day of 100 per cent. from those given by the formulæ are not uncommon and variations also occur with locality, etc., which are not covered by the formula.

The formula is therefore regarded as a starting point or base line, and the object of the actual measurement, which has been carried out by the Post Office, is to gain some insight into the magnitude of the variations and how these variations are affected by different conditions, such as the nature of the intervening country, effect of mountains, etc.

It has been the practice in the past to refer the strength of signal received at a wireless station to an arbitrary standard, dependent upon the operator's judgment; for example, a signal is said to be of strength "Six" when it is receivable with comfortably loud strength. This practice has many objections from a scientific point of view, but chiefly because of the indeterminate nature of the standard.

Austin and Cohen have introduced the practice of measuring a signal in terms of the potential gradient in the æther at the receiving station. This is usually measured in micro-volts per metre, so that to arrive at the effective E.M.F. induced in the receiving aerial we multiply the potential gradient by the height of the receiving aerial, the effective height, not the geometric height, being taken.

The effective height, or, as it is now called, the radiation height, is the height to the centre of the capacity of the antenna. It will be easily realised that a flat top antenna, having the greater portion of its capacity concentrated in one layer, will have a radiation height nearly the same as its geometric height, while on the other hand, a single vertical wire will have a radiation height of approximately half its geometric height. The "radiation height" of a frame antenna can be calculated from its dimensions and number of turns.

Experience has shown that with a normally good C.W. receiver it is necessary to provide a signal strength at the receiving station of 10 to 50 micro-volts per metre, in order to ensure good reception. The variation in the figure depends upon the frequency, strength and distribution of atmospherics at the receiving station.

The Austin-Cohen formula is:—

$$\varepsilon = \frac{377 . h . I . 10^6}{\lambda d} . e^{\frac{-\alpha d}{\sqrt{\lambda}}}$$

Where ε is the E.M.F. induced in a metre length of the receiving antenna in micro-volts.

h is the radiation height of the transmitting antenna in metres;
I is the current at the base of the antenna in amperes;
λ is the wavelength expressed in metres;
d is the distance from the transmitting station in metres;
e is the base of Naperian Logarithms;
α is the absorption coefficient.

The value given by Austin and Cohen for α, as the result of a very large series of observations on signals over sea in daylight, is 0.000048.

The Absolute Measurement of Radiation.

Basis of Method Employed.

The method employed consists in equating to equal strength the signal obtained from a distant station with a signal produced from a local oscillator of the same frequency of oscillation. The signal from the distant station is received on one of a pair of precisely similar frame antennæ, which are mounted at right angles and rotatable about a vertical axis, whilst the local signal is caused to induce into the other frame antenna of the pair. Either of these antennæ can be connected by means of a switch to the receiving apparatus.

The E.M.F. induced by the local oscillator is measurable by means described later, and hence, when the signals are equal in strength, this measured E.M.F. is equal to the E.M.F. induced by the radiation from the distant station. From the measured characteristics of the frame (linkage area) and the wavelength of radiation, the potential gradient of the æther is readily calculated.

Detail of Apparatus.

Fig. 1 shows schematically the arrangement of apparatus used for carrying out the radiation measurements. The frame antennæ

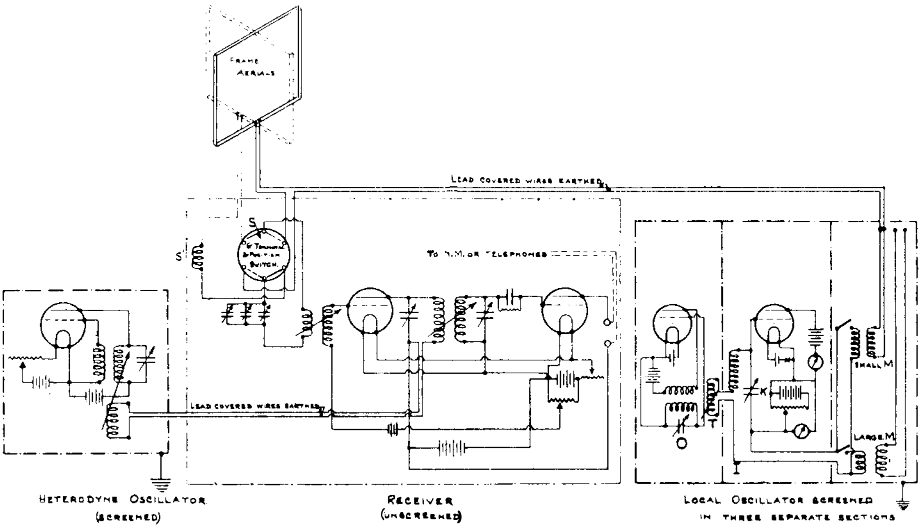


FIG. 1.

are wound on two wooden square formers of 6′ 6″ side, rigidly connected at right angles to one another, and wound with an equal number of turns of insulated wire. The frame antennæ are supported from an outer wooden framework with the lower face of the antennæ about 6′ above the ground, so that the antennæ can be rotated about a vertical axis.

The frame antennæ are not separately tuned, but either can be connected by means of a switch to the tuning condensers and small coil which serves to couple to the receiving circuit shown.

The receiving circuit consisits of a two valve unit which can be extended when required by using a low frequency amplifying unit. The oscillator used for heterodyning with either the local or incoming signals is screened.

The local oscillator used for producing the measurable E.M.F. (shown on the right of Fig. 1 and in more detail in Figs. 2 and 3), was purchased from the Marconi Company. It consists of three units separately screened from one another and the whole enclosed in a copper lined outer box.

Referring to Fig. 1, O indicates an oscillating circuit whose frequency can be varied by adjusting a condenser, the control of which is external to the screened case. This circuit in turn is coupled, through a controllable coupling T., to an intermediate circuit I, which has a calibrated condenser K. This intermediate circuit also includes the primary coil of a calibrated coupling the secondary of which is included in the frame antennæ. The coup-

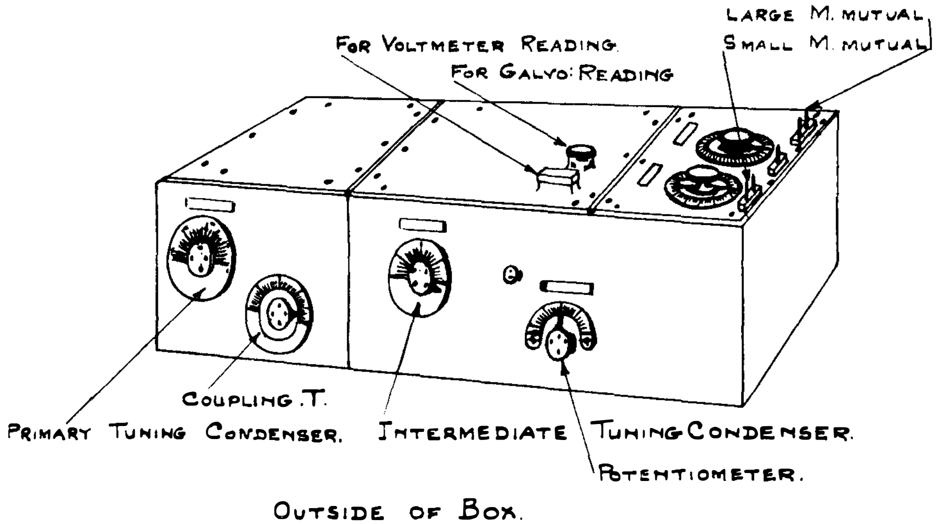


FIG. 2.

ling between these two coils is variable and is calibrated in terms of Mutual Inductance, the latter being determined by a scale fixed outside the outer case.

The oscillating unit, the intermediate circuit (with the exception of the primary of the calibrated coupling), and the calibrated coupling are screened from one another by being enclosed in separate copper lined boxes.

To obtain the value of the E.M.F. induced into the frame antennæ to which the secondary of the calibrated coupling is connected, it is sufficient to know the voltage across K, since, if this be V, then the E.M.F. induced in the frame antennæ:

$E = \omega M I$ where $\omega = 2\pi f$ f = frequency of oscillation.
M = value of Mutual Inductance.
I = Current in Intermediate circuit.

Also since $I = \omega K.V.$

$$E = \omega M. \times \omega K.V.$$
$$= \omega^2 M.K.V.$$

To determine V, the Slide-back method of measuring voltage as devised by Captain Round, of the Marconi Company, is utilised. (This method, in which it has been shown that an error

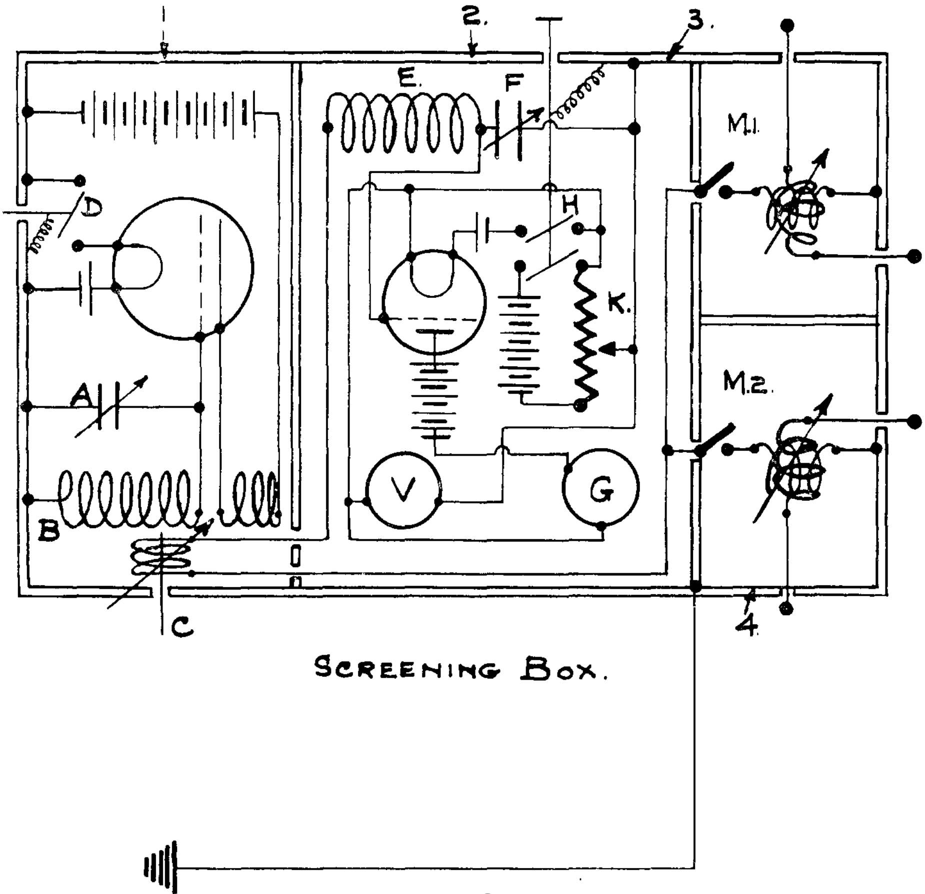


Fig. 3.

of at least 5 % is inherent, will, it is hoped, be replaced later by a more accurate method). To this end the valve connected across the condenser of the intermediate circuit is used. Firstly the grid voltage applied to this valve is made sufficiently negative to just cause the anode current to fall to zero when no oscillations are set up in the intermediate circuit. Call this grid voltage V_1. Secondly, the grid voltage required to just reduce anode current to zero when oscillations are set up in the intermediate circuit is obtained. Call this V_2.

Then $V = V_2 - V_1$ is the maximum voltage across the condenser C.

while the other, at right angles to the direction, does not.

The values of grid volts and anode current are observed through openings made in the screened cases, and which openings can be kept covered during the intervals of ascertaining the correct value of M.

Procedure of taking an observation.

The procedure of taking an observation consists in first adjusting the local oscillator to exactly the same frequency as the incoming signal.

The frames are then set so that one frame receives the signal,

The receiver is then switched over from one frame to the other and the coupling of the local oscillator is varied until the local signals are the same strength in the telephone as the real signals. The value of the received E.M.F. is then deduced as already described.

MEASUREMENTS OF THE EMISSION FROM NANTES (U.A.).

The following are the results of measurements carried out at Dollis Hill on the strength of field due to the emission from Nantes. The measurements were made whilst Nantes was emitting special signals of observed value of wavelength and aerial current in accordance with the scheme of the "Union Internationale de Radiotelegraphie Scientifique." The measurements made afford a determination of the absorption between London and Nantes. It will be seen that the absorption is of the same order as that given by the Austin-Cohen formula.

Frame aerials each of 10 turns and 6′ 6″ side were used for reception at Dollis Hill. The results obtained are given in tabular form in Table I. E gives the values of voltage in μV induced in the frame; ϵ gives the values of the potential gradient of the other in μV per metre, corresponding to these measured voltages, and α gives the value of the absorption co-efficient calculated from these quantities.

TABLE I.

Measurements of Radiation from Nantes.

Date.	λ Metres,	Aerial Amps. A.	E	ε	α	Remarks and Weather.
7-2-22	9000	182	46	1675	0.000032	V.G. Reading. Dry. High Clouds. X's not heavy.
8-2-22	9000	—	38.4	1400	—	Fair Reading. Sunny. Clear. X's nil.
9-2-22	9000	150	34.3	1247	0.0000503	Good Reading. Sunny. Clear. X's nil.
10-2-22	—	—	36.4	1324	—	,, ,, ,,
13-2-22	9000	182	34.6	1260	0.0000866	Reading not good. Dry. Cloudy. X's nil.
15-2-22	8970	185	38.3	1395	0.00007	Good Reading. Wet. X's nil.
16-2-22	8980	180	40.2	1463	0.0000563	Good Reading. Dull. X's nil.
2-3-22	8980	152	31.3	1140	0.0000702	Good Reading. Dry. Dull. Windy. X's nil.

Mean Value of α (neglecting reading of 13th) 0.0000558

Radiation from Stonehaven.

The following are the results of experiments carried out between Stonehaven W/T Station and Dollis Hill (London) for the purpose of measuring the radiation from Stonehaven. In particular, comparison was made of the emission, using arc and valve under similar conditions of aerial current. From the various measurements made an absorption co-efficient in the same form as the Austin-Cohen was determined for the line Stonehaven-London.

Conditions at Stonehaven.

The Admiralty Arc installed at Stonehaven and the Valve Transmitter under test there were used for the purpose of making the radiation comparison. The two sets were adjusted to as nearly as possible equal wavelengths and equal aerial currents, the latter being measured by the same ammeter in each case. The arc current was rather variable, the mean reading being slightly in excess of the valve current.

Measurements at Dollis Hill.

A three-wire aerial 110 feet high, with about 150 feet horizontal span, was used for reception in this case instead of the frames.

The results of various measurements on valve and arc are given in the table below.

TABLE II.

Measurements of Radiation from Stonehaven.

$\lambda = 4600$ m. in all cases.

Date.	Type of Transmitter.	Aerial Current Amperes.	E	ε	α	Remarks.
17-11-21	Arc	47.5	1166	63.6	---	Very pure and steady note.
,,	,,	—	1105	60.4	—	,, ,, ,,
,,	Valve	47	1140	62.3	0.000163	Valve note very pure and steady.
29-11-21	,,	73.5	1440	79.3	0.000184	,, ,, ,,
,,	,,	86.0	1744	95.5	0.000183	,, ,, ,,
,,	,,	87.0	2114	115.5	—	Heavy jamming by FL whilst measurements on.
,,	,,	92.0	2114	115.5	0.000168	Valve note pure and steady.
			Mean	Value	0.000174	

E, in the above table, gives the voltage induced in the receiving aerial in micro-volts and ε gives the equivalent potential gradient of the æther in micro-volts per metre, while α is the absorption co-efficient calculated from these values.

Comparison of Radiation from Arc and Valve.

The first and third readings in Table II. gives the mean values of several observations taken within short periods of time on the arc and valve. In this case the arc chamber was clean and the note emitted by the arc was as pure and steady as that emitted by the valve.

The results show that for the case where an arc is working under the best conditions, *i.e.*, where the resulting note is pure and steady, its radiation is equivalent to that of a valve. For the same aerial currents the "radiation value" for the arc will, however, probably diverge from the value for the valve by an amount depending upon the condition of the arc.

Absorption Co-efficient between Stonehaven and Dollis Hill.

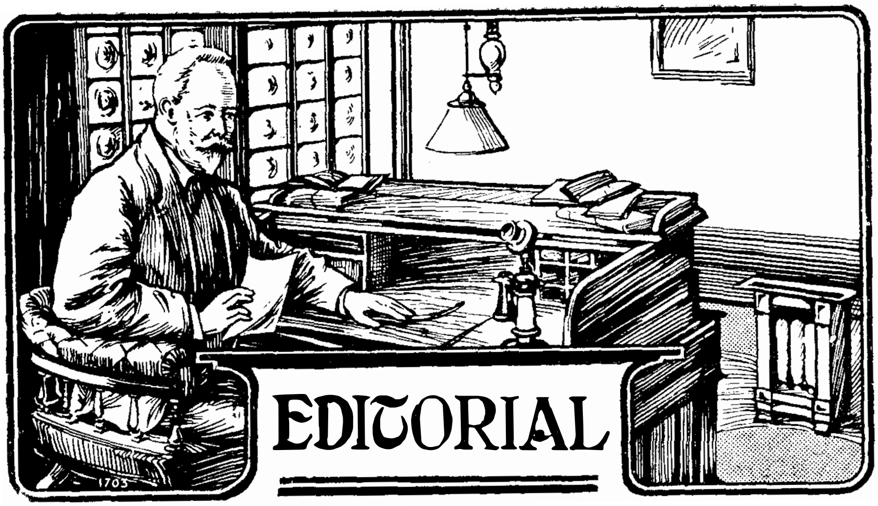
The mean value obtained for α, viz., 0.000174 is 3.7 times the value given by Austin and Cohen for daylight transmission over sea.

The cause of this wide departure from the Austin-Cohen formula lies probably in the hilly nature of the country near

Stonehaven, and also to the line between Stonehaven and Dollis Hill lying largely along the coast line. It is well known that a coast line causes refraction and reflection of wireless waves and it is probable that this is a large contributing factor to the heavy attenuation. The radiation from Nantes to London, on the other hand, suffers none of these drawbacks; it starts off from very flat land, does not pass over any extremely hilly country en route, and crosses the coast lines nearly at right angles, and hence arrives in London with an attenuation only slightly greater than that given by the Austin-Cohen formula for sea transmission.

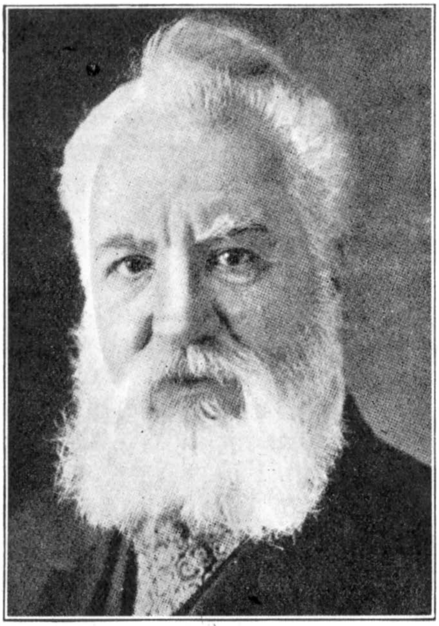
The comparative tests made between arc and valve transmission were carried out in order to investigate a widely held opinion that a given current in an aerial, due to an arc, was inferior to the same value of current provided by a valve. It will be seen that this opinion has been finally disposed of, and that the arc current, when running well, has the same radiation value as that of the valve.

Further experiments will probably be along the lines of investigating the effects of hilly country near the transmitting and receiving ends, determining absorption co-efficients for various kinds of country, deserts, forests, etc., ascertaining, if possible, the causes and magnitudes of the fading periods which are experienced daily on long distance reception, investigation of the causes which make a receiving site good or bad, and also the effect of weather, clouds, etc., on the absorption.



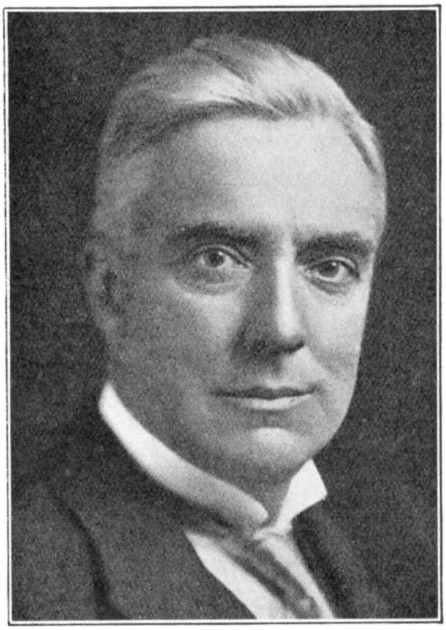
EDITORIAL NOTES AND COMMENTS.

THE death of Alexander Graham Bell has brought to notice a fact we are apt sometimes to forget—the comparative youth of the telephone industry. Less than fifty years ago, in 1874, Bell evolved the idea of sending a number of Morse messages over a single wire at the same time, by using several vibrating reeds whose natural frequencies were different. He took his "harmonic telegraph" to the workshop of Charles Williams, in Boston, who turned him over to a very intelligent and keen craftsman, one Thomas A. Watson. The latter made six instruments to Bell's instructions and the two young men laboured for about six months experimenting, but without getting much further on the road towards the production of a successful multiplex telegraph. But Bell was groping all the time towards something bigger than appeared on the surface. As professor of vocal physiology in Boston University he had achieved considerable success in the teaching of deaf mutes; he had studied Helmholtz on sound and he clung to the possibility of transmitting human speech over a wire by means of electric currents. One day a magnetised telegraph transmitter spring stuck, and on releasing it he found that a momentary impulse was sent over the wire which produced a sound on his receiving apparatus. This convinced him he was on the right track, and he persevered with his speech transmission experiments and abandoned the telegraph notion. On the 10th March, 1876, the first audible words were heard at the end of a line. Bell and Watson were working in adjoining rooms in a boarding house in Boston with a wire conecting the two. Bell put his mouth to his crude instrument and called out, "Mr. Watson, come here, I want you." Watson came rushing into the room in a great state of excitement and said he had heard the words from the instrument. At the opening of the New York—San Francisco telephone line, on January 25th, 1915, the same words were spoken again by Bell to Watson, Bell being the guest of the A.T. and T. Co. at a luncheon in New York, while Watson was being entertained at a similar function at the city of the Golden Gate.



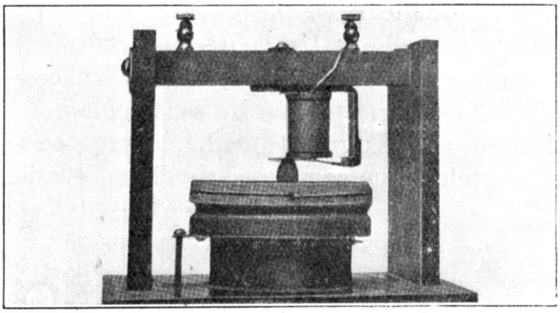
ALEXANDER GRAHAM BELL.

The two men had had a weary row to hoe for many years before then. Bell exhibited his telephone at the Centennial Exposition in 1876, at Philadelphia, but his stall in an obscure corner received little attention until one day he persuaded the Emperor of Brazil, then on a visit to the States, to listen on his receiver. The august personage made quite a fuss when he heard the spoken words and the interest of the whole exhibition was aroused. In spite of the attention directed to his invention at that time Bell found it difficult to persuade the public to make a practical use of his "scientific toy." He and Watson travelled over New England, Bell lecturing and Watson speaking from the distant end of a telegraph line which they hired on occasions for the purpose. Watson talked himself hoarse, he recited and finally broke into song. He tells an amusing tale of his efforts as a vocalist and avers that the telephone receiver is most sensitive to Sankey's well-known hymn, "Hold the Fort"—at least, as he used to sing it! Watson invented the magneto bell, and this instrument together with the then existing shuttle armature generator of Wernher Siemens provided a means for calling attention to the telephone when conversation was desired. In August 1877 there were 778 telephones in use, and the first telephone company, the Bell Telephone Associa-



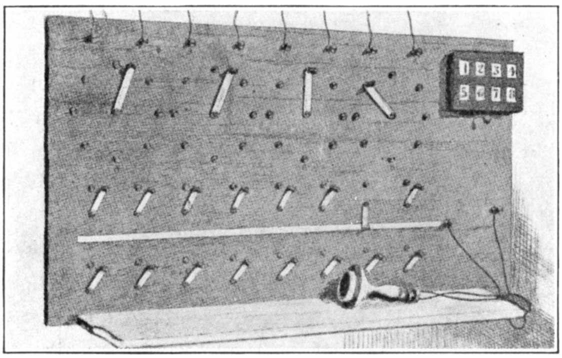
THOMAS A. WATSON.

tion, was formed, with no capital and four members—Bell, Watson, Hubbard, Bell's father-in-law, and Sanders, father of one of his pupils, in whose house the first experiments were made. In 1878 Theodore N. Vail was persuaded by Mr. Hubbard to resign his position on the Union Pacific Railroad and to accept the position of general manager of the American Bell Company. These three men, Bell, Watson and Vail, and perhaps Edison, who invented the carbon transmitter later, are responsible for the introduction of the telephone to the world. It could be argued that no mechanical invention has added to the net sum of human happiness; if the files of the world's press a couple of years ago were examined one would imagine the telephone had been invented for the purpose of adding to the torments of life on this earth. However, the telephone has become inextricably woven



THE FIRST TELEPHONE.

into the commercial and social life of all civilised communities, and its use in bringing distant parts of the world into closer communication has undoubtedly aided in increasing the sum of physical well-being.



THE FIRST SWITCHBOARD, USED IN NEW HAVEN, CONN., FOR EIGHT SUBSCRIBERS.

Bell and Watson did not continue long in the telephone business; they were too versatile for that, and it is remarkable that as far back as 1878 Bell confided to Watson that when the production of telephones had become a routine business they should direct their attention to the problems of flying. Although the inventor does not always possess the commercial instinct, the combination is indeed seldom present and Bell was certainly not a business man in the ordinary sense, it is gratifying to note that both he and Watson "made good" later in life. True to his aim, in 1878

Bell devoted himself mainly to the science of aviation and was associated with Glen Curtiss in many of his projects; Watson turned his attention to shipbuilding and founded the large Fore River Ship and Engine Coy. at Quincy, Boston.

Bell was born in Edinburgh on the 3rd March, 1847, and went to America for health reasons in 1870. He died on the 2nd August and was buried on the 4th, in a tomb blasted from rock on the crest of Beinn Bhreagh Mountain, Baddeck, Nova Scotia. He received many honours in his lifetime, and at the moment of his being laid to rest telephone service on about 15,000,000 telephones in the United States and Canada was suspended as a tribute to his memory. The service over his grave terminated with a recital of the first stanza of Robert Louis Stevenson's Requiem:—

Under the wide and starry sky
Dig the grave and let me lie,
Glad did I live and gladly die,
And I laid me down with a will.

A fitting end to a noble and unselfish career!

[*Our illustrations are taken from "The Telephone Review" published by the A.T. and T. Coy. on the occasion of the opening of the New York-San Francisco line.—Eds. P.O.E.E. Journal.*]

Critics in the lay press who ignore the economics of the subject and writers in the electrical journals who ought to know better are continually complaining about the lack of enterprise on the part of the post office administration with regard to the introduction of automatic telephone working. In this country there are automatic exchanges constructed and installed by the Automatic Telephone Manufacturing Coy., the Lorimer Coy., the Western Electric Coy., Siemens Brothers, and the Relay Automatic Coy. No other country in the world has delved further into the problem and the experience gained by the British Post Office with regard to the reliability and the maintenance costs of the various systems will be useful in the ultimate determination of the system or systems that will survive. The application of machine switching to London is largely a question of cost, and with a gradual return toward pre-war charges we may anticipate a start being made in the not far distant future. How the public will cope with the manipulation of a six-figure block of numbers or with coded exchanges is a question of considerable interest to the telephone engineer. In the meantime the provinces are being tackled systematically, as may be seen from our quarterly reports. An interesting development is taking place at the moment at Dundee and the neighbouring towns, where the Peel-Conner Company is engaged in installing its first automatic equipments. We hope to be able to describe this undertaking in our next issue.

We have to offer our congratulations to Mr. Reginald Alexander Dalzell, C.B.E., on his appointment to the newly created post of Director of Telegraphs and Telephones. Mr. Dalzell has practically grown up with the telephone service, as he joined the Globe Telephone Company in 1881, and has been in close touch with its evolution on both the engineering and administrative sides. Since the transfer he has taken a keen interest in telegraph problems, and approaches all difficulties with an intellect keen and alert. Quoting from an article in the *Electrical Review*, his aim is to give effect to the Postmaster-General's stated policy, and he will take the public, whom he regards as the most important part of the organisation, into the full confidence of the Post Office, so that they may understand thoroughly what is being done in the way of research and development in respect of both telegraphs and telephones. "If there is co-operation between the Post Office and the public," he says, "so far as co-operation is practicable in a service possessing the complexities of the telephone service, it will go far towards securing that higher standard of efficiency in the working for which the Post Office is constantly striving." Mr. Dalzell has always worked harmoniously with the engineering department, and he may rely upon our assistance in working towards that consummation we all desire.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

The following works have been completed:—

Exchange.	Type.	No. of Lines.
Grimbsy Extension ...	Automatic.	560
Paisley ,, ...	,,	525
North Eastern Marine Engineering Co.	Automatic P.B.X.	70
Leeds Extension	Automatic.	2600
Stockport Extension ...	,,	350
Fleetwood	,,	480

Orders have been placed for extending the Equipment at the undermentioned existing Exchanges:—

Exchange.	Type.	No. of Lines.
Darlington	Automatic	300
Epsom	Automatic	200

Orders have been placed for new Exchanges as follows:—

Exchange.	Type.	No. of Lines.
Marton (Middlesborough)...	Village Automatic.	80
London County Council New County Hall ..	Automatic P.B.X.	600
St. Annes-on-Sea	Manual C.B.	860
Minories	Manual C.B.	7,500

Fleetwood.—The transfer of this Exchange from Magneto to Automatic working (Relay Automatic Telephone Co.'s system) took place on the 15th July, 1922.

Grimsby.—In connection with the recently completed extension of this Exchange, dialling-out facilities to Cleethorpes were introduced. Grimsby subscribers obtain direct access to the Cleethorpes telephonist by dialling "71," without the intervention of the Grimsby telephonist.

AUTOMATIC DIAL.—STANDARDISATION OF IMPULSE.

The characteristics of the impulses to be produced by automatic dials have been standardised, and the exchange equipment on all future contracts for new automatic exchanges will be required to be suitable for these impulses.

The standard impulses are produced at the rate of 10 complete "breaks" and "makes" per second, and the ratio of "break" to "make" of each impulse is 2 to 1 (*i.e.*, the "break" constitutes 66⅔% of each complete impulse).

On new dials received from contractors small variations will be permitted in speed from 9 to 11 impulses per second, and in percentage break from 63% to 70%.

The new standard impulse is substantially the same as that at present employed on exchanges of the A.T.M. Company's manufacture. Other manufacturers of automatic exchange equipment on which the impulses hitherto used differ from the standard have agreed to redesign their apparatus to respond to the new impulses.

LONDON DISTRICT NOTES.

INTERNAL CONSTRUCTION.

DURING the quarter ended June 30th, 1922, 5,575 exchange lines, 4,413 internal extensions and 559 external extensions, were provided; in the same period 2,469 exchange lines, 3,277 internal extensions, and 367 external extensions were recovered, making nett increases of 3,106 exchange lines, 1,136 internal extensions, and 192 external extensions.

During the past quarter several exchange works have been brought to completion.

At Tottenham a new C.B. No. 1 Exchange was opened on July 1st. Capacity, 1,800 lines. Contractor—Western Electric Company.

Wembley.—A C.B. No. 1 Exchange was opened on August 16th. Capacity, 1,200 lines. Contractor—Western Electric Co.

Barnet.—A new No. 1 Exchange was opened on August 31st. Capacity, 1,700 lines. Contractor—Peel Conner Telephone Company.

Maida Vale.—A new No. 10 Exchange was opened on September 9th. Capacity 2,000 lines. In this case the whole of the work was performed by the Department's own staff.

Clerkenwell Operating School.—This installation, which consists of 24 "A" positions and 8 "B" positions, will be completed before the issue of this number.

Ilford Exchange.—An extension of 620 lines has been completed.

Central Telegraph Office.—At the Central Telegraph Office a quadruple duplex Baudot installation has been provided on the Eastbourne circuit, and a third set on the Liverpool circuit.

On the Bradford circuit has been installed a quadruple duplex set with two arms working to that centre. The remaining two arms will very shortly be extended to Newcastle, giving two duplex channels between the latter city and Bradford.

A similar installation has been completed between Hastings and Tunbridge Wells with London intermediate. In this case there are three duplex channels between the C.T.O. and each of the two towns, the fourth arm giving a direct duplex channel between Hastings and Tunbridge Wells.

To meet special traffic requirements the TS Brighton and TS Southampton Baudot sets have been converted from quadruple to quintuple duplex working.

EXTERNAL CONSTRUCTION.

During the three months ended 31st July, 1922, the following changes have occurred:—

Telegraphs.—Nett decrease of 4 miles open wire and of 173 miles underground.

Telephone (Exchange).—Nett increases of 153 miles open wire and 2,737 miles underground. There was a decrease of 392 miles in aerial cable.

Telephone (Trunks).—Nett increase of 512 miles in underground, the open remaining unaltered.

Pole Line.—Nett increase of 57 miles, making the total to date 3,132 miles.

Pipe Line.—Nett increase of 22 miles, the total now being 4,072 miles.

The mileage of underground cable shows a nett increase of 44 miles, the total now being 7,950 miles.

The total single wire mileages, exclusive of wires on Railways maintained by Companies, at the end of the period under review were:—

Telegraphs	18,092
Telephones (Exchange)	1,243,201
Telephones (Trunks)	20,881
Spare Wires	24,849

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

COUNCIL NOTES.

A MEETING of the Council was held in London on July 11th, 1922, under the Chairmanship of Mr. A. L. De Lattre, Assistant Engineer-in-Chief. The Secretary referred to the fact that on the appointment of Major T. F. Purves to the post of Engineer-in-Chief, Mr. De Lattre became Chairman of the Council and the members desired to offer him a cordial welcome. The Chairman in reply expressed his pleasure in meeting the Council for the first time, and stated that he and the rest of the Members were particularly pleased to see two representatives of the grade of Associate Members, Messrs. W. H. Cresswell and R. Towers, who were also present for the first time.

Rules.—The Secretary reported that the draft of the new Rules had been prepared and it was hoped to arrange for general circulation in due course.

Technical Pamphlets.—In response to a request from the Council the Engineer-in-Chief had arranged for a full set of these pamphlets to be supplied to the Central Lending Library and the Local Centre Libraries.

Proposed Extension of Membership to Clerical Officers (formerly Assistant Clerks and Clerical Assistants).—The Council considered the application from certain Centres in connection with this proposal, and the Secretary reported that enquiries were being made, the results of which would enable the Council to ascertain what support would be forthcoming from the staff concerned and the financial aspects of the proposed extension.

Papers.—The following papers, which had been reviewed by the Council, were forwarded to the Engineer-in-Chief for his consideration:—" Unit Costing," by Mr. T. Fewster; " Construction Economy," by Mr. J. Peel. The following papers were under consideration by the Council:—" Economics and Transmission of Development Schemes," R. Halton; " Concrete Work," B. J. Beasley; " Motor Transport," R. B. Graham; " Long Distance Cable Testing," G. W. Beaumont; " Some Experiments in Carrier Current Telephony," C. A. Taylor and R. Bradford.

Membership.—A large number of Inspectors had joined during the past three months, and the net increase to date on the general total of last year was 136.

Medal Awards.—The following Medal Awards were made:—

Senior Silver Medal to Messrs. C. Robinson and R. M. Chamney for their joint papers, entitled (*a*) " Gas Discharge Relays and their Application to Commercial Circuits"; and (*b*) " Telephonic Developments of Telephonic Repeaters since 1917."

Senior Bronze Medal to Mr. A. B. Hart for his paper, entitled " Telephone Repeaters."

Senior Silver Medal to Mr. G. F. O'Dell for his paper, entitled " The Influence of Traffic on Automatic Exchange Design."

Booth Baudot Award.—The Secretary reported that one application had been received in respect of this Award for the year ending December 31st, 1921, and the case had been referred to the Committee appointed to adjudicate thereon.

The Council decided to meet at Shrewsbury in October, provided suitable arrangements could be made to meet the Members of the North Wales Centre at the commencement of their Winter Session.

T. SMERDON,
Secretary.

LOCAL CENTRE NOTES.

NORTH WALES CENTRE.

IT is hoped to inaugurate the 1922 Session on the 10th October when members of the Council, which will be holding a meeting in Shrewsbury, are likely to be present. Mr. E. H. Shaughnessy will give a lecture on " The Wireless Station at Leafield."

The membership, which shows a considerable increase on the numbers for last year, now stands at 121 and a successful session is in prospect. A.J.W.D.

SOUTH WESTERN DISTRICT.

Retirement of A. T. Kinsey, Esq., A.M.I.E.E.

On the 7th June, Mr. Kinsey, Assistant Superintending Engineer, South Western District, retired from the Department's service on reaching the age limit, and after having completed 41 years' service of which 37 were spent in the P.O. Engineering Department. His first appointment was as Skilled Telegraphist in Manchester in 1881, but previously he had been assistant to the Postmaster of Congleton, Cheshire. In 1885 he joined the Engineering Department as Junior Clerk, and in 1888 was promoted to

A. T. Kinsey.

the first class at Dublin, being one of the first Englishmen to be sent across the Irish Sea. In 1891 he was appointed Relief Inspector for Ireland and in 1892 given a section with headquarters in Dublin. About this time following on Regulation of Railways Act of 1888 "Block" working on the Irish Railway Lines became compulsory and Mr. Kinsey was largely concerned with the introduction of both the "Harper's Blocks" Signalling System for double lines, and "Thompson's Train Staff Apparatus" for single lines. A descriptive paper written by Mr. Kinsey upon these systems was read by him before the Irish Section of the I.E.E. and subsequently published in extenso in the Electrical

Journals. Some notes on the "Life of Creosoted Timber," also read before the local branch was, owing to the interest the paper excited, reprinted in the United States.

Mr. Kinsey was promoted to be 1st Class Engineer in 1898 without change of Headquarters, and during his occupancy of this post the wiring of the Dublin Head Telegraph Office was converted from G.P. to Lead-covered Cables, and Secondary Cells, Generating Sets, Steam and Gas Engines, and Hydraulic Plant, were installed. In 1907 he was promoted to the rank of Assistant Superintending Engineer in the Southern Irish District under Mr. Moir, and was subsequently transferred to the Irish Northern District. On the formation of the South Western District of England he became the first Assistant Superintending Engineer there under Mr. Tremain.

Mr. Kinsey is an associate member of the I.E.E., having joined that Institution on the formation of its Irish Section and was a regular attendant and ready speaker at its meetings. He has served on the Committees of the "Irish & Western" sections of the Institute. He was also a regular attendant at the meetings of the I.P.O.E.E. in the South Western District, where his part in the discussions was invariably apposite and helpful. He never failed to lighten the more technical discussions by the introduction of some of his unique stories, of which he had an inexhaustible fund.

Mr. Kinsey was very methodical and scrupulous in all his dealings, and enjoyed the respect of the staffs he worked with. He was a staunch teetotaller and non-smoker, but notwithstanding he was ever a welcome figure at all staff social gatherings where his happy gift of striking the right note and rounding it off by some quaint story was greatly appreciated, and it is hoped he will continue to attend such gatherings for many years to come.

He was an energetic member of the Sports Club at Moreton House, and still plays a good game of tennis. He has many interests including Fishing, Geology, Botany and Natural History. He is a member of the Wesleyan Church and a lay preacher therein. With so diversified a range of subjects he will find no difficulty in fully occupying the time his freedom from official ties will provide. He leaves official life with the earnest good wishes of all the staff.

On the 24th May last a Garden Party in honour of Mr. Kinsey, attended by a full gathering of officers and friends from all parts of the District, was held at the District Headquarters at Moreton House, Bristol, and was made the occasion of a presentation to Mr. Kinsey of a silver tea-kettle, and a gold chain to Mrs. Kinsey. The presentation was made in a felicitous speech by Mr. Eldridge, who eloquently expressed the feelings of all present at the loss of Mr. Kinsey's services and voiced the hope of the whole of the staff of the District that both Mr. and Mrs. Kinsey would have health and strength to enjoy for many years the rest and freedom from official cares which his retirement provided.

Mr. Chapman, Mr. Roach, Mr. Weir, and Mr. Emlyn Jones each made appreciative reference to Mr. Kinsey's unfailing good nature and effective help in all difficulties. A charming day and a pleasing ceremony was brought to an effective close by the rendering of musical honours to both Mr. and Mrs. Kinsey.

WORK OF THE WIRELESS AND RESEARCH SECTIONS.

EXTRACTS FROM THE ANNUAL REPORT.

IN order that the general body of the staff may become acquainted with a portion of the Department's work which does not as a rule come immediately within their view, we have pleasure in reproducing the following extracts from the Engineer-in-Chief's Annual Report for the year ended 31st March last, dealing with the work carried out by the Wireless and Research Sections at headquarters.

WIRELESS.

The Leafield Imperial Station was formally opened by the Postmaster-General on August 18th, 1921. Pending completion of the Cairo station it is being used for other wireless services such as Foreign Office Press—Press Transmission to America—Rome commercial service—Long distance ship transmission—Genoa Conference Service. Leafield is now operated by distant control from Banbury. This station has also been completed and has been used for reception from Rome and the Genoa Conference until utilised for its normal function as the receiving station for Cairo. Good signals have been received from Cairo. The Cairo Imperial Station has been completed and undergone satisfactory trials. It is now being handed over for commercial working.

Stonehaven.—The duplicate arc installation at Stonehaven Station was completed and put in commission during the year. An experimental valve transmitter with glass valves (for use with the alternators of the 30 K.W. Spark set) was designed in this Department and a considerable amount of experimental work has been done at Stonehaven in connection with this transmitter. During the experiments reception tests were made in Egypt and, although the power would not be sufficient for reliable commercial working, it is interesting to note that satisfactory communication was obtained with Egypt during the two days trials. As a result of this experimental work, the installation of a transmitter of this type at Stonehaven for commercial working has been authorised. The aerial power of the valve transmitter will be between three and four times that of the existing arcs.

Northolt.—A contract for the power plant at Northolt was placed and the entire installation was nearing completion at the end of the year. (This station is now working).

Coast Stations.—The whole of the Coast Stations have been maintained throughout the year, but the two Irish Stations, Valencia and Malin Head, have remained in the control of the Admiralty.

The Port Patrick Station, taken over from the Admiralty, was brought into commission in November, 1921. The importance of the station from the point of view of British Wireless communication on the North Atlantic route has been increased by reason of the Malin Head Station passing from the control of the British Post Office.

The additions to the North Foreland Station were completed and a modern synchronous disc discharger transmitter installed at the station during the year.

A contract has been placed with the Radio Communication Company for installing a 1½ K.W. synchronous disc discharger spark set at Seaforth Wireless Station to displace the transmitter of fixed gap and obsolescent type in use at the station.

Orkneys and Shetlands.—A complete scheme was formulated during the year for wireless communcation between the various islands comprising the Orkney and Shetland groups to replace the inter-island cables. The particular point at present at issue is whether the replacement of the cables by wireless communication is economically justified.

Tests of Ships Sets.—A ¼ K.W. ships set of the R.M. Radio Company was submitted to test in July, 1921, and approved as satisfactory for fitting in ships. Quenched gap ships sets of ¼ K.W., ½ K.W. and 1½ K.W. power were submitted for test by the Marconi Company in July, 1921, and approved as satisfactory for fitting in ships.

Trials of Calling Devices.—The Radio Communication Company has evolved a calling device which is actuated only when a particular call of a station or the distress call (S.O.S.) is received.

Whether a calling device can be relied upon in the face of interference to function invariably with a distress call dependent upon a sequence of space signals is open to question. It has therefore been proposed by certain wireless authorities that the distress signal consist of a series of dashes of four seconds duration separated by spaces of one second duration. The Marconi Company has evolved a calling device dependent for its operation on this type of call.

Both the Radio Communication Company's and the Marconi Company's devices have been submitted to trial at the North Foreland Wireless Station. The percentage of failures, well over 50% in each case, was such as would not warrant approval being given to either of the devices in their present state in substitution of a listening operator.

Another distress call which has been suggested is that consisting of a dash of 15-20 seconds duration. A call device functioning with such signal has been devised in this office and good results obtained in trial on board the cable ships "Monarch" and "Alert;" a set of apparatus is permanently installed on each of these ships.

Direction Finding Stations.—An Inter-departmental Committee, on which officers of the Wireless Section serve, has recommended that a system of direction finding stations be established round the coasts of the British Islands. It would be a matter of great economy if the direction finding work could be combined in the one station with Coast Station work. In order to determine by actual trial whether such combination of work is practicable, the equipping of the Niton Wireless Station has been authorised and a contract placed with the Marconi Company for equipping the Station with direction finding gear. The gear has been inspected and approved and the work of installing will be completed shortly.

Communication with Lightships.—The wireless telephone communication installed by the Marconi Company between the Mersey Docks and Harbour Board's Liverpool Office and the Bar Lightship continues to give satisfactory service.

The Board of Trade has authorised Trinity House to proceed with the equipment of a group of lightships, the North, East and South Goodwin, Tongue and Gull lightships, and has requested the Post Office to enquire whether a Post Office on the Kentish Coast, where constant attention is given, could serve as a shore communicating station for these five ships. It has been recommended that the Ramsgate Post Office serve as the shore station. It should perhaps be added that a special calling device is part of the equipment at both the transmitting and receiving points of the communication.

Experimental Work.—Considerable development has taken place during the year in what may be called the quantitative side of wireless telegraphy, the measurement of the various factors that go to the making up of a successful signalling system. Amongst these the measurement of the radiation emitted by a transmitting station and the quantity received by a receiving station are perhaps the most important. The radiation emitted by Leafield on its fundamental wave length and also on its harmonics has been measured, and it has been found that the radiation on the harmonics, though disturbing to comparatively unselective receivers, is a very small quantity.

Another measurement of interest was the comparison between the radiation from an arc and a valve transmitter at Stonehaven, where it was found, contrary to expectation, that there was very little difference between the two systems when both were using the same aerial current.

Another set of radiation measurements was carried out for the Wireless Commission in order to determine the effect of the horizontal positon of a "T" aerial.

Work has been done during the year on counterpoise aerials, with a view to increasing the efficiency of transmitting stations by reducing the aerial resistances. This work has now passed the preliminary stages and it is proposed to try the system on a full size aerial.

A method was developed during the year of measuring the amplifying power under high frequency conditions of wireless receiving sets. This promises to be of great use in the future.

In reception a considerable amount of work has been done in the design of receivers which aim, as far as possible, at the re-reduction of interference from atmospherics. Work has been carried out on filter circuits, balanced aerials, barrage circuits, etc., and the efficiency of these arrangements has been tested in Egypt and India with satisfactory results by officers from this Department. The Post Office type of long distance receiver was tested against other receivers put forward by the Admiralty, Air Force, War Office and Radio Communication Company, and was found to be the best for long distance working, having regard to the reduction of jamming and atmospherics.

Experiments were carried out, in conjunction with the Air Force, on Wireless telephone communication between Aircraft and land stations.

Work has also been done on the design and manufacture of valve panels for Stonehaven and Northolt.

INVESTIGATION AND RESEARCH.

The total number of cases involving special study and experiments including the preparation of reports completed during the year ended 31st March, 1922, was 670, as compared with 397 cases including a small number of unfinished items dealt with in the previous year.

The years' work embraced the following experimental investigations:—

Telegraph apparatus and accessories	179
Telephone Trunk equipment (exclusive of cables) ...	63
Telephone Exchange and junction equipment (exclusive of cables)	104
Cable Loading Sections tested	448
Cable Section Groups tested	55

Apart from the work of collecting information and applying the latest scientific knowledge available to the study and solution of the problems dealt with in the foregoing summary, precision tests have been carried out by the Scientific Staff along the cable routes throughout Great Britain, 473,500 tests being made on 20,600 miles of underground cable conductors during construction. In addition to this field work, 2,704 tests on 20,800 miles of underground conductors have been made in connection with the localisation of faults in working cables.

The staff of the Research Section, which occupied premises in various buildings in Central London, was transferred to a new Post Office Engineering Research Station at Dollis Hill, N.W.2., on the 3rd October, 1921, when the new laboratories became available for occupation. As indicated by the summary, a large increase in the output of scientific work has resulted from the increased accommodation made available, although the full complement of authorised staff has not yet been appointed. A large amount of construction work has been planned and carried out at the new station in equipping the laboratories without interrupting the continuity of scientific work in hand. This equipment, which will greatly facilitate scientific work and the construction of experimental apparatus, may be briefly summarised as follows:—

One Instrument Workshop for the production of experimental apparatus has been equipped with power and metal working lathes and machines. Research Laboratories allocated to Telegraph Instruments and Systems, Local Telephone equipment, Telephone Transmission, Primary and Secondary electric batteries, Chemical and Physical experiments have been equipped and brought into use and the equipment of three more Research laboratories allocated to Automatic Telephones, Calibration of apparatus and Precision Tests, Thermionic Valve construction and development is nearing completion. A large amount of new apparatus has been designed by the scientific staff of the Section for research purposes and some of this apparatus has already been completed in the new workshops. The following items have been selected as examples:—

12 Cross talk sets for cable testing.

30● transformers for Telephone Repeaters.

80 experimental thermionic valves for Telephone Repeaters.

A telephone transmitter testing chamber for testing the life and efficiency of large numbers of transmitters under controlled atmospheric conditions as regards temperature, pressure and moisture.

The workshop staff have also satisfactorily dealt with the maintenance repairs of nine roadside motor testing vans with their precision testing apparatus which have been in active use continuously throughout the year.

A list of the investigations completed and reported upon during the year was furnished in an appendix.

Some of the more important cases are included in the following brief descriptions, viz.:—

Research in connection with the design of telephonic repeaters including details of filters, potentiometers and transformers. Repeater units have been designed, drawings completed and particulars furnished to permit of supplies being obtained.

Research in connection with telephonic articulation and transmission on coil-loaded underground circuits equipped with telephonic repeaters. Data to assist in the design of such circuits has been furnished. Research in the elimination of overhearing in loaded submarine phantomed cables..

A system of automatic signalling on trunk circuits in which transformers and relays are included has been developed.

Design of balancing circuits for underground loaded circuits for use on duplex telephonic repeaters.

Development of a two-stage amplifier for use on four-wire circuits, including the design of suitable thermionic valves.

Special Capacity balancing of continuously loaded cables.

Investigation and application of the method of localising high resistance faults on long underground cables.

Design of an amplifier for use on electrophone circuits.

Power efficiency of Induction Coils.—A comprehensive series of measurements at speech frequency was carried out. Amongst other results an auto transformer method of connecting LB induction coils has been suggested, involving increase in efficiency.

Dialling-in over loaded cables, etc., by alternating currents.—A method of signalling over loaded, phantomed or repeated transmission lines by means of alternating currents within the range of speech has been developed for dialling-in to an Automatic exchange.

Study of dial impulses.—A comprehensive examination of the action of auto dial-switches and their associated relays has been made by oscillograph.

Relay Contacts.—Tests of reliability, life and variation of resistance have been completed on two types of Tungsten contact, and Eureka. Other tests of the gold silver alloys are in hand, extending the investigations of the preceding year to manual equipment, and it is expected that the results will lead to a large saving in platinum for general telephonic purposes.

The selective lockout party-line system of R. C. Hastings has been tested exhaustively, and whilst containing possibly the basis of a working system has been found to be unsuitable in its present state of development.

Standardisation of Automatic Telephone Instrument.—Work carried out to fix a standard pattern of dial and instrument circuit suitable for all automatic systems.

Design of Electrophone Transmitter.—Further investigation has been made into the characteristics of a transmitter designed primarily for electrophone use. This is a transmitter having a high natural frequency above the normal range of speech frequencies and gives excellent articulation. It has been used successfully on exchange circuits and shows appreciable articulation improvement over the standard C.B. transmitter; some have been made with both volume and articulation superior to standard. Further investigation is proceeding to overcome certain defects, such as a tendency to "fry" and variations which have been found to occur under the severe temperature conditions of the theatre. It is thought to show promising results for a high resistance very articulate transmitter which may be useful both for exchange and electrophone use.

Amplifiers for Electrophone.—10 Amplifier sets designed on the lines suggested by the investigations carried out in this Section have now been installed and are giving complete satisfaction.

C.B. Circuit Characteristics.—Some preliminary work on the impedance of various types of exchange circuits and trunk lines has been carried out with a view to the design of an improved C.B. instrument.

Tests of Paris Call Office apparatus.—Tests were made of the Hall coin box for call office telephones, as used in Paris. The mechanism is the same as that in the stamp selling machines at present in use and is of the prepayment type designed so that the caller has to insert his money before the attention of the operator can be attracted. Some improvements were suggested in order to reduce the transmission loss. Suitable standard type apparatus for use in conjunction with the box have been selected. Some sets are now about to be put to practicable trial.

Thermophones submitted by the N.V. Holland Belgie Thermophoon Cie.—Some thermal receivers and transmitters of the "De Lange" type were tested. The suppliers suggested that they had advantages for use (1) as operators' receivers, and (2) as complete instruments for use by special subscribers on long distance cables. The advantages claimed were much better articulation and lightness. In order to obtain a volume of sound of the same order as with standard apparatus the thermophones require the use of three or four stage amplifiers, and these give rise to great trouble from induction caused by lighting and other circuits. The thermophones give only a slight improvement in articulation and it has been found that a suitably modified standard type receiver and also some experimental transmitters evolved by the Research Section can be made to give better results and only require single stage amplifiers.

It was considered that the improvement in articulation given by the thermophone does not warrant the increased cost and complication necessary.

Investigation into the W.E.Co.'s (American) method of transmission standardisation.—The methods of transmission standardisation in use by the Department are also followed by some other administrations, *e.g.*, France, South Africa, etc., but certain differences have grown up between the Department's methods and standards and those adopted by the American Western Electric and associated companies and it was suggested that steps should be taken to unify the methods with the ultimate object of evolving an international standard. With this in view a conference was held with representatives of the Western Electric Co., and it was decided to set up a complete transmission testing set as used by the W.E. Co. and to obtain standards from New York. This has been done and comparisons between the two methods and standards are now being made.

Tests on a Telegraphone.—This instrument was submitted by the inventor through the General Electric Co. It was intended to be connected to a subscriber's instrument and it could be made to reply to a calling subscriber in the absence of the owner or attendant. The caller could then record a message which the machine would repeat to the attendant on his return. Conversation could also be recorded when desired.

The instrument as submitted was not suitable for the Department's circuits generally, but could probably be modified to work without interference with the normal use of the subscriber's instrument.

The maintenance of these machines would probably be high.

Standards of Speech.—In connection with the maintenance of the Department's Standards of Speech, there are now 97 working standards in service by the Test Section and various contractors, and all these have been recalibrated every six months.

In addition the 28 primary, reference and working standards maintained in the Research Section have been recalibrated every three months.

Research is being continued into the effects of temperature, moisture and barometric pressure on the efficiency of Standards of Speech.

THE WIRELESS BOOM.

"Before any attachments are made to a building, the condition of the structure should be examined and unsubstantial property should be avoided."—*Extract from Technical Instructions.*

In the accompanying sketch our artist portrays the sad predicament of an amateur wireless enthusiast in the act of avoiding unsubstantial property.

Fixing the Aerial.

THE "AVERAGE MANHOUR COST."

By A. W. LINES

(Ass. Ins. Cost and Works Accountants.)

ARTICLES which appear in this Journal demonstrate that our Department is playing no mean part in the advancement of science and in the building of the greater civilization we hopefully envisage. As regards electrical and mechanical technology, a clerical member may state without risk of incurring the stigma of self-praise that we are entitled to pride in our achievements, and it is an additional source of gratification to realise that there are also phases of our accounting system which are equally daring and efficient.

Perhaps one of the best examples of these latter is the use of the average payment made during a month for one hour of non-clerical worker's time in a District. The use of these figures, usually termed in practice the " Average manhour rate " or simply the " Manhour rate," has probably had as great an influence as any single factor in simplifying accounting in the P.O.E.D. The arrangement, magnificently simple and boldly applied, has undoubtedly saved the taxpayer and telephone subscribers many thousands of pounds since its introduction, first for financial, and more recently for cost accounting. The simplicity of the present system is more clearly realised when contrasted with the arrangement it superseded. In days not so many years ago the actual payments made as wages to the linemen, labourers or other workmen were charged to the W.O., Maintenance item, or other authority, and at the estimating stage the men whom it was proposed to employ on the work had to be borne in mind. Often there were explanations to be made when the actual was compared with the estimated labour cost!

It is difficult to imagine a more severe strain on the average manhour rate system than that to which it is now subjected owing mainly to the discharge of men as the result of the decrease in the volume of work. Notwithstanding the fact that the percentages of higher paid men must at the present time vary in the various Sections, due in great measure to the impracticability of securing that the discharges shall be evenly distributed between the Sections, it was decided in the autumn of 1921 to substitute one monthly rate for each District in place of separate rates for internal and for external men in each Sectional Engineer's area.

It would be interesting to investigate, as far as an officer not at Headquarters can do so, the result of this daring policy of using the one rate for a whole District during these times of extraordinary labour conditions.

As the hourly rate is calculated to the nearest eighth of a penny, the maximum error must on the average amount to about 3d. per week for the whole of the workmen in a District, or assuming that the manhour rate is 1/5 per hour, the difference cannot be more than $\frac{1}{3}$ of 1 per cent. (actually about 0.37%). No such limitations, however, apply to the difference between the actual average hourly rate of pay of workmen in a given Section and the District average manhour rate applied to that Section. The following figures show approximately the adjustments which it was necessary to make in a Provincial District during the current financial year in order to raise or reduce actual labour costs incurred in the different Sections to the cost of the same number of hours calculated at the District average rate. A plus sign indicates that it was necessary to raise the actual charges, and a minus sign to reduce them :—

1922.	District Hqrs. £	Section "A." £	Section "B." £	Section "C." £	Section "D." £	Section "E." £	Whole District. £
April	−2	−17	+102	+35	−2	−57	+59
May	−2	−25	+41	+29	+30	−134	−61
June	−2	−9	+67	+38	+97	−121	+70
For three months	−6	−51	+210	+102	+125	−312	−68

As there are a large number of men employed in Section "E," the greatest percentage difference in the District between actual labour costs and the amount calculated at the average District rates occurs in Section "B," and this difference amounts on the average to about £5 5s. 0d. per man per annum, or approximately $2\frac{1}{2}$% of the average pay for a year's work.

Although the field surveyed in this contribution is a small one, it would not be surprising to find that the maximum percentage of error resulting from the abandonment of the old arrangement whereby pounds were spent to ensure penny accuracy rarely exceeds 3%, and it may be agreed that the bold innovation made in 1921 is surviving its time of trial.

Since the recent introduction of the nucleus of a costing system, the importance of the average manhour rate has increased. At the present time only the labour component is analysed in the U.C.C. statistics, and this is quoted not in cash but merely as the average number of manhours expended on the various units of work. Theoretically, as the check made is upon the average number of hours of work required for a specied operation, the incentive to employ lower paid men on work requiring lesser skill in order to keep down the actual labour cost is not so strong as it would be if the U.C.C. system showed the real money cost put into the tasks.

Still dwelling in the realms of theory, there should be a temptation for Supervising Officers, in order to incur as few manhours per unit as possible, to agree with reluctance to the substitution of trained staff by learners. The average manhour rate system masks the present artificial and doubtless temporary labour conditions which, it is anticipated, time will restore to normal. The system has obvious imperfections, but there is probably a heavy balance of advantage in its favour, and our Department is entitled to the credit of being close to the pioneers in adopting the arrangement. It reads like heresy to suggest that Private Enterprise might follow the lead of a Government Department in anything. It is, however, contended that economy in cost offices of other industries would follow the adoption of the average manhour rate system by cost accountants who deal with repetition operations on which workers of approximately equal pay are employed. It should also serve where the ratio existing between the numbers of workpeople on different rates of pay is constant or is nearly constant.

Rightly applied the average manhour rate is a potent implement for economising the time of Supervising Officers as well as that spent on financial and cost accounting processes, but it would be unwise to ignore the limitations and inherent weaknesses of the arrangement. There is an opportunity for minor research work in the investigation of the results which are due to the adoption of the average manhour rate; the many merits of the system are obvious, its few demerits should be discovered and understood.

BOOK REVIEWS.

"Wireless for the Home." By Norman P. Hinton, B.Sc., A.C.G.I. (Sir Isaac Pitman & Sons, Ltd., London. 87 pages; 34 illustrations and diagrams. 2*s*. net).

To those of us who receive, at more or less frequent intervals, appeals for advice as to the best way of acquiring some knowledge of "wireless," without a preliminary study of any branch of physical science, the appearance of this little book should be welcome. It is notoriously difficult for the expert in any field of work to meet the requirements of the layman and amateur who "wants to know," and our colleague is to be congratulated on the result of his effort in this direction. It is true that in a few instances revision of the phrasing would be beneficial; but we are satisfied that the author will take advantage of his second edition to remove the few imperfections of the present work.

The illustrations, including the diagrams, as well as the printing, are excellent.

J.W.A.

"History of the Telephone and Telegraph in the Argentine Republic (1857-1921); in Brazil (1851-1921; in Colombia, S.A. (1865-1921)." By Dr. Victor M. Berthold, Chief Foreign Statistian to the American Telephone and Telegraph Company.

By the courtesy of Dr. Berthold we have received copies of these three brochures, recently published by him. They contain a wealth of interesting information in regard to the development of the telegraph and telephone services in the countries named and we hope in our next issue to refer to some of the more important features.

J.W.A.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	Grade.	Promoted to	Date.
Lockhart, James ...	Chief Inspector, Telegraph Section E.-in-C.O.	Assistant Engineer, Telegraph Section E.-in-C.O.	24:7:22
Engineer-in-Chief's Office (Clerical).			
Renshaw, A. S. ...	First Class Clerk	Principal Clerk	To be fixed later.
Burge, C. W. ...	Second Class Clerk	Higher Ex. Grade	
Hardham, H. A. ...	Do.	Do.	
Bell, G. W.	Do.	Do.	
Few, H. P.	Do.	Do.	
Brown, B. M. ...	Third Class Clerk	Executive Grade	
Chenery, E. J. ...	Do.	Do.	
Ramsay, J.	Do.	Do.	
Howlett, T.	Do.	Do.	
Oldfield, G.	Do.	Do.	
Rhodes, H.	Do.	Do.	
Lilburn, G. L. ...	Do.	Do.	
Keifer, F. C. ...	Do.	Do.	
Stephenson, W. H....	Do.	Do.	
Buzzing, W. F. ...	Do.	Do.	
Butterfield, P. ...	Do.	Do.	
Bertram, J.	Do.	Do.	
Andrews, G. C. G....	Do.	Do.	
Laws, W.	Do.	Do.	
Wilcock, S.	Do.	Do.	
O'Regan, D. ...	Do.	Do.	
Bayly, A. E. ...	Do.	Do.	
Flanagan, W. J. ...	Do.	Do.	
Bishop, H. G. ...	Do.	Do.	
Farries, L. J. ...	Do.	Do.	
Warren, S. R. ...	Do.	Do.	
Harrison, F. A. ...	Do.	Do.	
Johnson, J. A. ...	Do.	Do.	

Appointments.

The following have been appointed Assistant Engineers on probation as a result of the Open Competition held last April.—

COMMUNICATIONS.

Name.	Section E.-in-C. O.
Beer, C. A.	Research.
Davis, H. G.	,,
Warren, A. C.	Wireless.
Little, G. J. S.	Research.
Harris, L. H.	,,
Ray, F. I.	,,
Reyner, J. H.	Wireless.
Palmer, W. T.	Research.
Hudson, W. E.	,,
Yeadon, N.	,,
West, W.	,,
Perris, F. R.	,,

DEATH.

Name.	Grade.	District.	Date.
Roberts, P. A. ..	Assistant Engineer	London	26 : 7 :22

COMMUNICATIONS.

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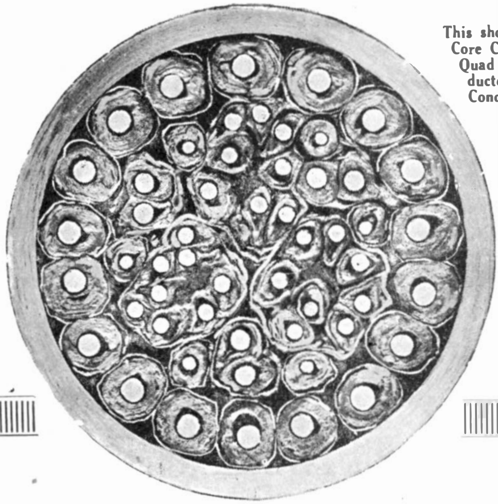

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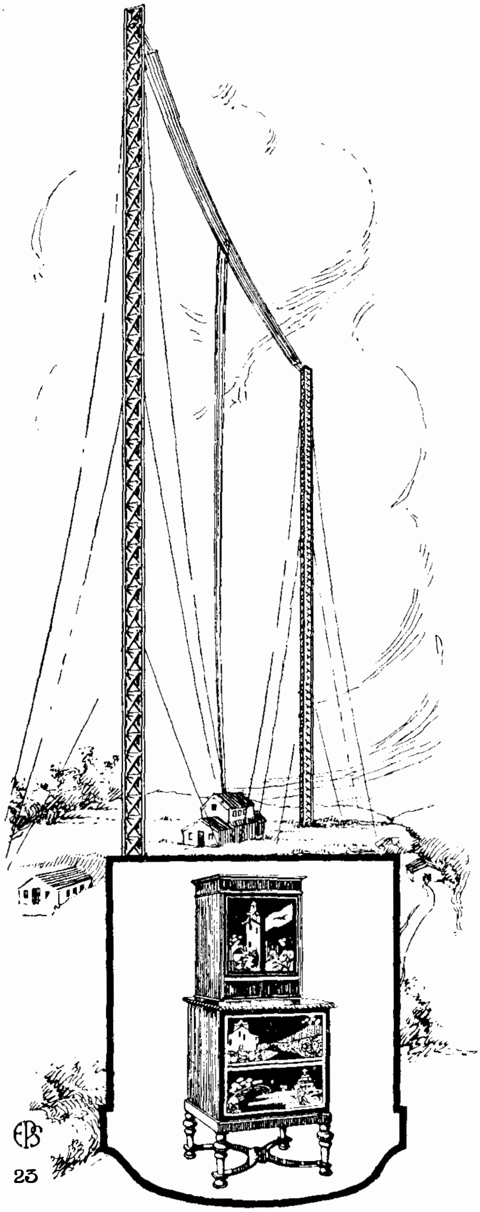

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